Anatomic Variations of the Obturator Nerve in the Inguinal Region: Implications In Conventional and Ultrasound Regional Anesthesia Techniques

Sofia Anagnostopoulou, PhD, Georgia Kostopanagiotou, PhD,†‡ Tilemachos Paraskeuopoulos, MD,* Christina Chantzi, MD,§ Evangelos Lolis, MD,* and Theodosios Saranteas, PhD†‡*

Background and Objectives: This study was conducted to provide a thorough description of the variability in the obturator nerve branching pattern in the inguinal region.

Methods: The anatomic variability of obturator nerve branching among 84 dissected embalmed cadavers was investigated. Ultrasound examination of the inguinal region was undertaken in 20 cases and the location of the obturator nerve was identified.

Results: The point of division for the obturator nerve into the anterior and posterior branches was intrapelvic (23.22%), within the obturator canal (51.78%), or in the thigh (25%). Most commonly, the anterior branch was divided among 3 major muscular branches (66.66%) that innervated the adductor longus, adductor brevis, and gracilis muscles. Four, and 2 subdivisions of the anterior branches were observed, in 4.76% and 28.57% of cases, respectively. The posterior branch predominantly separated into 2 divisions (60.11%), which provided innervation to the adductor brevis and adductor magnus muscles. In addition, either 1 (13.69%), 3 (19.04%), or 4 (7.14%) muscular divisions of the posterior branch were observed. The articular branch of the obturator nerve showed 9 different branching patterns, which most frequently arose from the common obturator nerve. The fascias medial to the femoral vessels and deep to the pectineus muscle were clearly visualized (100%) by ultrasound imaging. This region was used as an "imaging" landmark for localization (success rate of 80%) of the common obturator nerve.

Conclusions: High anatomic variability in the obturator nerve's divisions and subdivisions does exist, and explains the difficulty frequently encountered in the application of regional anesthetic techniques.

Key Words: obturator nerve, regional anesthetic techniques

(*Reg Anesth Pain Med* 2009;34: 33–39)

It is well established that the obturator nerve arises from the ventral divisions of the second, third, and fourth lumbar nerves. The nerve descends through the fibers of the psoas major muscle and emerges from its medial border. The obturator nerve runs along the lateral wall of the lesser pelvis, above and in front of the obturator vessels, to the upper part of the obturator foramen. Passing through the obturator canal, the nerve extends to the thigh. During this course, it divides into anterior and posterior branches. These branches are first separated by some of the fibers of the obturator externus muscle and are then separated by the adductor brevis muscle. After a short course in the inguinal region, the anterior branch of the obturator nerve runs between the adductor longus and adductor brevis muscles. In contrast, the posterior branch runs between the adductor brevis and adductor magnus muscles. During this course, the 2 nerves divide into branches that supply innervation to the above-mentioned muscles.[1]

Obturator nerve block is not routinely performed because nerve localization and clinical evaluation of the nerve block's success can be difficult, and time consuming. One possible reason for these complications is the high anatomic variability that the nerve demonstrates at the level of the inguinal region. Studies have described anatomic variations of the obturator nerve,[2] but less is known about the exact number of divisions and subdivisions in the inguinal region. Indeed, there have been relatively few anatomic reports on this subject and those that exist are based on a small number of specimens.[2,3]

Therefore, this study was conducted to provide a detailed description of the variability in the obturator nerve branching pattern at the level of the inguinal region in a series of anatomic specimens, and to clarify the potential usefulness of such a description in the implementation of regional anesthetic techniques.

METHODS

Anatomic Study

For this study, a series of 84 adult human formalin-embalmed cadavers (54 male, 30 female, 72 ± 12 years of age, 67 ± 15 kg) were used. The study was based on a macroscopic preparation of cadavers in the dissection room of the Anatomy Department at the Medical School of the University of Athens (Athens, Greece) in compliance with strict institutional and federal regulations. The dissections were performed by anatomists, and all cadavers (donators) were used for teaching of medical students and in the training program of the department.

The obturator nerve anatomy was examined bilaterally and variations in its branching pattern were recorded. The anatomic preparation of the obturator nerve included its extrapelvic course and its main divisions (anterior, posterior, and articular nerve branches) in 168 human specimens. More precisely, after removal of the skin and the subcutaneous tissues of the anterior and medial thigh, the sartorius, pectineus, and adductor longus muscles were dissected free from the anterior fascias. With great care, the pectineus and adductor longus muscles were dissected at their fascial septum and were incised in a transverse pattern to expose the adductor brevis and external obturator muscles lying at a deeper level. The anterior branch of the obturator nerve was identified within the connective tissue covering the adductor brevis muscle. The course of the posterior branch of the obturator nerve was exposed after dissection and anterolateral

From the Department of Anatomy, and the †Department of Anesthesia and Intensive Care, School of Medicine, University of Athens; ‡Department of Anesthesia and Intensive Care, Attikon Hospital; and the §Department of Anesthesia, General State Hospital of Athens, Athens, Greece.
Accepted for publication May 22, 2008.
Address correspondence to: Theodosios Saranteas, PhD, 19 Karatza Str and Klemanso, 18534 Piraeus, Greece (e-mail: saranteas@ath.forthnet.gr).

