

Human obturator nerve: Gross anatomy

Sophia Anagnostopoulou, Ioannis Mavridis

Sophia Anagnostopoulou, Ioannis Mavridis, Department of Anatomy, University of Athens School of Medicine, 11527 Athens, Greece

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Correspondence to: Ioannis Mavridis, MD, PHD, Department of Anatomy, University of Athens School of Medicine, Mikras Assias Str. 75, Goudi, 11527 Athens, Greece. pap-van@otenet.gr
Telephone: +30-697-8327199 Fax: +30-210-2833600

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Abstract

AIM: To study the anatomy (formation, course, relationships and branching pattern) of the obturator nerve in detail.

METHODS: The study was based on 500 adult human formalin-embalmed cadavers, 342 males and 158 females. We studied the anatomical formation, course and relationships of the obturator nerve within the lesser pelvis before the obturator canal. Finally, the whole course of the obturator nerve was examined.

RESULTS: We found numerous anatomical variations about the formation of the obturator nerve, its division into two main branches, its articular branches, its intrapelvic branches for the periosteum of the pubic bone, and also the number of its muscular divisions and its anatomical relationship to the obturator externus muscle and obturator artery. We found that fibers from the L3 and L4 spinal nerves are standard components of the obturator nerve. The main trunk of the obturator nerve divides into anterior and posterior branches, within the pelvis in 23.30%, within the obturator canal in 52.30% and extrapelvic in 24.35% of cases. The anterior branch of the obturator nerve supplies three muscular branches in 67.10%, two muscular branches in 28.94% and four muscular branches in 3.94% of the cases. The posterior branch of the obturator nerve supplies two muscular branches in 60.52%, three muscular

branches in 19.07%, one muscular branch in 14.47% and four muscular branches in 5.92% of cases.

CONCLUSION: We present a gross anatomical study of the human obturator nerve based on a remarkably large number of cases as well as potential clinical applications of our findings.

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Key words: Anatomy; Articular branches; Lumbar plexus; Muscular branches; Obturator nerve

Core tip: Our purpose was to study the anatomy of the obturator nerve in detail. The study was based on 500 adult human formalin-embalmed cadavers, 342 males and 158 females. We studied the anatomical formation, course and relationships of the obturator nerve within the lesser pelvis before the obturator canal. We found numerous anatomical variations about the formation of the obturator nerve, its division into two main branches, its articular branches, its intrapelvic branches for the periosteum of the pubic bone, and also the number of its muscular divisions and its anatomical relationships to the obturator externus muscle and obturator artery.

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INTRODUCTION

The obturator nerve is a peripheral nerve, a branch of the lumbar plexus. It usually arises from the ventral divisions of L2-L4 spinal nerves and innervates the medial thigh adductor muscles: gracilis, pectineus, adductor longus, brevis and magnus, as well as obturator externus. The obturator nerve pierces the medial border of the psoas muscle entering the pelvic cavity along the wall in

the retroperitoneum within the obturator fossa. It is the only motor nerve arising from the lumbar plexus which passes through the pelvis without innervating any pelvic structures. The nerve then leaves the pelvis *via* the obturator foramen accompanied by the obturator artery and vein^[1].

A good working knowledge of the location and anatomy of the nerves of the lumbar plexus on the posterior abdominal wall is necessary for the surgeon who operates in this region^[2]. The obturator nerve belongs to these nerves and its detailed anatomy, together with its variations, is necessary information, not only for surgical specialists who may intervene in this area, but also for anesthesiologists applying regional anesthesia techniques. However, anatomical studies of the obturator nerve are infrequent and the available data are based on restricted numbers of specimens.

MATERIALS AND METHODS

This anatomical study of the obturator nerve was based on 500 adult human formalin-embalmed cadavers, 342 males and 158 females, which we had over several years in the dissection room of our department from cadaver donors for students' education.

Our study, which lasted for more than 15 years (1970-1985), focused on the following aspects: (1) the formation (nerve fibers) of the obturator nerve (on 88 lumbar plexuses); (2) its course and anatomical relationships (on 1000 lumbar plexuses); (3) the level of its division into two main branches (on 390 lumbar plexuses); (4) the relationships of its main trunk and main branches with the obturator externus muscle (on 1000 lumbar plexuses); (5) its articular branches (on 168 lumbar plexuses); (6) its intrapelvic branches for the periosteum of the pubic bone (on 56 lumbar plexuses); and finally (7) the muscular divisions of its anterior and posterior branches after it exits the obturator canal (on 152 lumbar plexuses).

