Anatomy and Clinical Implications of the Ultrasound-Guided Subsartorial Saphenous Nerve Block

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Background: We evaluated the anatomic basis and the clinical results of an ultrasound-guided saphenous nerve block close to the level of the nerve's exit from the inferior foramina of the adductor canal.

Methods: The anatomic study was conducted in 11 knees of formalin-preserved cadavers in which the saphenous nerve was dissected from near its exit from the inferior foramina of the adductor canal. The clinical study was conducted in 23 volunteers. Using a linear probe, the femoral vessels and the sartorius muscle were depicted in short-axis view at the level where the saphenous nerve exits the inferior foramina of the adductor canal. Ten milliliters of 1.5% lidocaine was injected into the compartment structured by the sartorius muscle and the femoral artery.

Results: The saphenous nerve was found to exit the adductor canal from its inferior foramina in 9 (81.8%) of 11 and at a more proximal level in 2 (18.2%) of 11 of the anatomic specimens. In a single specimen (9%), the saphenous nerve was formed by the anastomosis of 2 branches. In all the dissections, the saphenous nerve, after exiting the adductor canal, passed between the sartorius muscle and the femoral artery. Of the 23 volunteers, 22 responded with a complete sensory block, whereas a single volunteer demonstrated no sensory blockade. None of the volunteers experienced a motor block of the hip flexors and knee extensors.

Conclusions: Ultrasound-guided injection directly caudally from the inferior foramina of the adductor canal, between the sartorius muscle and the femoral artery, seems to be an effective approach for saphenous nerve block.

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The recent introduction of ultrasound imaging for the facilitation of nerve localization and blockade is an important advance in regional anesthesia.[1–4] Recently, a number of studies have ultrasonographically identified the saphenous nerve. The exact anatomic region, however, at which the nerve is visualized differs between studies.[5–8] Tsai et al[5] showed that an ultrasound-guided subsartorial approach to saphenous nerve blockade at the midfemoral level (at the midpoint between the knee and inguinal crease) is a moderately effective means to anesthetize the anteromedial lower extremity. Tsui and Ozelsel[6] used ultrasound imaging to describe a saphenous nerve block 10 to 12 cm above the popliteal crease, using the femoral artery as an "imaging" landmark, whereas Krombach and Gray[7] described a more distal approach, 5 to 7 cm proximal to the popliteal crease and performed a trans-sartorial approach to saphenous nerve block. Manickam et al[8] also performed a descriptive study to evaluate the efficacy of an ultrasound-guided saphenous nerve block technique at the distal part of adductor canal. The authors identified the saphenous nerve within the adductor canal and found that with this technique the nerve was blocked successfully in all 20 of their patients.

The adductor canal is an aponeurotic tunnel in the middle third of the thigh. It courses between the anterior-medial compartment of thigh and is covered by strong aponeurosis, the vastoadductor membrane. The canal contains the femoral artery, femoral vein, and branches of the femoral nerve (specifically, the saphenous nerve and the nerve to vastus medialis). The saphenous nerve exits the vastoadductor membrane at the level of the inferior foramina of the adductor canal and runs on the medial side of the knee.[9] Up to now, only a small number of reports have thoroughly studied the anatomy of the saphenous nerve in the adductor canal[10–12] and, more specifically, the place at which the nerve exits the inferior foramina of the canal.

In the present study, a dissection was conducted in a series of cadavers to provide a detailed description of the saphenous nerve anatomy at the inferior foramina of the adductor canal, and the anatomic basis for an ultrasound-guided saphenous nerve block was clinically evaluated.