ISSN: 1098-7339
DOI: 10.1097/AAP.0b013e3181933b51

removal of the adductor brevis muscle. Both branches of the obturator nerve were followed cranially and caudally, and were carefully dissected from the surrounding tissues. Special attention was paid to the point where the common obturator nerve divided into its anterior and posterior branches, as well as to the identification of the articular branch for the hip joint.

Ultrasound Study

An ultrasound study was performed on a group of 20 patients (aged 69 ± 18 years, body mass index 18 ± 4 [calculated as weight in kg divided by the square of height in meters]) who had submitted to lower extremity orthopedic surgery. Following approval by the local Ethics Committee, a femoral nerve block combined with an obturator nerve block were scheduled for postoperative pain management. The nerve blocks were performed with 5 to 10 MHz linear ultrasound probe (HD11 XE ultrasound machine, Philips, Andover, MA) and Vivid i (General Electric Healthcare, Waukesha, WI). In addition, a low frequency 2 to 5 MHz transducer was used only for visualization of the obturator nerve. The wide field of the beam of the ultrasound probe more precisely defined the anatomic relationship between the obturator nerve and the surrounding tissues.

For the obturator nerve block, the patients were placed in a supine position with the lateral thigh rotated slightly externally. The probe was placed perpendicular to and just below the inguinal ligament, at the pubic tubercle level, and the inguinal region was scanned. The femoral vessels and the adductor muscles were also visualized (Figs. 1A and 1B). The pectineus muscle was easily identified between the femoral vessels and the adductor muscles. The probe was then tilted cranially 30° to 40° and a thick hyperechoic fascia was visualized (Figs. 1C and 1D). Afterwards, an insulated needle connected to a neurostimulator was advanced (using the out of plane technique) within the visualized fascia, and the obturator nerve and its branches were localized with a current lower than 0.75 mA. Confirmation of obturator nerve stimulation was attained by observing adductor muscles twitching in real time, and by palpating the respective contraction area. After successful localization of the common obturator nerve or its divisions, 7 mL of local anesthetic solution (ropivacaine 0.75%) was injected.

RESULTS

Division of the Common Obturator Nerve Into Anterior and Posterior Branches

Careful dissection exposed the division of the common obturator nerve into anterior and posterior branches (Table 1). The point of division was considered extrapelvic when located after the obturator canal, while it was considered intrapelvic when the 2 branches separated as they entered the obturator canal. In 23.22% (39/168) of specimens, the division was determined to be intrapelvic. The division was located within the obturator canal in 51.78% (87/168) of cases. In 25% (42/168) of specimens, the common obturator emerged united from the obturator canal and separated into anterior and posterior branches in the medial thigh (Figs. 2A and 3A).

Anatomic Variations of the Anterior Obturator Nerve Branch in the Inguinal Region

The anterior branch of the obturator nerve innervates a variable number of muscular divisions. Most commonly, it is