There are different numbers of each aspect of the study because not all the aspects were included for our study's purposes from the beginning and not all the studied branches were able to be examined in all our specimens.

All cadavers were carefully studied bilaterally using the same methodology. First, we carried out gross anatomical examination of the structures (*e.g.*, femoral fascia) of the anterior and internal thigh after removal of the skin and subcutaneous tissues. We identified and examined anatomically the local sensory nerves as well as the obturator nerve as it exits the obturator canal and the course and distribution of its main branches (anterior, posterior). Then we opened the abdominal wall and carried out gross anatomical examination of the retroperitoneal organs, especially the lumbar plexus. We studied the anatomical formation, course and relationships of the obturator nerve within the lesser pelvis before the obturator canal. Finally, the whole course of the obturator nerve (from the abdomen to the thigh) was examined.

Table 1 Formation (spinal nerves) of the obturator nerve studied on 88 lumbar plexuses

Spinal nerves (fibers)	Number of lumbar plexuses				Total (<i>n</i> = 88)
	Left lumbar plexuses		Right lumbar plexuses		
	Males	Females	Males	Females	
L1, L2, L3, L4	1	2	1	1	5 (5.64%)
L2, L3, L4	19	9	17	11	56 (63.60%)
L3, L4	4	4	4	2	14 (15.90%)
L2, L3, L4, L5	4	1	6	2	13 (14.72%)

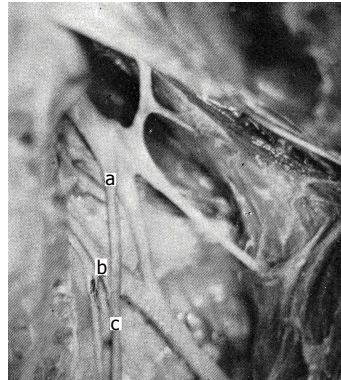


Figure 1 The left obturator nerve arising from the ventral divisions of the L3 and L4 spinal nerves. The contribution of the ventral division of the L2 spinal nerve is absent. a: Ventral division of the L3 spinal nerve; b: Ventral division of the L4 spinal nerve; c: Obturator nerve.

RESULTS

We found numerous anatomical variations regarding:

(1) the formation of the obturator nerve (nerve fibers); (2) its division into two main branches; (3) its articular branches; (4) its intrapelvic branches for the periosteum of the pubic bone; (5) the number of its muscular divisions; and (6) its anatomical relationships with the obturator externus muscle and obturator artery.

Formation, course and division

The obturator nerve includes nerve fibers from the ventral divisions of the L2, L3, L4 spinal nerves in 63.60%, of the L3, L4 in 15.90% (Figure 1), of the L2, L3, L4, L5 in 14.72% and of the L1, L2, L3, L4 in 5.64% of specimens (Table 1). Thus we found that fibers from the L3 and L4 spinal nerves are standard components of the obturator nerve. The distribution between sides and gender of these findings are shown on Table 1.

Even though it is well established^[3], we report our observations that the obturator nerve descends through the fibers of the psoas major muscle and emerges from its medial border. It 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.

The main trunk of the obturator nerve divides into anterior and posterior branches, within the pelvis in 23.30%, within the obturator canal in 52.30% and extra-

Table 2 Muscular branches of the obturator nerve studied on 152 lumbar plexuses

Number of branches	Anterior branch	Posterior branch
1	-	14.47%
2	28.94%	60.52%
3	67.10%	19.07%
4	3.94%	5.92%
Muscles innervated	Gracilis (70.10%) Adductor longus (70.10%) Adductor brevis (25.90%) Pectineus (4.00%)	Adductor magnus (85.53%) Adductor longus (85.53%) Adductor brevis (25.00%) Obturator externus (6.00%)

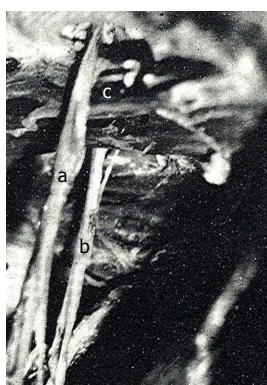


Figure 2 A muscular mass of the left obturator externus muscle intervening between obturator nerve's anterior and posterior branches, as the latter exits the obturator canal. a: Anterior branch of the obturator nerve; b: Posterior branch of the obturator nerve; c: Obturator externus muscle.

pelvic in 24.35% of cases ($n = 390$). The level of division of the main trunk was similar between male and female cadavers.

