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ORIGINAL ARTICLE

Topographical relationships between the obturator nerve, artery, and vein in the lateral pelvic wall

Hyung-Sun Won[1] · Jun-Ho Kim[1] · U-Young Lee[1] · Koon Ho Rha[2] · Dae Keun Kim[2]

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Abstract
Introduction and hypothesis The aims of this study were to determine the topographical relationships between the obturator nerve (ON), artery (OA), and vein (OV) in the lateral pelvic wall.
Methods One hundred and fifty hemipelvises of 84 Korean cadavers were dissected.
Results The ON, OA, and OV ran in that order (from upper to lower) within the lateral pelvic wall in 46.7 % of specimens. In 32 % of cases, the three structures were separated at the posterior portion of the wall and then converged toward the obturator canal (OC). In 10 %, the OA and OV were in contact with each other and separate from the ON; in 2 %, the ON was contiguous with the OA and separate from the OV; in 2.7 %, all three structures were in contact with each another. Alternately, the order of ON, OA, and OV was altered in the lateral pelvic wall in 41.3 % of specimens. Finally, in 12 % specimens, either the OA or OV or both were absent from the lateral pelvic wall.
Conclusions The possibility of the presence of either the OA or OV being between the ON and the external iliac vein, and the potential contact between the ON and either the OA or OV in the lateral pelvic wall, should be borne in mind during pelvic procedures.

✉ U-Young Lee
cicloaum@catholic.ac.kr

[1] Department of Anatomy, Catholic Institute for Applied Anatomy, College of Medicine, The Catholic University of Korea, Seoul, Korea

[2] Department of Urology, Urological Science Institute, Yonsei University College of Medicine, Seoul, Korea

Keywords Obturator nerve · Obturator artery · Obturator vein · Lateral pelvic wall · Pelvic surgery

Abbreviations

ON	Obturator nerve
OA	Obturator artery
OV	Obturator vein

Introduction

Nerves generally run together with the artery and vein of the same name (e.g., femoral and intercostal nerves). In the case of the obturator nerve (ON), obturator artery (OA), and obturator vein (OV), relative positions have been described in anatomical textbooks, from upper to lower, as ON–OA–OV [1–3]. All of these three structures converge upon the obturator canal (OC) in the pelvic wall [4], which means that they do not run in parallel with each another. The ON, OA, and OV can be defined as structures that pass through the OC, irrespective of their origins in the pelvic wall. The course of the ON is relatively constant from its origin to the OC, while those of the OA and OV vary according to their origins. The OA usually arises from the internal iliac artery, but in cases where the OA does not appear in the lateral pelvic wall, it originates from the inferior epigastric artery [5–7]. Furthermore, while the OV generally drains into the internal iliac vein, it can also drain into the inferior epigastric or external iliac vein. These potential variations mean that the relationships between the OA and OV can also vary [6, 8, 9].

The ON is an important landmark that is retracted during pelvic lymph node dissection [10–12] and is therefore prone to injury. The ON is at particular risk of injury during pelvic lymphadenectomy in gynecologic [12, 13] or urologic [10, 14,

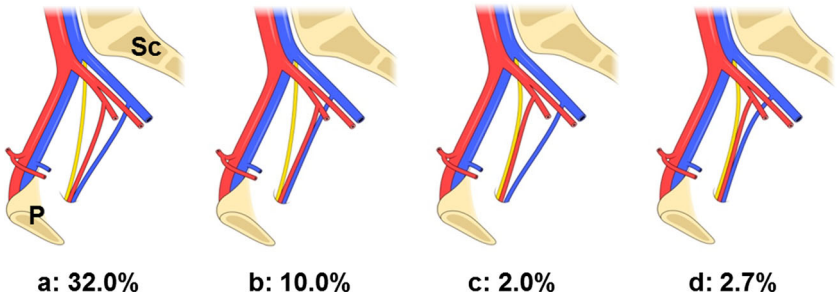

Fig. 1 The obturator nerve (ON) (*yellow*), obturator artery (OA) (*red*), and obturator vein (OV) (*blue*) ran together in that order from upper to lower in the lateral pelvic wall, regardless of the OA and OV existing on the superior pubic ramus. *P* pubis, *Sc* sacrum

15] surgery. Vessels that are closely contiguous with the ON may be also be injured during such procedures. To the best of our knowledge, topographical variations of the ON and obturator blood vessels have yet to be properly elucidated. The aims of this study were therefore to describe the topographical relationships between the ON, OA, and OV in the lateral pelvic wall and to improve understanding around the occurrence of simultaneous injury of the ON and OA or OV in pelvic surgery.