METHODS

Anatomic Study

The cadaver study was performed in the dissection room of the Anatomy Department at the Medical School of the University of Athens, after approval by the institutional review board (Medical school, University of Athens, Athens, Greece). Eleven knees from 9 adult human formalin-embalmed cadavers were dissected. Each cadaver was placed in the supine position with the legs fully abducted. The skin and subcutaneous tissues of the anterior and medial thigh were carefully removed from the level of the superior third of the thigh to the level of the medial tibial condyle, revealing the underlying sartorius and vastus medialis muscles. The sartorius muscle was reflected laterally, allowing examination of the adductor canal and the subsartorial compartment. The connective tissue overlying the vastus medialis and adductor magnus muscles was carefully dissected. The course of the saphenous nerve, along with the courses of the major nerve branches at this region, was documented from the distal end of the adductor canal to the level of the medial epicondyle of the femur. The relationship of the saphenous nerve with the vastoadductor membrane was also examined.

Case Series

After receiving approval by the ethics committee of the Attikon University Hospital (Athens, Greece), an observational

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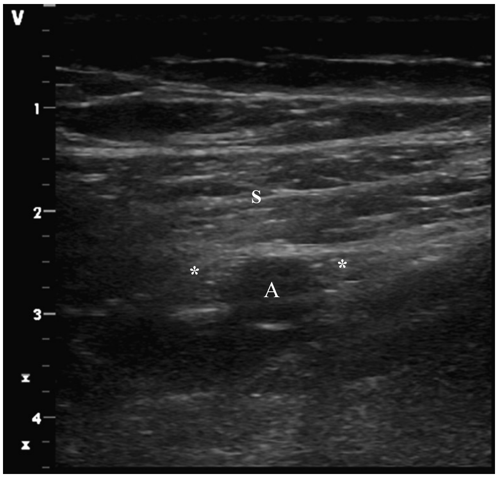

FIGURE 1. The ultrasound probe was placed on the medial aspect of the leg at the midpoint between the knee and the inguinal crease, perpendicular to the skin with the ultrasound beam directed to obtain a cross-sectional view of the femoral artery, the vastoadductor membrane (*) and the sartorius muscle in the short axis. A indicates femoral artery; S, sartorious muscle.

prospective study, including 23 adult volunteers, was conducted. Written informed consent was obtained from all volunteers. Volunteers who were younger than 18 years or older than 80 years; had allergy to local anesthetics, bleeding disorders, pregnancy, neurologic deficits; or a body mass index greater than 35 kg/m^2 were excluded from this study.

Standard monitoring was applied, including pulse oximetry, heart rate, electrocardiography, and noninvasive arterial blood pressure measurements, in all the volunteers.

Anatomic structures of the subsartorial region were visualized using a portable ultrasound machine (Vivid I; GE Healthcare, Waukesha, Wis) with a linear 5- to 10-MHz probe. The blocks were performed by 3 different anesthesiologists skilled in ultrasound-guided regional anesthesia and on the same leg in each of the volunteers. During the procedure, each volunteer was supine, with his/her lower extremity externally rotated at the hip and a slightly flexed knee. The midthigh area was prepared with 2% chlorhexidine in 70% isopropyl alcohol. The ultrasound transducer was placed perpendicular to the skin on the medial side of the thigh, at the midpoint between the knee and inguinal crease. A cross-sectional (short-axis) view of the femoral vessels and sartorius muscle was obtained (Fig. 1). The transducer was then moved caudally until the femoral vessels were visualized to exit the inferior foramina of the adductor canal and pass through the adductor hiatus into the popliteal fossa (Video, Supplemental Digital Content 1, http://links.lww.com/AAP/A31). At this point, the femoral artery was seen to move away from the sartorius muscle, and the anatomic compartment formed by the femoral artery and sartorius muscle was clearly depicted. After local skin infiltration with 3 mL of lidocaine 1.5%, a 22-gauge needle with extension tubing (Stimulplex; B Braun, Melsungen, Germany) was advanced by using the out-of-plane technique. Ten milliliters of 1.5% lidocaine was then injected into the compartment between the sartorius muscle and the femoral artery (Fig. 2 and Video, Supplemental Digital Content 2, http://links.lww.com/AAP/A32). After the injection, the progression of the block was monitored at 5-minute intervals in the sartorial branches of the saphenous nerve for 15 minutes in total.[13,14] Sensory block was rated as follows: 0, normal sensation; 1, decreased sensory block; and 2, complete sensory block. We considered the sensory block successful if there was a complete absence of sensation to pinprick in 2 tested areas (just proximal to the medial malleolus and at the midpoint between the medial malleolus and the tibial tubercle). The strength of the flexors of the thigh at the hip and the extensors at the knee was rated according to the following scale: 0, no motor block; 1, partial motor block (weakness of the hip flexors and leg extensors); 2, complete motor block (inability to flex the hip or extend the leg). The volunteers were contacted the day after the block procedure and, if symptomatic, daily thereafter until their symptoms resolved.