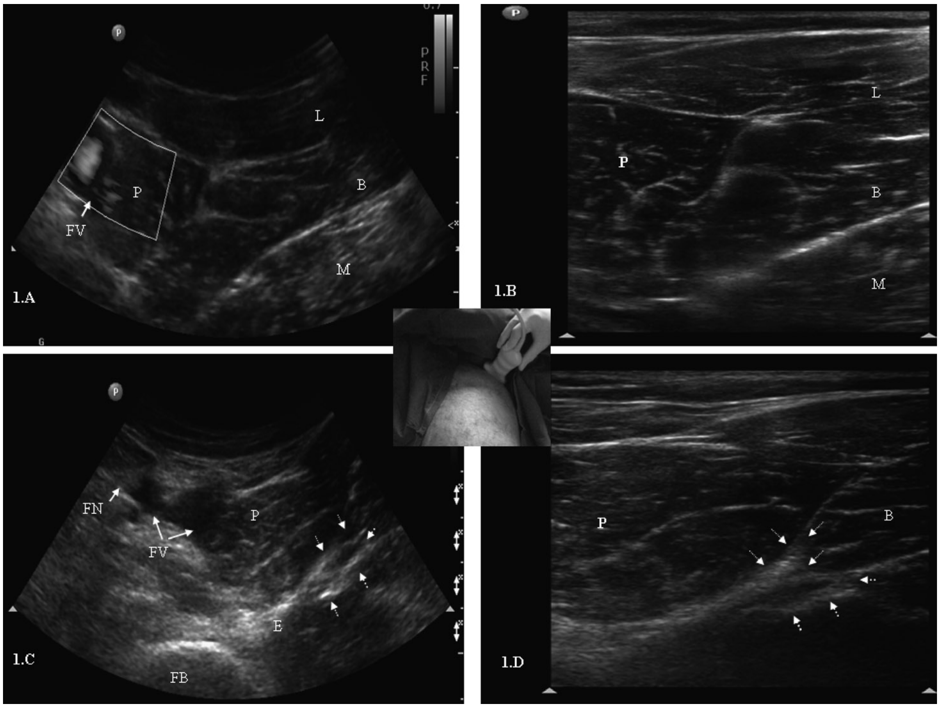

FIGURE 1. Ultrasound identification of the obturator nerve. (A) The curved 2 to 5 MHz and (B) the linear 5 to 10 MHz transducers were placed perpendicularly just below the inguinal ligament, at the pubic tubercle level. The inguinal region was scanned (inset) and the femoral vessels together with the adductor muscles were also visualized. (C) The curved and (D) linear transducers were then tilted cranially 30° to 40° and a thick hyperechoic fascia (dashed arrows) was visualized, and used as an "imaging" landmark for the identification of the obturator nerve or its divisions. B, adductor brevis muscle; E, obturator externus muscle; FB, femoral bone; FN, femoral nerve (white arrows); FV, femoral vessels (double arrow); L, adductor longus muscle; M, adductor magnus muscle; P, pectineus muscle.

TABLE 1. Level of Division of the Common Obturator Nerve to Anterior and Posterior Branch

Level of Division	Percentage (n = 168)
Obturator canal	23.22
Medial thigh	51.78
Intrapelvic	25

divided among three major muscular branches that innervate the adductor longus, adductor brevis, and gracilis muscles. This anatomic pattern was observed in 66.66% (112/168) of the specimens (Figs. 2A and 3A). Two muscular divisions of the anterior branch of the obturator nerve were observed in 28.57% (48/168) of the specimens. When only 2 divisions were found, they were distributed in the adductor longus and gracilis muscles (Figs. 2B and 3B). In 4.76% (8/168) of specimens, 4 divisions of the anterior branch were observed. Those muscular branches innervated the adductor longus, adductor brevis, gracilis, and pectineus muscles (Table 2).

Anatomic Variations of the Posterior Obturator Nerve Branch in the Inguinal Region

The posterior branch of the obturator nerve was usually smaller than the anterior branch, and traveled in a thick fascia between the adductor brevis and the adductor magnus muscles. Throughout its course, it supplied multiple nerve branches to the adductor magnus muscle. In 13.69% (23/168) of the specimens, 1 muscular division in the adductor magnus muscle was observed (Table 3) (Figs. 2C and 3C). This division emerged from the trunk of the posterior branch of the obturator nerve as a thick and easily recognizable formation that was further divided into multiple thin filaments. These filaments entered the mass of the adductor magnus along its course. In 60.11% (101/168) of the specimens, the posterior branch of the obturator nerve provided innervation to both the adductor brevis and adductor magnus muscles (Figs. 2D and 3D). In 19.04% (32/168) of the specimens, muscular divisions of the posterior branch of the obturator nerve were distributed to the external obturator, adductor brevis, and adductor magnus muscles (Figs. 2E and 3E). In 7.14% (12/168) of the specimens, the posterior branch of the obturator nerve provided 4 divisions that were distributed to adductor longus, adductor brevis, adductor magnus, and external obturator muscles (Figs. 2F and 3F).

Interestingly, the adductor longus (7.14%) and adductor brevis (70.3%) muscles demonstrated a double innervation pattern by both the anterior and posterior obturator branches.

Anatomic Variations of the Hip Articular Branch of the Obturator Nerve in the Inguinal Region

Recognition of the articular branches of the obturator nerve for the hip joint presented difficulties in some cases due to their small size and variability in their number and level of divisions. The total number of obturator nerve branches distributed to the hip joint among all of the specimens was 3 in 17.85% (30/168),