Materials and methods

One hundred and fifty hemipelvises of 84 embalmed adult Korean cadavers (61 males, 23 females; mean age 62.5 years, age range 13–99 years) were dissected for this study. Both sides of 68 of these cadavers were used, and 77 right and 73 left sides were examined. The ON, OA, and OV were exposed and identified after reflecting the parietal peritoneum and removing the fat tissue. The OA was traced from its origin, and venous drainage of the OV was determined. In the lateral pelvic wall, the courses of the ON, OA, and OV and their relationships with adjacent structures were also noted. Chi-square test was used to compare the relationships of ON, OA, and OV between genders, with a statistical significance level of $p<0.05$.

Due to domestic law that cadavers must be donated and managed under the informed consent and ethical process, the institutional review board of the Catholic University of Korea rules a cadaveric study out of its review. All cadavers stored in Catholic Institute for Applied Anatomy are qualified as materials for education and research according to domestic law.

Results

The ON, OA, and OV ran in that order, from above to below, in the lateral pelvic wall in 46.7 % ($n=70$) of specimens, regardless of presence of OA or OV on the superior pubic ramus (Fig. 1). In 32 % ($n=48$) of specimens, the three structures were separated at the posterior portion of the wall and then converged toward the OC (Figs. 1a and 2). The OA and OV were in contact with each other and were separated from the ON in 10 % ($n=15$) of specimens (Fig. 1b), the ON was contiguous to the OA and separate from the OV in 2 % ($n=3$) (Fig. 1c), and the three structures were in contact with each another in 2.7 % ($n=4$) (Fig. 1d).

Unlike the 46.7 % of specimens in which the order of the three structures was ON–OA–OV, as described above, their order was altered in the lateral pelvic wall in 41.3 % ($n=62$) of tspecimens. In 5.3 % ($n=8$) of specimens, the order was ON–OV–OA (3.3 %, $n=5$) or OA–ON–OV (2 %, $n=3$), without any topographic variations. In 16.7 % ($n=25$) of specimens, two of these three structures were twisted around each other in the lateral pelvic wall: the ON and OA in 6.7 % ($n=10$), the

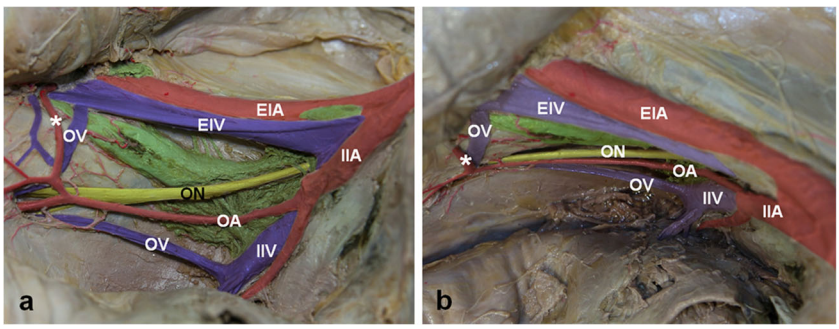

Fig. 2 The most common arrangement of the obturator nerve (ON), obturator artery (OA), and obturator vein (OV) in the lateral pelvic wall. **a** Medial and **b** superoposteromedial views of the same specimen. In this particular specimen, the accessory OA (*asterisks*) arises from the inferior epigastric artery, and the OV drains into the external iliac vein on the superior pubic ramus. *EIA* external iliac artery, *EIV* external iliac vein, *IIA* internal iliac artery, *IIV* internal iliac vein

