

Saphenous Nerve in the Distal Adductor Canal: Anatomic Position of the Nerve in Relation to the Superficial Femoral Artery

Daryl S. Henshaw, MD, Robert S. Weller, MD

ABSTRACT

Background: For ultrasound-guided saphenous nerve blockade within the adductor canal, the location of the saphenous nerve relative to the superficial femoral artery may be important for continuous blockade or low-volume, diagnostic block. Currently, there are inconsistencies in the literature and anatomy textbooks as to the anatomic relationship of these two structures in the distal adductor canal. Using anatomical position to characterize structural relationships, the saphenous nerve has been described or depicted as being either anterior or posterior to the artery, depending on the reference. The objective was to determine the location of the saphenous nerve relative to the superficial femoral artery in the distal adductor canal.

Methods: One lower extremity in 18 unenbalm cadavers was dissected to examine the relationship of the saphenous nerve to the superficial femoral artery just proximal to the adductor hiatus. In 11 of 18 specimens, pre-dissection ultrasound examination and dye injection adjacent to the structure thought to be the saphenous nerve was performed. Standard anatomical position was used to describe the relationship of the nerve and artery.

Results: The saphenous nerve was found anterior (11/18) or anteromedial (7/18) to the superficial femoral artery at the distal adductor canal. It was never found posterior to the artery 0/18 (95% C.I. 0.0–0.158). Dye stained the saphenous nerve in 10/11 cases.

Conclusion: We found a consistent anatomic relationship between the saphenous nerve and the superficial femoral artery in the distal adductor canal just proximal to the adductor hiatus, with the nerve always anterior or anteromedial to the artery.

Introduction

The application of ultrasound to saphenous nerve (SAPH) blockade has led to a number of descriptions for ultrasound-guided saphenous blockade within or distal to the adductor canal.¹⁻¹⁰ One such approach within the adductor canal is performed at the mid-thigh level just proximal to the adductor hiatus. This approach is attractive because of the ease of identifying the large superficial femoral artery (SFA) just deep to the sartorius muscle. Additionally, at this location, SAPH blockade may be achieved by injecting local anesthetic (LA) into the fascial compartment of the

From the Department of Anesthesiology, Wake Forest School of Medicine, Winston-Salem, NC

Address correspondence to: Daryl S. Henshaw, MD, Department of Anesthesiology, Wake Forest School of Medicine, Medical Center Boulevard, Winston-Salem, NC
Phone: 336-716-4498
Fax: 336-716-8190
dhenshaw@wakehealth.edu

adductor canal without directly identifying the nerve, which may not always be visible on ultrasound. However, when placing a catheter for continuous saphenous analgesia or when using a low volume of LA, such as for diagnostic or therapeutic blocks for pain, the precise relationship of the SAPH relative to the SFA may be important.^{11,12}

Some have commented on the “remarkable consistency” of the anatomy in the adductor canal.¹¹ Surprisingly, however, one can find notable variability in both anatomy textbooks and the current literature regarding the anatomic position of the SAPH relative to the SFA as they course distally in the adductor canal (Figures 1 and 2). The purpose of this study was to characterize the anatomic position of the SAPH relative to the SFA in a series of unembalmed cadavers, especially the distal adductor canal just proximal to the adductor hiatus.

Methods

For anatomic specimens donated to Wake Forest School of Medicine, Institutional Review Board approval is not required for dissection and study. Eighteen unembalmed cadavers were preserved by refrigeration and dissected within 2 weeks of death. The cadavers were positioned supine with the thigh externally rotated and the knee flexed approximately 20°. Anatomical position was consistently used to characterize the anatomy.¹³ With the leg in this position, the sartorius muscle is anterior in the proximal thigh at its origin from the anterior superior iliac spine, becomes medial at the distal adductor canal, and inserts on the medial, proximal tibia.