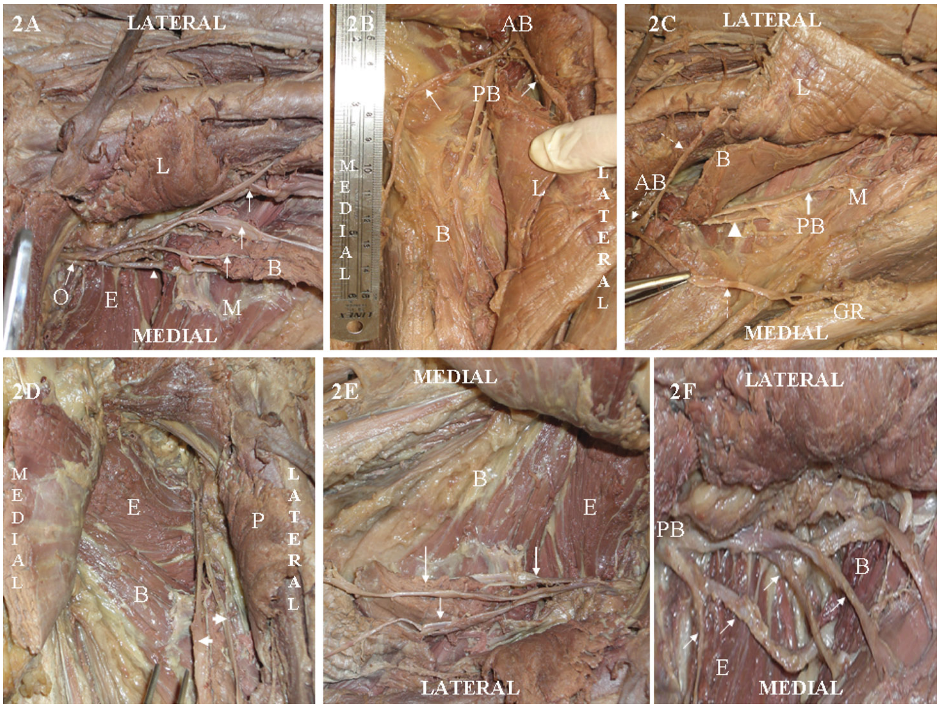

FIGURE 2. Branching patterns of the anterior and posterior obturator nerve in the inguinal region. (A) The common obturator nerve exiting the obturator canal and dividing into the anterior (arrows) and posterior (arrowhead) branch in the inguinal region. (B) The anterior branch of the nerve bifurcates into 2 subdivisions (arrows). (C) The posterior branch of the obturator nerve provides 1 muscular division (arrowhead) to the adductor magnus muscle. The anterior branch is also seen, divided into subdivisions (dashed arrows). (D) The posterior branch of the obturator nerve divides into 2 subdivisions (arrows). (E) Muscular divisions of the posterior branch of the obturator nerve are distributed to external obturator, adductor brevis, and adductor magnus muscles (arrows). (F) The posterior branch of the obturator nerve gives rise to 4 subdivisions, distributed to the adductor longus, adductor brevis, adductor magnus, and obturator externus muscles (arrows). AB, anterior branch of the obturator nerve; B, adductor brevis muscle; E, obturator externus muscle; GR, gracilis muscle; L, adductor longus muscle; M, adductor magnus muscle; O, common obturator nerve; PB, posterior branch of the obturator nerve.