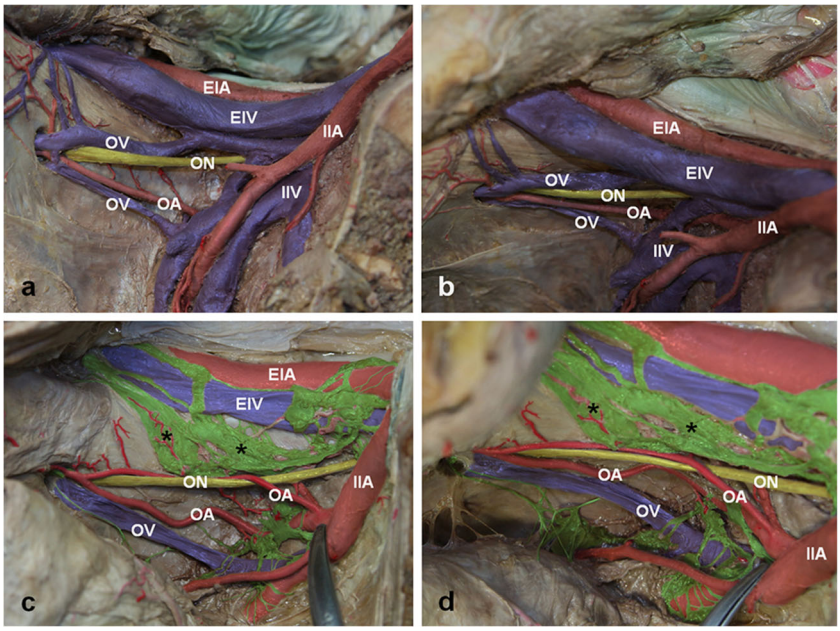

Fig. 3 Case in which the obturator vein (OV) drained into the external iliac vein in the lateral pelvic wall: **a** medial, and **b** superoposteromedial views of the same specimen. Case in which two obturator arteries (OAs) were observed in the lateral pelvic wall; **c** medial and **d** superoposteromedial views of the same specimen; the upper OA twists around the obturator nerve (ON) and is in contact with the medial group of external iliac lymph nodes (*asterisks*). *EIA* external iliac artery, *EIV* external iliac vein, *IIA* internal iliac artery, *IIV* internal iliac vein

ON and OV in 2 % (n=3), and the OA and OV in 8 % (n=12). In 19.3 % (n=29) of specimens, the topographical relationships between the ON, OA, and OV were altered due to the presence of two or three OVs (16.7 %, n=25) or two OAs (3.3 %, n=5). In the former case, one OV ran above the ON in the lateral pelvic wall in 14 % (n=21) of specimens and usually joined with an angle of 40–50° to the external iliac vein (Fig. 3a, b). This vein was also found in specimens with only a single OV, with an incidence of 4.7 % (n=7). The distance from the superior tip of the symphysis pubis to the origin of this vein was 78.5±9.1 mm [mean±standard deviation (SD)]. In cases with two OAs, one of them crossed the ON and ran superior to it, becoming conjoined with the other OA to form a single vessel before entering the OC (Fig. 3c, d). In cases in which the OA was located superior to other structures or where there were two OAs in one specimen (4.7 %, n=7), the OA usually originated from the trunk or proximal part of the anterior division of the internal iliac artery (Fig. 2).

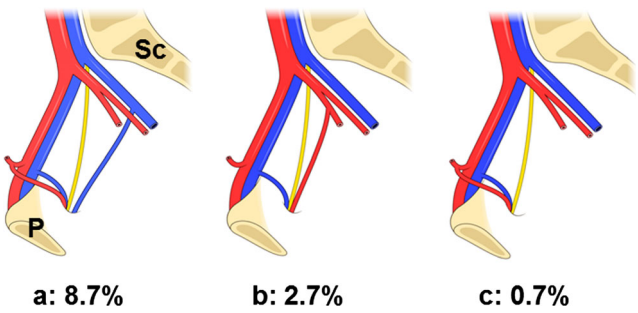

Fig. 4 In some cases, either one obturator vessel or both were either present or absent from the lateral pelvic wall. **a** The obturator artery (OA) is absent, and only the obturator vein (OV) (*blue*) runs with the obturator nerve (ON) (*yellow*). **b** The OV is absent, and only the OA (*red*) runs with the ON. **c** Both the OA and OV are absent, and the ON runs alone. The proportion of all specimens in this study with each arrangement is given as a percentage in each panel. *P* pubis, *Sc* sacrum

In 12 % (n=18) of specimens, either the OA, OV, or both were absent from the lateral pelvic wall (Fig. 4). In these cases, the OA arose from the inferior epigastric or external iliac artery and the OV drained to the external iliac vein. The ON was observed with only the OV in 8.7 % (n=13) of specimens (Figs. 4a and 5a) and with only the OA in 2.7 % (n=4) (Fig. 4b). In only one specimen did the ON run alone without the OA or OV in the lateral pelvic wall (Figs. 4c and 5b). In the lateral pelvic wall, arrangements and variations between ON, OA, and OV did not differ between genders.