RESULTS

Anatomic Study

Eleven dissections in 9 cadavers were performed. There were 6 women and 3 men with a mean (SD) age of 67 (12) years and a mean (SD) weight of 71 (12) kg.

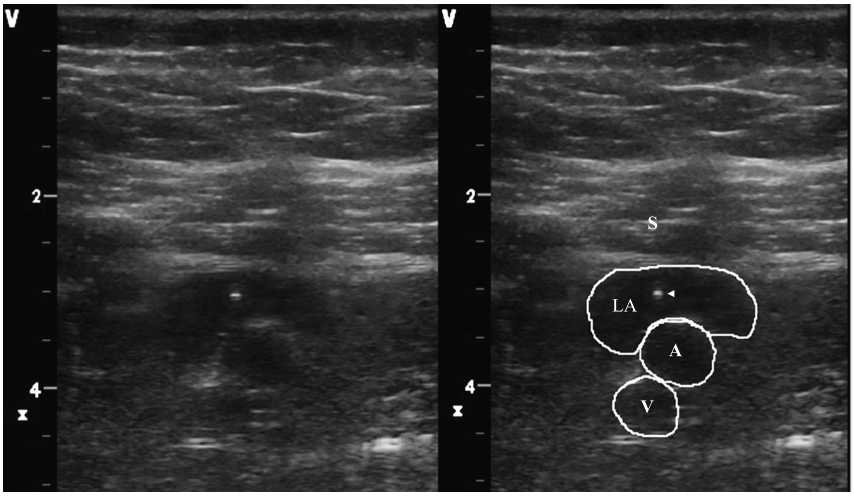

FIGURE 2. The needle tip was positioned in the compartment formed by the sartorius muscle and the femoral artery and then 10 mL of local anesthetic were injected. A indicates femoral artery; LA, local anesthetic; S, sartorious muscle; V, femoral vein.

The vastoadductor membrane was a strong thickened fascia and was identified in all the specimens. In 9 (82%) of 11 specimens, the saphenous nerve exited the adductor canal from the distal end of the vastoadductor membrane (Fig. 3), whereas in 2 (18%) of 11 specimens, the saphenous nerve pierced the vastoadductor membrane and exited the vastoadductor canal more proximally. In 1 specimen (9%), the saphenous nerve was formed by the anastomosis of 2 branches (Fig. 4). The one branch demonstrated an anatomic course similar to the saphenous nerve, entering the adductor canal and giving an anastomotic branch. The second branch emerged from the femoral nerve, coursed in proximity and parallel to the femoral artery, but outside the adductor canal, and joined the first branch at the inferior foramina of the adductor canal. In all the dissections (100%), the saphenous nerve, as it exited the adductor canal, did not demonstrate anatomic variations, always passing between the sartorious muscle and the femoral artery.

Case Series

Twenty-three volunteers (9 women and 14 men) included in the study with a mean (SD) age of 50 (22) years and a mean (SD) weight of 74 (11) kg.

Of 23 volunteers, 22 (95.6%) underwent complete sensory blocks (4/4). One volunteer experienced no sensory blockade (0/4). None of the volunteers tested had motor blocks of the hip flexors or knee extensors after this approach. One subject experienced mild systemic symptoms of local anesthetic toxicity (lightheadedness, numbness of the tongue, and circumoral tissues) after the completion of the saphenous nerve block. No other complications were recorded.