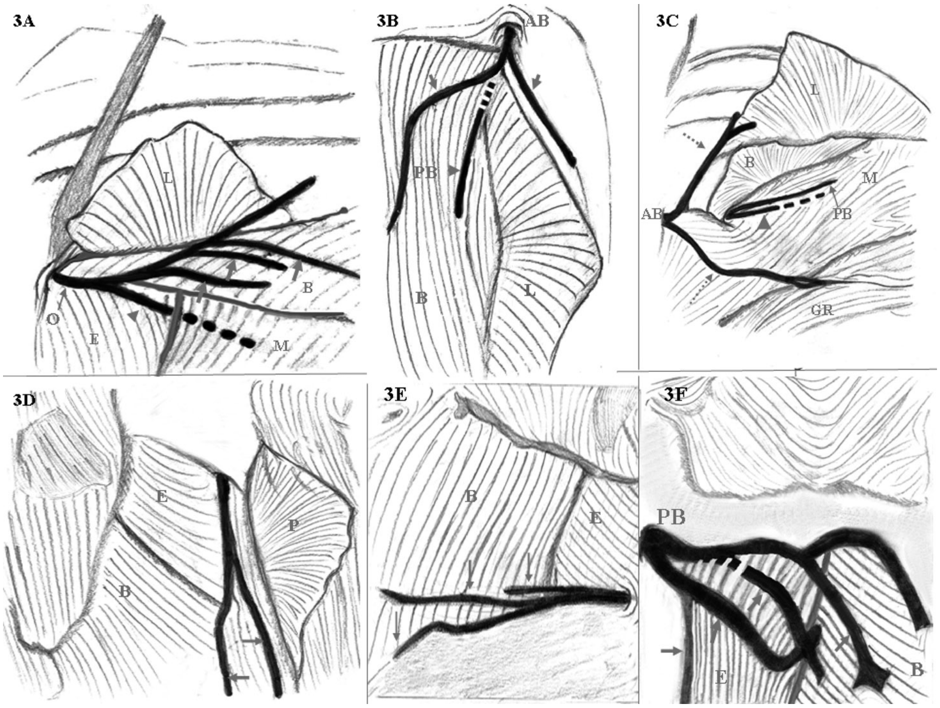

FIGURE 3. Branching pattern of the anterior and posterior obturator nerve in the inguinal region. (A) The common obturator nerve (thin arrow) exiting the obturator canal and dividing into the anterior (thick arrows) and posterior (arrowhead) branch in the inguinal region. (B) The anterior branch of the nerve bifurcates into 2 subdivisions (arrows). (C) The posterior branch of the obturator nerve provides 1 muscular division (arrowhead) to the adductor magnus muscle. The anterior branch is also seen, divided into subdivisions (dashed arrows). (D) The posterior branch of the obturator nerve divides into 2 subdivisions (arrows). (E) Muscular divisions of the posterior branch of the obturator nerve are distributed to external obturator, adductor brevis, and adductor magnus muscles (arrows). (F) The posterior branch of the obturator nerve gives rise to 4 subdivisions, distributed to the adductor longus, adductor brevis, adductor magnus, and obturator externus muscles (arrows). AB, anterior branch of the obturator nerve; B, adductor brevis muscle; E, obturator externus muscle; GR, gracilis muscle; L, adductor longus muscle; M, adductor magnus muscle; O, common obturator nerve; P, pectineus muscle; PB, posterior branch of the obturator nerve.

2 in 20.23% (34/168), and 1 in 61.9% (104/168) of the cases (Fig. 4). The articular branch for the hip joint arose from the common obturator nerve or its branches at different levels in conjunction with the obturator canal.

In 76.92% (80/104) of the specimens that possessed a single articular branch, we observed that the articular branch for the hip joint derived from the common obturator nerve (Figs. 5A and 5B). From the remaining specimens with a single branch, 19.23% (20/104) possessed an articular branch derived from the anterior branch of the obturator nerve, while 3.84% (4/104) had an articular branch for the hip joint that originated from the posterior branch of the obturator nerve.

Out of 34 specimens that possessed 2 articular branches, the origin of both branches was the common obturator nerve in 47.05% (16/34), and the posterior branch of the obturator nerve in 41.17% (14/34). However, in 11.76% (4/34) of specimens, the first articular branch derived from the common obturator nerve, and the second from the posterior branch of the obturator nerve.

From the 30 specimens that possessed 3 articular branches for the hip joint, the origin of the 3 branches was the common obturator nerve in 53.33% (16/30) of the cases. In 26.66% (8/30) of the specimens that possessed 3 articular branches, we noted that 2 articular branches derived from the common obturator nerve, and the third articular branch derived from the posterior branch of the obturator nerve. In 20% (6/30) of the specimens

TABLE 2. Number of Divisions in the Anterior Obturator Nerve Branch in the Inguinal Region

Number of Divisions	Percentage (n = 168)
2 Branches: A. longus and gracilis	28.57
3 Branches: A. longus, A. brevis and gracilis	66.66
4 Branches: A. longus, A. brevis, gracilis and pectineus	4.76

Abbreviation: A, adductor.

TABLE 3. Number of Divisions in the Posterior Obturator Nerve Branch in the Inguinal Region

Number of Divisions	Percentage (n = 168)
1 Branch: A. magnus	13.69
2 Branches: A. magnus and A. brevis	60.11
3 Branches: A. magnus, A. brevis, and E. obturator	19.04
4 Branches: A. magnus, A. brevis, E. obturator, and A. longus	7.14

Abbreviations: A, adductor; E, external.

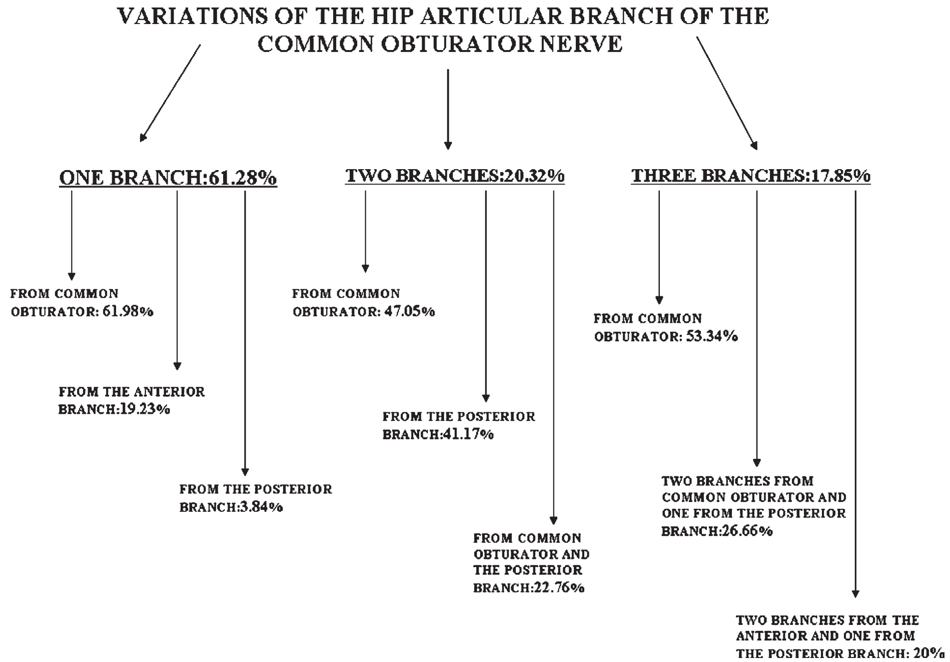

FIGURE 4. Variations in the hip articular branch of the common obturator nerve.

that possessed 3 articular branches, 2 of them originated from the anterior branch of the obturator nerve, and the third originated from the posterior branch of the obturator nerve.