The frequency of occurrence of OA and OV on the superior pubic ramus was also examined: the OV only was observed in 38 % (n=57) of specimens, and in all those cases, the vein drained into the external iliac vein (Fig. 5). The distance between the superior tip of the symphysis pubis to the origin of this vein was 56.6± 9.6 mm. In 3.3 % (n=5) of tspecimens, this OV existed without any other OVs of the lateral pelvic wall, running with the ON or OA. In these cases, the OVs were usually large and were sometimes duplicated (Fig. 5d). The OA and OV were simultaneously found on the superior pubic ramus in 10 % (n=15) of specimens. These structures were observed without another OV or OA in the lateral pelvic wall in only 4 % (n=6) of specimens. In 6 % (n=9) of specimens, only the OA was observed on the superior pubic ramus, and in 4.7 % (n=7), this OA existed without any OAs in the lateral pelvic wall.

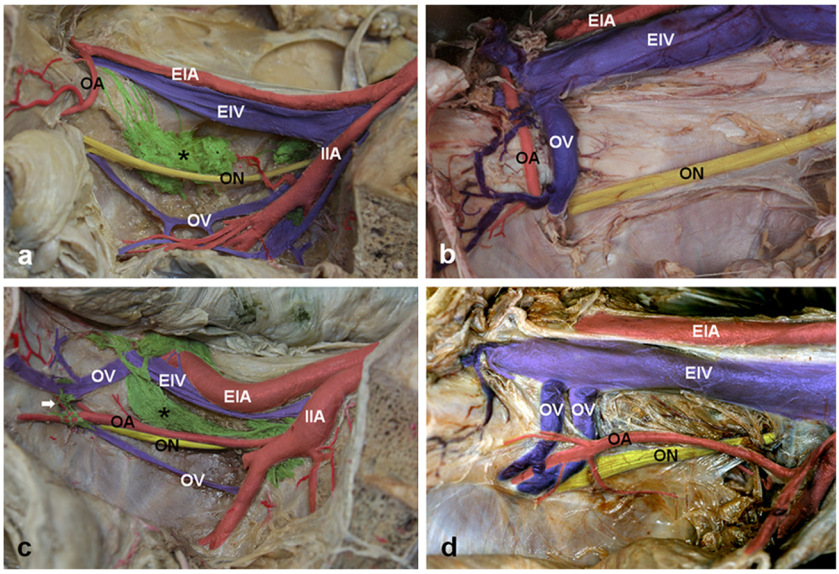

Fig. 5 Cases in which obturator vessels (either one or both) were absent in the lateral pelvic wall and cases in which an obturator vein (OV) was observed without an obturator artery (OA) on the superior pubic ramus. **a** The obturator nerve (ON) and OV exist without an OA in the lateral pelvic wall; the ON and OV curve slightly downward, and a huge lymph node is located lateral to the nerve. **b** Neither obturator vessel is present in this specimen; the ON exists alone in the lateral pelvic wall. On the superior pubic ramus in these cases, the OA arises from a common trunk with the inferior epigastric artery, and the OV drains into the external iliac vein. **c** One or **d** two OVs are observed. The medial group of external iliac lymph nodes (*asterisks*) is located between the external iliac vein and the OA. Part of the obturator lymph node (*arrow*) can be observed at the entrance of the obturator canal. *EIA* external iliac artery, *EIV* external iliac vein, *IIA* internal iliac artery

Discussion

Anatomical textbooks and atlases provide varying descriptions and images showing the topographical relationships between the ON, OA, and OV [1–4, 9, 16–18]. However, if these descriptions and images are considered together, two textbook-described arrangements of the ON, OA, and OV (I and II) can be defined. In type I [1–3], the ON, OA, and OV present in that order from above to below and are separated from each other behind the lateral pelvic wall (Fig. 1a). In type II [9, 16, 18], the OA and OV come into contact with each other and are separated from the ON (Fig. 1b), and they converge toward the OC. In our study, textbook-described type I and II arrangements were observed in about 33 % and 10 % of specimens, respectively.