In 11 of 18 cadavers, ultrasound examination of the adductor canal was performed with a linear 13-6 MHz transducer (Sonosite Turbo™, Bothell, WA) in the short-axis view immediately proximal to the adductor hiatus. There we identified the thick-walled, but collapsed SFA. After putative identification of the SAPH—as a 1-3mm, round, hyperechoic, honeycomb-like structure adjacent to the SFA—

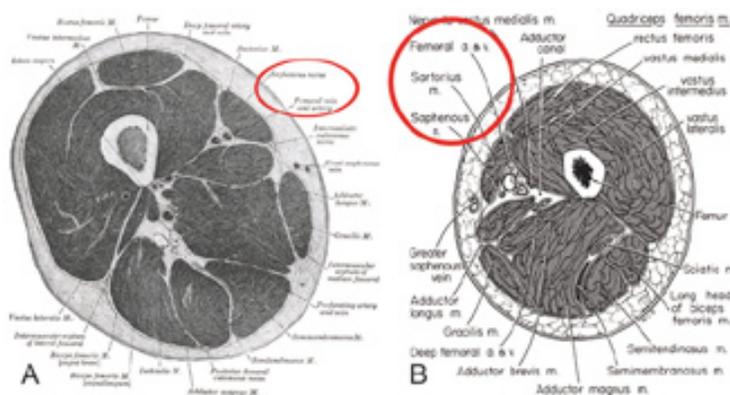


Figure 1:

A. Figure 432. Cross-section through the middle of the thigh. (From Gray’s Anatomy of the Human Body (online). Available at: <http://www.bartleby.com/107/illus432.html>. Accessed March 14, 2012.)

B. Figure 416. A cross-section of the thigh through levels of the adductor canal. (Permission pending from Woodburne RT. *Essentials of Human Anatomy*. New York, NY: Oxford University Press, 1973: pg. 532 (fig. 416)).

an in-plane needle was inserted from the anterior side of the thigh and 0.2 ml of methylene blue was injected adjacent to the identified nerve prior to the dissection (Figure 3). In the remaining 7 cadavers, no pre-dissection dye was injected.

In all specimens, the skin and subcutaneous tissues overlying the upper thigh were incised and reflected laterally to minimize the likelihood of disturbing the nerve from its native location. The femoral artery, vein, and nerve were identified in the femoral triangle and the sartorius muscle was divided and reflected caudally from its origin at the anterior superior iliac spine. The aponeurosis connecting the quadriceps and adductor muscles, and forming the roof of the adductor canal, was incised to identify the SFA, the SAPH, and the nerve to the vastus medialis. The adductor tendon forming the adductor hiatus was identified, and the location of SAPH relative to the SFA just proximal to the adductor hiatus was recorded. Serial digital images were taken of all dissections for later review, if necessary. In all specimens, the dissection was extended and the nerve was followed to its terminal branches on the medial leg for positive identification of the SAPH (Figure 4).