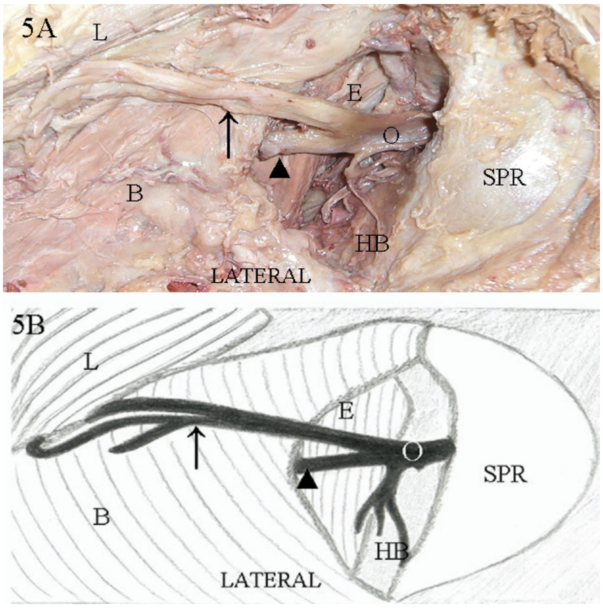

FIGURE 5. Anatomic variations in the hip articular branch of the obturator nerve in the inguinal region. (A) The common obturator nerve exiting the obturator canal and separating into anterior (arrow) and posterior (arrowhead) branches in the inguinal region. The hip articular branch (HB) is administered by the common obturator nerve. (B) Illustration of the common obturator nerve administering the hip articular branch (HB) and dividing into the anterior (arrow) and posterior (arrowhead) branches. B, adductor brevis muscle; E, obturator externus muscle; L, adductor longus muscle; O, common obturator nerve; SPR, superior pubic ramus.

Ultrasound Identification of the Obturator Nerve

With this approach, neither the obturator nerve nor its main branches could be identified. A thick fascia was easily recognized medial of the femoral vessels and visceral to the pectineus muscle with a visibility rate of 100% (Figs 1C and D). The distance of the fascia from the skin surface was 4 ± 0.6 cm. The needle was advanced with the out of plane technique within the fascia plane. Neither the common obturator nerve nor its branches could be visualized within the thick fascia and thus multiple needle maneuvers were needed to achieve contraction of all adductor muscles. Contractions of adductor longus, adductor brevis, adductor magnus, and gracilis muscles (stimulation of the common obturator nerve or its main divisions) were observed in 16 of 20 cases (80%). In 4 of 20 cases, contractions were observed only in the adductor longus, adductor brevis, and gracilis muscles (stimulation of nerve fibers of the anterior branch of the obturator nerve) with a 20% success rate. In 1 case (5%), contractions of the pectineus muscle were also observed.

DISCUSSION

The results of the present anatomic study clearly demonstrate that the branching pattern of the obturator nerve is highly variable. Therefore, examination of the anatomic variability of the obturator nerve may explain some of the difficulties experienced when locating and blocking the obturator nerve either with neurostimulation or with ultrasound-guided techniques.

So far, it has been suggested that a femoral nerve block supplemented with an obturator nerve block provides a better quality of postoperative analgesia following total knee replacement.[4] The combination of an obturator nerve block with a femoral and sciatic nerve block has also been shown to be beneficial to patients recovering from a major knee surgery. Further clinical applications of an obturator nerve block include prevention of the obturator reflex during transurethral bladder tumor resections, relief of thigh adductor spasms in patients suffering from multiple sclerosis or paraplegia, and treatment of chronic hip pain.[5–7]

For anesthesiologists, the most important part of a mixed nerve is usually its sensory branches. In the case of the obturator nerve, there are 3 branches: (1) the articular branch to the hip joint; (2) the articular branch to the knee; and (3) the cutaneous branch to the medial thigh.[1,8] The articular branch of the posterior division of the obturator nerve supplies the capsule of the knee joint with a fine terminal branch. The cutaneous branches supply the skin over the medial side of the thigh and above the medial side of the knee. These are very small nerve branches that originate from the anterior branch of the obturator nerve.[8,9] Effective blockade of the common obturator nerve or of both its anterior and posterior branches at a high level includes sensory contribution of the articular branch for the knee and the cutaneous branches of the medial thigh. Therefore, we investigated the anatomic variability in the anterior and posterior branches of the common obturator nerve, especially because blockade of these 2 branches is of fundamental importance in daily clinical practice. Furthermore, the difficulty of implementing anesthesia at the hip joint,[10] as well as the controversy in the anatomical literature over the origin of the articular branch of the obturator nerve for the hip joint,[8,9,11,12] led to the thorough anatomic examination of this nerve branch.