As the obturator nerve exits the obturator canal, a muscular mass of the obturator externus muscle intervenes between its anterior and posterior branches in 25.70% of cases ($n = 1000$) (Figure 2).

Articular branches

The obturator nerve supplies articular branches to the human hip joint. These branches originate most frequently from the common obturator trunk in 68.70% and rarely from either the anterior or the posterior branch of the obturator nerve. These articular branches, one to three (but usually one with similar proportions between male and female cadavers), arise within the pelvis in 47.60% (44.40% in male cadavers, 53.30% in female cadavers), within the obturator canal in 32.14% (35.18% in male cadavers, 26.60% in female cadavers) and finally extrapelvic in 20.23% (20.30% in male cadavers, 20.00% in female cadavers) of specimens ($n = 168$).

Muscular branches

The anterior branch of the obturator nerve supplies three muscular branches in 67.10% (slightly more frequent in female cadavers), two muscular branches in 28.94% (more frequent in male cadavers) (in some cases these branches

look like the two main branches of the obturator nerve's trunk) and four muscular branches in 3.94% of the cases (Table 2). We found no remarkable difference between the two sides. These branches innervate the gracilis and adductor longus muscles in 70.10%, the adductor brevis muscle in 25.90% and the pectineus muscle in 4% of the cases ($n = 152$).

The posterior branch of the obturator nerve supplies two muscular branches in 60.52%, three muscular branches in 19.07%, one muscular branch in 14.47% (more frequent in male cadavers) and four muscular branches in 5.92% (more frequent in female cadavers) of cases (Table 2). We found no remarkable difference between the two sides, although there was noticeably higher variability in comparison with the anterior branch's muscular divisions. These branches innervate the adductor magnus and adductor longus muscles in 85.53%, the adductor brevis muscle in 25.00% and obturator externus muscle in 6.00% of cases ($n = 152$).

Other branches

The obturator nerve supplies one to three intrapelvic branches for the periosteum of the posterior surface of the pubic bone in 61.36% of cases ($n = 56$). In both sides and gender, the most frequent branching pattern for the pubic bone's periosteum was the presence of a single intrapelvic branch, with a proportion of about 60% (ranging from 55.50% to 62.50%).

DISCUSSION

Formation, course and division

As shown in Table 1, the anatomical formation of the obturator nerve is remarkably variable. We noticed that, apart from our results, the obturator nerve has been also described to be formed from the union of the L1, L2 and L3 spinal nerves^[4]. In combination with our findings, it is obvious that L3 is the only standard spinal nerve in forming the obturator nerve.

A recent study by our department based on 84 cadavers revealed similar results about the obturator nerve's level of division: within the obturator canal 51.78%, in the medial thigh 25% and finally intrapelvic 23.22% of cases^[3]. High anatomical variability in the obturator nerve divisions and subdivisions does exist and explains the difficulty frequently encountered in the application of regional anesthetic techniques^[3].

The obturator nerves lie outside the psoas muscle at the L5 spinal vertebrae^[5]. Within the psoas major, the obturator nerve is often separated from the lateral femoral cutaneous and femoral nerves by a muscular fold, with commonly presenting anatomical variations^[6].

Articular branches

In the mentioned recent study by our department^[3], we found a high variability of the proportion of cases where the articular branches arose from the common obturator trunk. This proportion was 76.92% in cases

where only one articular branch was observed. This proportion was 47.05% in cases where two articular branches were observed and 53.33% in cases with three articular branches^[3].

The hip joint is innervated by articular branches of the obturator, femoral, superior gluteal and sciatic nerves. The responsible nerve can be determined by a diagnostic nerve block in cases of hip joint pain. Then, radiofrequency ablation of the identified articular branches of the hip can be applied in order to provide hip pain relief^[7]. They vary in location over a wide area, especially for the articular branches of the obturator nerve. So radiofrequency denervation of these branches should be accomplished by multiple lesions to account for the location of the target nerves and their variability^[8]. Our study orientates the clinician as to where to search for these branches.

Moreover, regarding the hip joint capsule, there is a separation between its anterior and posterior sensory innervation. The anteromedial innervation has been found to be determined by the articular branches of the obturator nerve. Consequently, the obturator nerve block is insufficient for the treatment of hip pain^[9].

Muscular branches

The importance of the obturator nerve in the innervation of the adductor muscles is well known^[10] and also confirmed by our findings (innervation of adductor magnus, longus and brevis muscles). In our department's recent study, we found similar proportions of numbers of muscular divisions of the obturator nerve's anterior and posterior branches^[3].