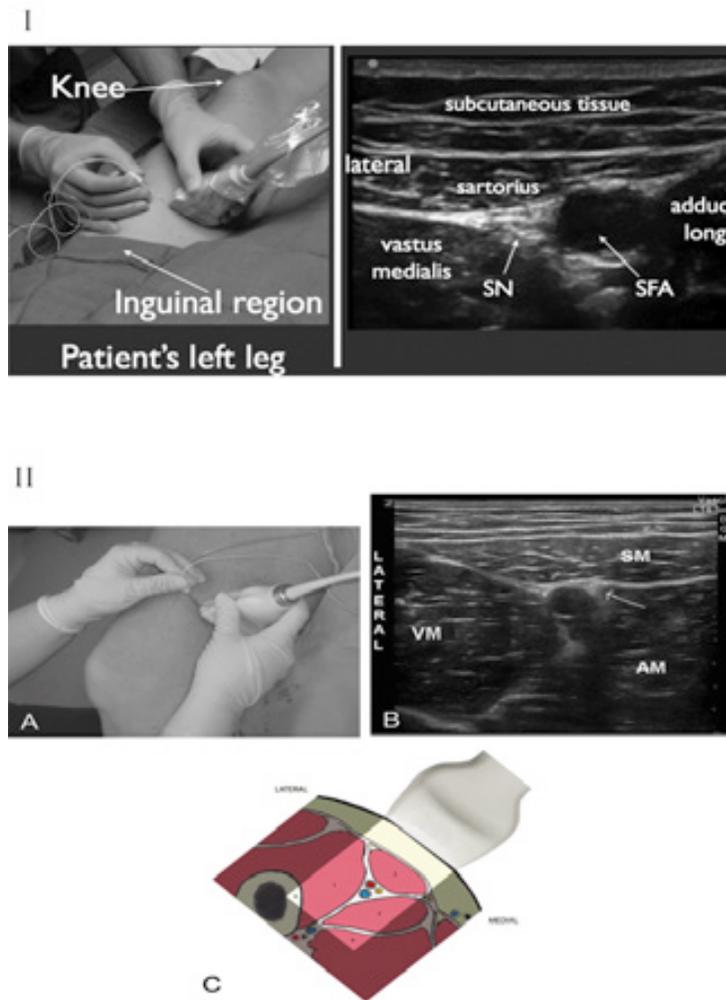


Figure 2:

I. The short-axis image of the left neurovascular structures in the mid to proximal femur. SN=saphenous nerve; SFA=superficial femoral artery.³

II. A. Probe and needle orientation for SAPH block in the distal adductor canal (right thigh). B. Cross-sectional sonoanatomy of the distal adductor canal. AM=adductor muscles; SM=sartorius muscle; VM=vastus medialis muscle. Arrow points to the saphenous nerve (SAPH). C. Schematic representation of the cross-sectional anatomy of the distal adductor canal as it relates to the SAPH. 1=vastus medialis muscle, 2=sartorius muscle, 3=adductor longus muscle, 4=adductor magnus muscle, 5=femoral artery, 6=saphenous nerve (yellow circle), 7=femoral vein, 8=femur.⁷

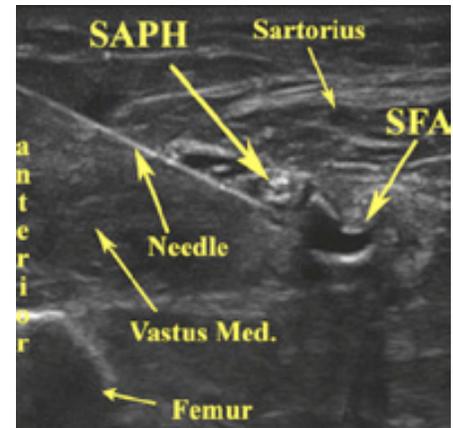


Figure 3: Ultrasound image from dye-injection portion of the study. The needle is shown approaching from the anterior side of the leg between the vastus medialis and the sartorius. The saphenous nerve is anteromedial to the SFA.

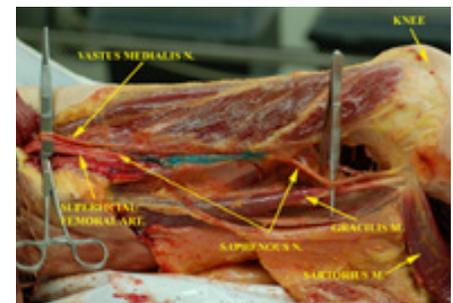


Figure 4: Cadaveric dissection showing the saphenous nerve stained with methylene blue. Dissection is extended distal to adductor hiatus to verify course and that the nerve stained with dye is the saphenous nerve.