Until now, both clinical and radiological studies have demonstrated that the 3-in-1 technique provided poor and unpredictable obturator nerve blockade.[13,14] Therefore, injecting local anesthetic around the obturator nerve separately was necessary to reliably block the nerve. Among the selective obturator nerve blockade techniques described at the level of the upper thigh and the inguinal region, Labat's classical approach,[7,15] seemed to localize the nerve more cranially as the nerve passed through the obturator canal. Although Labat's technique is considered to be more uncomfortable and has a higher degree of complications (damage of bladder, rectum, spermatic tone, and hematoma) relative to Choquet's inguinal approach,[7,15] it has a greater probability of blocking the common obturator nerve before it divides into its anterior and posterior branches. According to our data, division of the common obturator nerve into its anterior and posterior branches was only extrapelvic in 25% of our specimens. In those cases, and with Choquet's approach, the anterior and posterior branches of the obturator nerve must be blocked separately, with the former being situated at a more superficial position than the latter. Injection of a local anesthetic following localization either of the anterior or the posterior nerve branch may lead to incomplete nerve block, because each nerve is individually surrounded by thick fascia and the 2 branches are usually separated by some of the fibers of the obturator externus muscle.

Moreover, the anterior and posterior branches exhibit multiple branching patterns, which were widely distributed among the adductor muscles. Therefore, even though muscular contraction may be observed in 1 of these muscles with the neurostimulation technique, it is possible that this response may be due to stimulation of a subdivision, and not to the obturator nerve's main branch. Thus, injection of the local anesthetic at this point may lead to an unsuccessful block. Additional complexity in innervation of the area may be caused by the presence of the accessory obturator nerve. When present, this accessory nerve always participates in innervation of the hip joint.[16]

The contribution of the obturator nerve to the hip joint exhibits considerable variability concerning the number of branches involved, as well as the level of their origin. Indeed, the source of the articular branch could be the anterior or posterior branch, or common obturator nerve. However, because innervation of the hip joint most probably includes the articular branch that originates from the common obturator nerve, blocking of the anterior or posterior branches will result in incomplete anesthesia of the articular branch, which possesses a more cranial origin. Therefore, the very cephalad position of the needle along with the high volume of local anesthetic may increase the likelihood of successful anesthesia of this branch.

Recently, a few studies have been published that provide ultrasound identification of the common obturator nerve and its branches.[17–20] However, in these studies, the number of the obturator nerve divisions was not widely investigated, and the muscles surrounding the nerve were not clearly defined. Moreover, the position of the common obturator nerve seems to be superficially below the skin's surface.[17–20] In another study, the transducer was placed just below the inguinal ligament such that the posterior branch and 3 subdivisions of the anterior branch of the obturator nerve were visualized.[21]

Based on our anatomic observations, it is feasible that the very cephalad position of the obturator nerve bifurcation necessitates placement of the transducer very close to the inguinal crease where the common obturator nerve or its main branches are located. Instead, when the position of the probe is caudal, divisions or subdivisions and not the main trunk of the obturator nerve are likely to be identified.[17,18] For this reason, in our series, the probe was positioned exactly below the level of the inguinal ligament and angulated 30° to 40° cranially. At this point, a thick fascia plane deep to the pectineus muscle was identified. The needle was then positioned within the thick fascia and led to successful localization of the obturator nerve or its main branches. Importantly, the nerve structures could not be visualized with this approach. Nevertheless, the deep thick fascia was successfully used as an "imaging" landmark for localization of the obturator nerve. This approach seemed to lead to successful localization of the common obturator nerve or its main branches (in 25% of cases, the common obturator emerged united from the obturator canal), because the ultrasound beam and the needle are directed cranially toward the exit of the obturator canal, and before the main branches of the obturator nerve bifurcate into subdivisions. Nevertheless, the high angulation of the transducer and the deep location of the nerve structures surrounded by thick fascia make the application of this approach difficult.

From the results described above, it is likely that the obturator nerve demonstrates a high degree of variability. Therefore, successful application of regional anesthetic techniques, based either on pertinent anatomic landmarks or ultrasound technology, must overcome certain problems. These challenges include the intrafascial course of the obturator nerve in the thigh, and the high variability and complicated branching patterns of the obturator nerve divisions and subdivisions displayed in the innervation of adductor muscles.

ACKNOWLEDGMENT

We appreciate Professor A. Karabinis for the technical support and scientific comments in the implementation of this study.