DISCUSSION

The saphenous nerve is usually detected by ultrasound within the adductor canal.[5,8,15] In a retrospective study by Tsai et al,[5] the ultrasound probe was placed on the medial aspect of the leg at the midpoint between the knee and the inguinal crease, and the saphenous nerve was depicted as a hyperechoic structure positioned medial to the femoral artery. Manickam et al[8] identified the saphenous nerve 12 cm proximal to the knee crease as a hyperechoic formation that was located anteromedially to the femoral artery. In this study, 30% of the patients reported no paresthesia as a result of needle-to-nerve contact, indicating that a paresthesia response may not be reliable as a sole end point. According to our anatomic preparations, along with other anatomic studies,[10–12] the vastoadductor membrane is a strong, thickened fascia that overlies the saphenous nerve. Within the adductor canal the vessel sheath is structured by strong network of collagen and elastic fibers, whereas the perivascular tissue contains thin lamellae of connective tissue that delimits lobules of adipose tissue.[16,17] Therefore, in the adductor canal, the combination of the vastoadductor membrane and the vessel sheaths may form structures that present a hyperechoic echotexture resembling that of nerve structures; thus, during ultrasound imaging, anesthesiologists may be misled and consider the hyperechoic appearance of these tissues (both the vastoadductor membrane and the adductor canal content) as the saphenous nerve. Consequently, the placement of the needle tip through the vastoadductor membrane, within the adductor canal, may result in the successful localization of the saphenous nerve.

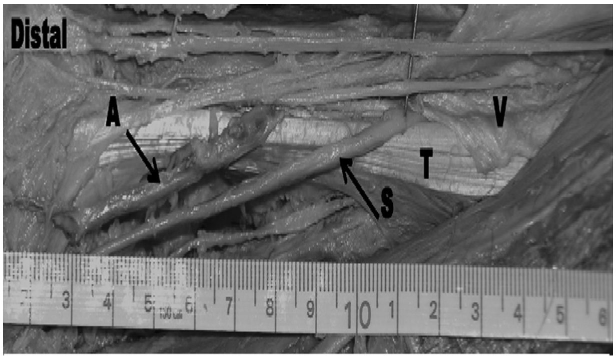

FIGURE 3. The sartorious muscle has been totally excised and the anatomic relationship of the femoral artery and the saphenous nerve has been revealed. The saphenous nerve exits from the inferior foramina of the adductor canal. A indicates saphenous branch of the descending genicular artery; I, = infrapatellar branch; M, vastus medialis; S, saphenous nerve; T, tendon of the adductor magnus; V, vastoadductor membrane.

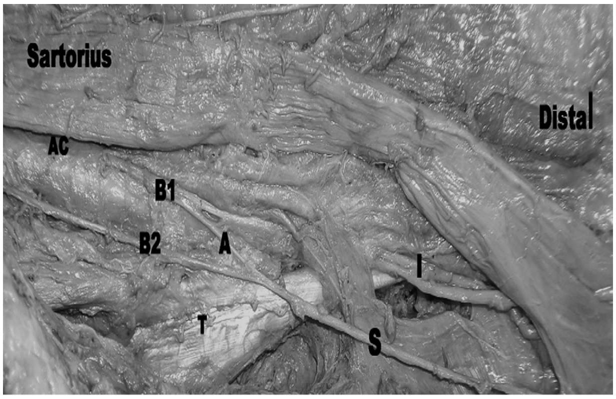

FIGURE 4. The sartorious muscle has been reflected so as the saphenous and the infrapatellar nerves have been exposed. Part of the adductor canal has been also removed so that the 2 branches (B-1 and B-2) that form the saphenous nerve can be clearly seen. B-1 gives off an anastomotic branch (A) within the adductor canal that joins the B-2 and forms the saphenous nerve at the level of the inferior foramina of the adductor canal (removed section). B-1 exits the adductor canal by piercing the vastoadductor membrane (removed section) and continues as the infrapatellar nerve. AC indicates adductor canal; F, femoral artery; I, infrapatellar branch; S, saphenous nerve; T, tendon of the adductor magnus.