Wilson's interval was used to analyze the results, and a two-tailed 95% confidence interval was calculated, without correcting for continuity, for the proportion of the dissections in which the nerve was found posterior to the SFA.¹⁴

Results

All cadavers were individuals who were above the age of 60 at death, and they ranged from thin to overweight. Nine were male and 9 were female; the right leg was dissected in 6, and the left in 12. In all cadaver dissections, we readily identified the adductor canal, SFA, SAPH, and the nerve to the vastus medialis. Using the anatomic position for description, in the proximal canal, the SAPH originated lateral to the SFA and then traveled anterior to the artery in all dissections. In the distal adductor canal just proximal to the adductor hiatus, the SAPH was anterior (11/18) or anteromedial (7/18) to the SFA in the area bounded by the vastus medialis, Sartorius, and SFA. In no specimen was the nerve found posterior or posteromedial to the SFA between the sartorius and the adductor longus or magnus.

Dye injection under ultrasound guidance stained the SAPH in 10 of 11 cadavers upon subsequent dissection, confirming accurate identification of the SAPH. In one cadaver, the nerve to the vastus medialis was stained and likely was misidentified as the SAPH.

For a result of zero of 18 specimens with the SAPH posterior to the SFA, the 95% confidence interval calculates a lower limit of 0.0 and an upper limit of 0.158. The likelihood, then, that the SAPH would be found in this location in more cadavers was < 16%.

Discussion

Blockade of the SAPH in the adductor canal has recently become a topic of interest in regional anesthesia due to increased use of ultrasound and recognition of unavoidable motor weakness from proximal blockade of the femoral nerve, which can interfere with rehabilitation and lead to patient falls.¹⁵ Several studies have recently demonstrated preservation of motor strength following adductor canal blockade when compared to femoral nerve blockade, whether performed by single injection or continuous technique.^{16,17}

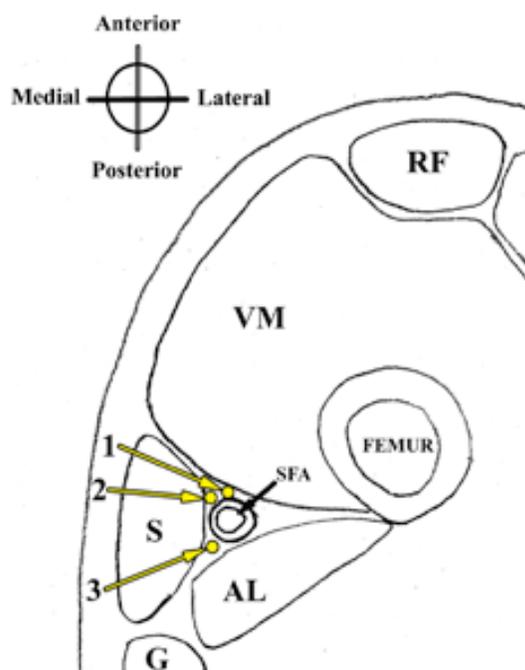


Figure 5: Diagrammatic representation of a cross-section of the thigh just proximal to the adductor hiatus. Three possible anatomic locations of SAPH relative to the SFA described or depicted in the literature and anatomic texts are numbered 1, 2, and 3. VM = vastus medialis, RF = rectus femoris, S = sartorius, G = gracilis, AL = adductor longus, SFA = superficial femoral artery.

The adductor canal is a triangular compartment in cross-section, bounded by the adductor longus and magnus muscles posteriorly, the vastus medialis anterolaterally, and the sub-sartorial fascia anteromedially. The adductor canal transmits femoral vessels and nerves from the apex of the femoral triangle to the opening in the tendon of the adductor magnus, known as the adductor hiatus. The course of both the SAPH and SFA distal to the adductor canal is well described.^{1,18,19} There is incongruity, however, in the current literature and in anatomy textbooks (Figures 1 and 2) about the relationship of the SAPH to the SFA as they travel together in the distal adductor canal before diverging at the adductor hiatus where ultrasound-guided SAPH block is commonly performed. The SAPH shown variously as anterior, anteromedial, or posterior to the SFA (Figure 5: positions 1, 2, or 3).