It has been found that the obturator nerve is responsible for the majority of cases with loss of adduction strength, with following the sacral plexus and the femoral nerve, respectively. The obturator nerve plays a major role in the adduction of the lower limbs. Furthermore, assessing the adductor strength is the only way to effectively evaluate the obturator nerve function^[10].

In general, the adductor magnus is innervated by branches of the obturator nerve that enter its anterior surface^[11]. We found that these muscular branches come from the posterior branch of the obturator nerve. A twig of a branch from the quadratus femoris nerve can communicate with a twig of the obturator nerve within this muscle. It has been reported that the root of the branches to the adductor magnus occupies the caudal most region of the obturator nerve and frequently forms a common trunk with the root of the quadratus femoris nerve^[11].

The human adductor brevis (specific adductor brevis) muscle, found in 23% according to the study of Miura *et al.*^[12] (1994), is innervated dually by the anterior and posterior branches of the obturator nerve. Specifically, its anterior and posterior surfaces receive twigs from the anterior branch of the obturator nerve and filaments from the posterior branch respectively. Based on our findings, we confirm that this muscle can be innervated by the anterior and posterior branches of the obturator nerve.

The gracilis muscle is, according to our results, innervated by muscular branches of the obturator nerve's anterior branch. The gracilis perforator flap is used in plastic surgery. Occasionally a sensory branch of the anterior obturator nerve is found to accompany the perforators. It can be used as a sensory flap in these few cases of the existence of nerve supply by a sensory branch of the obturator nerve^[13].

Other branches

In some people there is also cutaneous contribution of the obturator nerve^[10]. Branches derived from the anterior branch of the obturator nerve have been reported to pierce the vastoadductor membrane en route to the skin of the medial thigh^[14]. Cutaneous innervation of the obturator nerve to the medial aspect of the knee has also been reported but is highly variable and sometimes missing^[10]. The anatomy of these important branches will be the object of a future study by our department.

Nerve injury

Obturator nerve injury could happen due to disease or procedures in obstetrics and gynecology. It has been reported primarily in patients with endometriosis, malignancy and obstetrical forceps injury. Gynecological oncology patients undergoing lymph node dissection or extensive retroperitoneal surgery at the sidewall in the obturator fossa are at an increased risk for injury^[1].

Obturator nerve injury, in the form of neurapraxia, axonotmesis and neurotmesis, causes morbidity in the form of pain, sensory loss to the medial thigh and inconstant motor loss to the adductor muscle group. Therapy should be directed at correcting the condition and surgical repair by an epineurial approach should be performed if nerve division is noted during surgery. In contrast to surgical division of other complex pelvic nerves, obturator nerve injury is a highly treatable condition^[1].

Limitations

The fact that there are different numbers of each aspect of the study (for reasons already explained in our methodology) could be considered as a major limitation (potential selection bias).

In conclusion, there is high anatomical variability in the human obturator nerve divisions and subdivisions^[3] and just a few already published data about its detailed gross anatomy. We presented a gross anatomical study of the human obturator nerve based on a large number of specimens. We believe that our findings could be useful for clinicians, especially those who intervene at the obturator nerve's area, such as anesthesiologists, urologists, gynecologists, orthopedic surgeons, neurosurgeons, plastic surgeons and others.

COMMENTS

Background

The obturator nerve is a peripheral nerve, a branch of the lumbar plexus. It

usually arises from the ventral divisions of L2-L4 spinal nerves and innervates the medial thigh adductor muscles: gracilis, pectineus, adductor longus, brevis and magnus, as well as obturator externus. Anatomical studies of the obturator nerve are infrequent and the available data are based on restricted numbers of specimens.

Research frontiers

The detailed anatomy of the obturator nerve, together with its variations, is necessary information, not only for surgical specialists who may intervene in this area, but also for anesthesiologists applying regional anesthesia techniques.

Innovations and breakthroughs

The authors found numerous anatomical variations about the formation of the obturator nerve, its division into two main branches, its articular branches, its intrapelvic branches for the periosteum of the pubic bone, and also the number of its muscular divisions and its anatomical relationship to the obturator externus muscle and obturator artery. The authors found that fibers from the L3 and L4 spinal nerves are standard components of the obturator nerve.

Applications

These findings could be useful for clinicians, especially those who intervene at the obturator nerve's area, such as anesthesiologists, urologists, gynecologists, orthopedic surgeons, neurosurgeons, plastic surgeons and others.

Peer review

This study may have reasonable scientific merit.

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