In our study, the transducer was initially placed on the medial aspect of the distal third of the thigh and then slid caudally, until the hyperechoic appearance of the vastoadductor membrane faded and the femoral artery was seen "diving" toward the posterior compartment of the thigh, usually 1- to 2-cm distal to the inferior foramina of the adductor canal. Although we did not search for the saphenous nerve, we exploited the fact that the femoral artery and vein passed through the adductor hiatus at this point and proceeded into the popliteal fossa, whereas the saphenous nerve continued on its original course underneath the sartorius muscle. From the inferior foramina of the adductor canal to the adductor hiatus, the saphenous nerve ran in the space between the sartorius muscle and the femoral vessels. In our anatomic study, after the saphenous nerve and the femoral vessels exited the inferior foramina of the adductor canal, they demonstrated an invariable anatomic relationship. Therefore, applying this observation in our case series, the local anesthetic was injected at the point where the femoral artery moved away from the sartorius muscle, at the anatomic compartment structured by the sartorius muscle and the femoral artery. Tsui and Ozelsel[6] also used the femoral artery and the sartorius muscle as "imaging" landmarks for the blockade of the saphenous nerve just proximal to where the femoral artery becomes the popliteal artery. In their study, the local anesthetic was injected medially to the artery, but the precise success rate of this technique was not recorded. Horn et al[18] used a subtle imaging landmark, the descending genicular artery, for the saphenous nerve block. This block was successfully performed in prone position on 1 patient scheduled for ankle surgery. In our case series, 10 mL of local anesthetic was able to spread sufficiently and block (success rate, 95.6%) the saphenous nerve. Although the success rate of the saphenous nerve block using ultrasound imaging techniques was satisfactory, the variability between the different studies was likely related to the anatomic variations of the nerve. In fact, in our anatomic preparation, the saphenous nerve was observed to exit the canal from its lower foramina. There were, however, 2 cases in which the saphenous nerve pierced the vastoadductor membrane more proximally. Despite this anatomic variation identified, the anatomic course of the saphenous nerve after exiting the adductor canal was invariable, with the nerve always passing between the sartorius muscle and the femoral artery. Interestingly, in one of our preparations, the saphenous nerve was formed by 2 roots. The one root run within and the other out of the adductor canal. The 2 branches joined each other at the inferior foramina of the adductor canal, forming the saphenous nerve that, in turn, also passed between the femoral artery and the sartorius muscle. In this case, injection of the local anesthetic inside the adductor canal might have led in an incomplete saphenous nerve block.

One potential limitation of the saphenous nerve block in the adductor canal is the secondary blockade of the vastus medialis nerve, which results in some degree of vastus medialis weakness.[19] This outcome might prohibit the early discharge of ambulatory patients. In our study, none of our patients reported muscle weakness of the thigh.

In addition, studies[20–22] have reported that the distribution of the infrapatellar branch of the saphenous nerve to the skin in front of the patella can vary significantly. For this reason, the distribution of the local anesthetic to the infrapatellar branch of the saphenous nerve was not evaluated; thus, the sensitivity to pinprick for the infrapatellar region was not assessed.

CONCLUSIONS

1. The saphenous nerve always passes between the sartorious muscle and the femoral artery as it exits the inferior foramina of the adductor canal.
2. Ultrasound-guided injection directly caudal from the inferior foramina of the adductor canal, between the sartorius muscle and the femoral artery, is a reliable and likely a safe approach for saphenous nerve block. It is a simple method because ultrasound identification of the saphenous nerve is not required and it can be successfully performed without a nerve stimulator.

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