In this series of cadaver studies, we consistently found the SAPH anterior or anteromedial to the SFA (Figure 5: positions 1 and 2). This is in contrast to a study performed by Manickam et al.⁷ There the SAPH was depicted (Figure 2,II,B,C) as posterior to the SFA (Figure 5: position 3, between the artery and the adductor longus muscle, although described as “lateral” since anatomic position was not used to define position. In their study, the needle was inserted through the vastus medialis and the investigators could elicit a sensory paresthesia in the ankle in 75% of participants at this posterior location, perhaps via stimulation through vascular structures. A more recent study by Kim et al. referenced the block technique described by Manickam in their methods.²⁰ One of the earliest descriptions of the adductor canal block by Tsui et al. depicts the desired spread of LA again (Figure 5: position 3) posterior to the SFA.¹⁰ In a later study by Tsai et al., the SAPH is labeled on an ultrasound image as being on the medial side of the SFA.⁹ However, this position is shown again (Figure 5: position 3) posterior to the SFA, using anatomical position to define direction. Tsai et al noted that when performing the block, the needle was inserted lateral to the ultrasound probe and advanced to the medial side of the artery. In the accompanying image, the injectate of LA is shown at position 3 (Figure 5) or posteromedial to the SFA. Other reports and anatomy textbooks depict the SAPH anterior to the SFA, as found in all of our dissections.^{1,3,4,16,19,21-30}

Historically, single injections of moderate volumes of LA into the adductor canal have been successful despite discrepancies in the literature as to the location of the SAPH relative to the SFA at the adductor hiatus. Since the boundaries of the adductor canal form a tight compartment around the SFA and SAPH, the exact location of the SAPH in relation to the SFA may not be critical when moderate to large volumes of LA are injected. This is because the limits of the canal may facilitate spread of LA to the SAPH, whether it is thought to be posterior or anterior to the SFA. In fact, Davis et al. showed spread of 30 ml methylene blue proximal to the femoral triangle when injected into the distal adductor canal in unembalmed cadavers.³¹ Conversely, when low-volume injection or continuous catheter placement is used for SAPH blockade, the LA's proximity to the nerve may be

important for successful nerve block. This concept has yet to be investigated, but a more clear understanding of the anatomical relationship between the SAPH and the SFA and more accurate LA placement may be important. The only investigations of continuous SAPH (adductor canal) blockade reported to date depict the SAPH anterior to the SFA and positioned the catheter to produce LA spread in this location.^{17,21,27-30,32,33}

A recent investigation of ultrasound-guided SAPH blockade included dissection of 9 embalmed cadavers and SAPH blocks in 23 volunteers.⁸ Unlike studies that used injections above the adductor hiatus, Saranteus et al.⁸ identified a block level just distal to the adductor hiatus where the femoral artery departed from the sartorius muscle. They did not attempt to identify the SAPH directly, and they injected 10 ml of LA directly between the sartorius muscle and the artery with a 95.6% success rate.

An important limitation of our series is the small number of dissections performed and the potential for anatomic variability undetected by this sample size. However, the likelihood that the SAPH is located in a position other than anterior or anteromedial to the SFA is < 16%, and in most patients the SAPH can be assumed to be in this location even if not apparent on ultrasound imaging.

As interest continues in how best to administer adductor canal blocks to provide successful analgesia for surgeries of the lower extremity and preserve motor strength, it may be relevant to understand the relative locations of the SAPH and SFA in the distal adductor canal. We believe that this study further clarifies that anatomic relationship. More studies are needed to determine if needle/catheter to nerve approximation is important for block success or allows lower LA dosage/volume without sacrificing analgesia.