REFERENCES

1. O'Brien M. Peripheral nerves and plexuses. In: Williams PL, ed. *Gray's Anatomy.* 38th ed. New York: Churchil Livingstone, Inc.; 1995:1280–1281.

2. Moghaddam TC. Variations in the obturator nerve and the accessory obturator nerve. *Anat Anz*. 1963;113:1–18.

3. Harvey G, Bell S. Obturator neuropathy. An anatomic perspective. *Clin Orthop Relat Res*. 1999;363:203–211.
4. Macalou D, Trueck S, Meuret P, Heck M, Vial F, Ouologuem S, Capdevila X, Virion JM, Bouaziz H. Postoperative analgesia after total knee replacement: the effect of an obturator nerve block added to the femoral 3-in-1 nerve block. *Anesth Analg*. 2004;99:251–254.
5. McNamee DA, Parks L, Milligan KR. Post-operative analgesia following total knee replacement: an evaluation of the addition of an obturator nerve block to combined femoral and sciatic nerve block. *Acta Anaesthesiol Scand*. 2002;46:95–99.
6. Kahle W, Leonhardt H, Platzer W. *Nervous System and Sensory Organs*. 4th ed. Stuttgart: Georg Thieme Verlag; 1993.
7. Enneking FK, Chan V, Greger J, Hadzic A, Lang SA, Horlocker TT. Lower-extremity peripheral nerve blockade: essentials of our current understanding. *Reg Anesth Pain Med*. 2005;30:4–35.
8. Ellis H, Feldman S. Distribution of the lumbar plexus. In: Ellis H, Feldman S, eds. *Anatomy for Anaesthetists*. 7th ed. Oxford: Blackwell Science Publishers, Inc.; 1997:184–187.
9. Gosling JA, Harris PF, Whitmore I, Willan P. Medial compartment of the thigh. In: Gosling JA, Harris PF, Whitmore I, Willan P, eds. *Human Anatomy*. 4th ed. Edinburg: Mosby, Inc.; 2002:234–236.
10. Locher S, Burmeister H, Bohlen T, Eichenberger U, Stoupis C, Bernhard M, Siebenrock K, Curatolo M. Radiological anatomy of the obturator nerve and its articular branches: basis to develop a method of radiofrequency denervation of the hip joint. *Pain Med*. 2008;9: 291–298.
11. Lazorthes G. Le plexus lombaire. In: Lazorthes G, ed. *Le Systeme Nerveux Peripherique*. 2nd ed. Paris: Masson Cie, Inc.; 1971: 335–337.
12. Francis CC. Peripheral nervous system. In: Anson JB, ed. *Human Anatomy*. 12th ed. New York: Blakistone Division of McGraw-Hill Book Company, Inc.; 1966: 1079–1080.
13. Atanassoff PG, Weiss BM, Brull SJ, Horst A, Kulling D, Stein R, Theiler I. Electromyographic comparison of obturator nerve block to three-in-one block. *Anesth Analg*. 1995;81:529–533.
14. Marhofer P, Nasel C, Sitzwohl C, Kapral S. Magnetic resonance imaging of the distribution of local anesthetic during the three-in-one block. *Anesth Analg*. 2000;90:119–124.
15. Choquet O, Capdevila X, Bennourine K, Feugeas JL, Bringuier-Branchereau S, Manelli JC. A new inguinal approach for the obturator nerve block: anatomical and randomized clinical studies. *Anesthesiology*. 2005;103:1238–1245.
16. Katritsis E, Anagnostopoulou S, Papadopoulos N. Anatomical observation on the accessory obturator nerve (based on 1000 specimens). *Anat Anz*. 1980;148:440–445.
17. Soong J, Schafhalter-Zopoth I, Gray A. Sonographic imaging of the obturator nerve for regional block. *Reg Anesth Pain Med*. 2007; 32:146–151.
18. Halayel PE, Conceicao DB, Pavei P, Knasel JA, Oliveira Filho GR. Ultrasound guided obturator nerve block: A preliminary report of case series. *Reg Anesth Pain Med*. 2007;32:221–226.
19. Fujiwara Y, Sato Y, Kitayama M, Shibata Y, Komatsu T, Hirota K. Obturator nerve block using ultrasound guidance. *Anesth Analg*. 2007;105:888–889.
20. Saranteas T, Anagnostopoulou S, Chantzi C. Obturator nerve anatomy and ultrasound imaging. *Reg Anesth Pain Med*. 2007;32:539–540.
21. Saranteas T, Paraskeuopoulos, Alevizou A, Kouskouri A, Zogogiannis J, Anagnostopoulou S, Chantzi C. Identification of the obturator nerve divisions and subdivisions in the inguinal region: a preliminary study with ultrasound. *Acta Anaesthesiol Scand*. 2007;51:1404–1406.