ON injury within the pelvis has been reported to occur at a rate of 0.2 % [19] during pelvic lymph node dissection for urologic [14, 15] and gynecologic [12, 13] surgery. Neuropraxia of the ON was reported in 0.2–3 % of patients after this procedure [19, 20]. The ON was reportedly injured by inadvertent clipping, stretching, electrocautery, or transection [10, 21]. The external iliac lymph nodes form three subgroups: lateral, intermediate (anterior), and medial to external iliac vessels [17, 22]; medial nodes were frequently found between the external iliac vein and the ON in our study (Figs. 2, 3, and 5) and are removed during pelvic lymph node

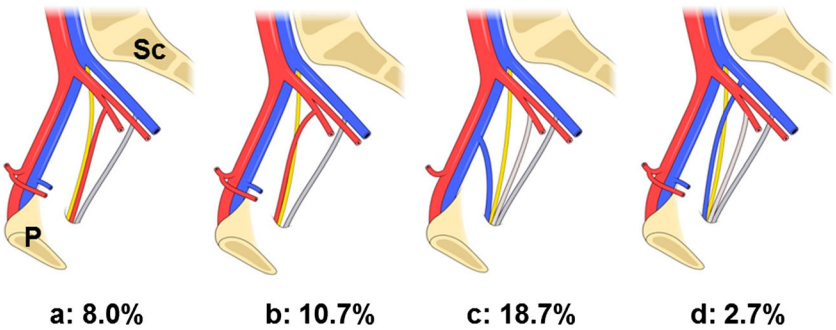

Fig. 6 Potential arrangements of the obturator nerve (ON) (*yellow*), obturator artery (OA) (*red*), and obturator vein (OV) (*blue*) that should be considered during pelvic lymph node dissection. **a**, **b**, **d** In the lateral pelvic wall, the OA or OV can be in close contact with the ON and **b**, **c**, **d** can be located between the ON and the external iliac vein, regardless of their order and other variations. The proportion of all specimens in this study with each arrangement is given as a percentage in each panel. *P* pubis, *Sc* sacrum

dissection [11]. The definition and extent of extended lymph node dissection are innconsistent in previous reports. Some authors have suggested that the total number of lymph nodes resected contributes to staging accuracy [23, 24]. In our study, locations of these lymph nodes were diverse, with some being firmly attached to the lateral side of the ON and obturator blood vessels. These vessels can be damaged during pelvic lymphadenectomy when they closely accompany the ON. Regardless of other variations, the OA was in contact with and below the ON in 8 % of cases in our study (Fig. 6a), and the OA crossed the ON superficially or deeply and ran above and closely adhered to it in 10.7 % of cases (Figs. 3c, 5c, d, and 6b). The OV ran above the ON in 21.3 % of cases, including two cases in which the OV was rarely in contact with the ON (Figs. 3a, and 6c, d). Therefore, to avoid unsuspected damage to the ON and obturator blood vessels, it is preferred that pelvic lymph node dissection in the area, including medial nodes, is carefully performed from the proximal side of the external iliac vessels to the distal side of the ON and in the lateral to medial direction.

The ON can also be injured by orthopedic complications as a result of, for example, acetabular screw placement [25] or intrapelvic cement extrusion [26], as well as by gynecologic procedures such as laparoscopic tubal ligation [27]. A case of massive hemorrhage following OA injury associated with bladder perforation during transurethral bladder surgery has also been reported [28]. During these procedures, simultaneous injury of the ON and OA or OV may be attributable to close contact between the ON and one or other of the obturator blood vessels.

There were cases in the study we report here in which the OA arose from the inferior epigastric artery (aberrant OA) and the OV drained into the external iliac vein (aberrant OV) across the superior pubic ramus. These vessels are particularly prone to injury during retropubic-space procedures, such as midurethral sling [29], tension-free vaginal tape [30], and Burch urethropexy [31] procedures. The frequencies of aberrant OA and OV on the superior pubic ramus are variously reported at a rate of 6–65 % [6, 7, 32] and 26–96 % [5, 8, 32], respectively. In our study frequencies were 16 and 48 %, respectively, regardless of vessel organization in the lateral pelvic wall. In some cases, a large OV drained into the external iliac vein over the superior pubic ramus from the OC (Fig. 5b, d).

Conclusion

The textbook-described arrangement of the ON, OA, and OV in the lateral pelvic wall was observed in 42 % of specimens in this study (Figs. 1a, b). The medial group of external iliac lymph nodes was usually located between the ON and the external iliac vein. The possibilities of the OA or OV being located between the ON and the external iliac vein, and the ON being in contact with the OA or OV in the lateral pelvic wall (Fig. 6), should be borne in mind during pelvic procedures to avoid potential injuries. The anatomical descriptions provided in this study may help to clarify mechanisms underlying the occurrence of obturator blood vessel damage and ON injury.

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Conflicts of interest None

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