References:

1. Andersen, HL, Gray AT. The Saphenous Nerve Block. ASRA News (Newsletter) February 2012: 10-12. Available at: <http://www.asra.com/Newsletters/feb-2012.pdf>. Accessed March 10, 2014.
2. Horn JL, Pitsch T, Salinas F, Benninger B. Anatomic basis to the ultrasound-guided approach for saphenous nerve blockade. Reg Anesth Pain Med 2009; 34: 486-9.

3. Kirkpatrick JD, Sites BD, Antonakakis JG. Preliminary experience with a new approach to performing an ultrasound-guided saphenous nerve block in the mid to proximal femur. *Reg Anesth Pain Med* 2010; 35: 222-3.
4. Krombach J, Gray AT. Reply to Drs. Tsui and Özsel. *Reg Anesth Pain Med* 2009; 34: 178-9.
5. Krombach J, Gray AT. Sonography for saphenous nerve block near the adductor canal. *Reg Anesth Pain Med* 2007; 32: 369-70.
6. Lundblad M, Kapral S, Marhofer P, Lönnqvist PA. Ultrasound-guided infrapatellar nerve block in human volunteers: description of a novel technique. *Br J Anaesth* 2006; 97: 710-4.
7. Manickam B, Perlas A, Duggan E, Brull R, Chan VW, Ramlogan R. Feasibility and efficacy of ultrasound-guided block of the saphenous nerve in the adductor canal. *Reg Anesth Pain Med* 2009; 34: 578-80.
8. Saranteas T, Anagnostis G, Paraskeuopoulos T, Koulalis D, Kokkalis Z, Nakou M, Anagnostopoulou S, Kostopanagioutou G. Anatomy and clinical implications of the ultrasound-guided subsartorial saphenous nerve block. *Reg Anesth Pain Med* 2011; 36: 399-402.
9. Tsai PB, Karnwal A, Kakazu C, Tokhner V, Julka IS. Efficacy of an ultrasound-guided subsartorial approach to saphenous nerve block: a case series. *Can J Anaesth* 2010; 57: 683-8.
10. Tsui BC, Ozsel T. Ultrasound-guided transsartorial perifemoral artery approach for saphenous nerve block. *Reg Anesth Pain Med* 2009; 34: 177-8.
11. Morganti CM, McFarland EG, Cosgarea AJ. Saphenous neuritis: a poorly understood cause of medial knee pain. *J Am Acad Orthop Surg* 2002; 10: 130-7.
12. Romanoff ME, Cory PC Jr, Kalenak A, Keyser GC, Marshall WK. Saphenous nerve entrapment at the adductor canal. *Am J Sports Med* 1989; 17: 478-81.
13. Weller RS, Henshaw DS. The use of anatomical position for regional block description. *Reg Anesth Pain Med* 2014; 39(3):263-4.
14. Wilson EB. Probable inference, the Law of Succession, and statistical inference. *J Am Stat Assoc* 1927;22:209-12. Available at: http://www.med.mcgill.ca/epidemiology/hanley/tmp/proportion/wilson_jasa_1927.pdf. Accessed March 10, 2014.
15. Ilfeld BM, Duke KB, Donohue MC. The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty. *Anesth Analg* 2010; 111: 1552-4.
16. Kwofie MK, Shastri UD, Gadsden JC, Sinha SK, Abrams JH, Xu D, Salviz EA. The effects of ultrasound-guided adductor canal block versus femoral nerve block on quadriceps strength and fall risk: a blinded, randomized trial of volunteers. *Reg Anesth Pain Med* 2013; 38: 321-5.
17. Jæger P, Zaric D, Fomsgaard JS, Hilsted KL, Bjerregaard J, Gyrn J, Mathiesen O, Larsen TK, Dahl JB. Adductor canal block versus femoral nerve block for analgesia after total knee arthroplasty: a randomized, double-blind study. *Reg Anesth Pain Med* 2013; 38: 526-32.
18. Horner G, Dellon AL. Innervation of the human knee joint and implications for surgery. *Clin Orthop Relat Res* 1994; (301): 221-6.
19. Gray's Anatomy (British Edition), 35th ed. Philadelphia: W. B. Saunders, 1973. Pg 1054
20. Kim DH, Lin Y, Goytizolo EA, Kahn RL, Maalouf DB, Manohar A, Patt ML, Goon AK, Lee YY, Ma Y, Yadeau JT. Adductor canal block versus femoral nerve block for total knee arthroplasty: A prospective, randomized, controlled trial. *Anesthesiology* 2014; 120: 540-50.
21. Andersen HL, Gyrn J, Møller L, Christensen B, Zaric D. Continuous saphenous nerve block as supplement to single-dose local infiltration analgesia for postoperative pain management after total knee arthroplasty. *Reg Anesth Pain Med* 2013; 38: 106-11.
22. Børglum J, Johansen K, Christensen MD, Lenz K, Bendtsen TF, Tanggaard K, Christensen AF, Moriggl B, Jensen K. Ultrasound-guided single-penetration dual-injection block for leg and foot surgery: a prospective, randomized, double-blind study. *Reg Anesth Pain Med* 2014; 39: 18-25.
23. Grant's Atlas of Anatomy, 6th ed. Baltimore, MD: Williams & Wilkins, 1972. (Fig 264)
24. Hanson NA, Derby RE, Auyong DB, Salinas FV, Delucca C, Nagy R, Yu Z, Slee AE. Ultrasound-guided adductor canal block for arthroscopic medial meniscectomy: a randomized, double-blind trial. *Can J Anaesth* 2013; 60: 874-80.
25. Kent ML, Hackworth RJ, Riffenburgh RH, Kaesberg JL, Asseff DC, Lujan E, Corey JM. A comparison of ultrasound-guided and landmark-based approaches to saphenous nerve blockade: a prospective, controlled, blinded, crossover trial. *Anesth Analg* 2013; 117: 265-70.
26. Moore KL, Dalley AF. *Clinical Oriented Anatomy*, 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2005. pg. 602 (Fig 5.20)
27. Lund J, Jenstrup MT, Jæger P, Sørensen AM, Dahl JB. Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results. *Acta Anaesthesiol Scand* 2011;55:14-9.
28. Andersen HL, Andersen SL, Tranum-Jensen J. The spread of injectate during saphenous nerve block at the adductor canal: a cadaver study. *Acta Anaesthesiol Scand*. 2015 Feb;59(2):238-45.
29. Andersen HL, Gyrn J, Møller L, Christensen B, Zaric D. Continuous saphenous nerve block as supplement to single-dose local infiltration analgesia for postoperative pain management after total knee arthroplasty. *Reg Anesth Pain Med*. 2013 Mar-Apr;38(2):106-11.
30. Mariano ER, Kim TE, Wagner MJ, Funck N, Harrison TK, Walters T, Giori N, Woolson S, Ganaway T, Howard SK. A randomized comparison of proximal and distal ultrasound-guided adductor canal catheter insertion sites for knee arthroplasty. *J Ultrasound Med*. 2014 Sep;33(9):1653-62.
31. Davis JJ, Bond TS, Swenson JD. Adductor canal block: more than just the saphenous nerve? *Reg Anesth Pain Med* 2009; 34: 618-9.
32. Jenstrup MT, Jæger P, Lund J, Fomsgaard JS, Bache S, Mathiesen O, Larsen TK, Dahl JB. Effects of adductor-canal-blockade on pain and ambulation after total knee arthroplasty: a randomized study. *Acta Anaesthesiol Scand* 2012; 56: 357-64.
33. Mudumbai SC, Kim TE, Howard SK, Workman JJ, Giori N, Woolson S, Ganaway T, King R, Mariano ER. Continuous adductor canal blocks are superior to continuous femoral nerve blocks in promoting early ambulation after TKA. *Clin Orthop Relat Res*. 2014 May;472(5):1377-83.