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Corona mortis, aberrant obturator vessels, accessory obturator vessels: clinical applications in gynecology

Corona mortis in gynecological practice

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Abstract

"Corona mortis " (CMOR) is a heterogeneous and often dubious term that causes much confusion in medical literature, especially in regard to its modern day significance in pelvic surgery. Some authors define CMOR as any abnormal anastomotic vessel between the external iliac and obturator vessels, whereas others define it as any vessel coursing over the superior pubic branch, regardless whether it is a vascular anastomosis, an accessory obturator vessels, an obturator vessel related to the external iliac system or a terminal small vessel. There is no standard classification of CMOR and obturator vessels variations, although there are multitudes of classifications describing the diverse variations in the obturator foramen region. We define accessory obturator, aberrant obturator vessels and CMOR as different structures, as CMOR is an anatomical term that reflects a clinical situation rather than an anatomical structure. A new clinical classification for aberrant, accessory obturator vessels and CMOR is proposed regarding the anatomical variations, and the location of vessels to the deep femoral ring. The clinical significance of accessory obturator, aberrant vessels and CMOR is delineated in oncogynecological and urogynecological surgery.

Key words: corona mortis, aberrant obturator vessels, accessory obturator vessels, deep femoral ring, oncogynecology, urogynecology

INTRODUCTION

"Corona mortis " (CMOR) is defined as any abnormal anastomotic vessels between the external iliac and obturator vessels [1]. Studies have shown that the definition of CMOR is heterogeneous and causes much confusion in medical literature [1]. Although in the past CMOR was defined as arterial anastomosis between an external iliac and an obturator artery, currently in medical reports the widely accepted definition includes the arterial and/or venous vascular anastomosis between an obturator and an external iliac vessel [2]. Moreover, some authors define CMOR as a connection between the external and internal iliac system, whereas others define it as any vessel coursing over the superior pubic branch, regardless whether it is a vascular anastomosis, an accessory obturator vessels, an obturator vessel related to the external iliac system or a terminal small vessel [1 -5].]. Additionally, there is no standard classification of CMOR and obturator vessels variations, although there are multitudes of classifications describing the diverse variations in the obturator foramen region [3, 5, 6]. Studying CMOR is crucial because of its association with a high risk of severe hemorrhage during surgeries. Various gynecological procedures carry the risk of CMOR injury. The aim of this study is to define accessory obturator vessels (ACOVs), aberrant obturator vessels (AOVs) and CMOR. Moreover, we propose a new classification for the clinical use and delineate the clinical significance of ACOVs, AOVs and CMOR in oncogynecological and urogynecological surgery.

OBTURATOR ARTERY ANATOMY AND VARIATIONS

In the majority of cases, the obturator artery (OA) is a branch of the anterior division of the internal iliac artery (7). It runs anteriorly and inferiorly on the pelvic wall and lies longitudinally to the obturator foramen on the medial part of the obturator internus muscle. The OA is located cranially to the obturator vein and caudally to the obturator nerve (ON) [7-9] (Figure 1).

The ureter lies medial to it. The OA gives branches within the pelvis before piercing the obturator foramen [7-12]. The OA gives branches to the obturator internus muscle, psoas muscle and to the iliac fossa for the iliacus muscle and the ilium. Sometimes the inferior vesical artery is replaced by caudal branch of the OA. The pubic branch arises before the obturator canal and runs cranially over the pubis to anastomoses with the pubic branch of the inferior epigastric artery and the contralateral artery [7 -15] (Figure 2).

There is, perhaps, no artery of proportionate size having as variable origin as the OA (Table 1) [5, 7-15].

Although studies reported different percentages for the OA origin variations, in the majority of cases the most common OA origin is from the IIA, followed by the inferior epigastric, external iliac artery, femoral artery [8-13]. When the OA arises from the IIA, it descends almost horizontally to the obturator foramen, whereas when the OA arises from the external iliac system, it crosses vertically over the superior pubic ramus and the external iliac vein. OA arising from the inferior epigastric artery is the commonest source of aberrant obturator artery (AOA)[8]. The incidence of an AOA arising from the inferior epigastric artery ranges from 20% to 34% [16]. Such an AOA has a great clinical significance. It is of a great caliber and has atypical passage through the superior pubic ramus. This artery passes posterior to the lacunar ligament and coursed the superior pubic ramus vertically to enter the obturator foramen. Therefore, OA arising from inferior epigastric artery is susceptible to injury during the dissection of the preperitoneal space using endoscissors or stapling of the mesh [8, 16]. Berberogly et al. reported for such an artery with diameter of 2.2 mm [17]. Darmanis et al. reported that an AOA originating from the inferior epigastric artery or external iliac artery is presented in 20% - 30 % of hemipelvises and it is of a greater diameter on average than a CMOR when it is presented [4].OA arising from the external iliac artery is rare type of OA origin – 1-2% [5, 8-13, 16]. Other authors also reported for an AOA arising from inferior epigastric artery running superior to the inguinal ligament and lateral or medial to the femoral ring [2, 8]. In conclusion, an AOA arising from the inferior epigastric artery is an extremely relevant substitute of the corona mortis.

OA can arise as a common trunk with most of the internal and external iliac arteries. Although rare, the OA shares a common trunk with the inferior epigastric and the deep circumflex iliac artery. The trunk can arise in the femoral or external iliac region [12]. Although some authors reported more OA origin anomalies in females, the majority of studies showed no statistically significant difference between genders [13].

We define an AOA as an artery that origins from an external iliac artery or its branches and pierce the obturator membrane, not participating in anastomosis. There is no other obturator artery.

An accessory obturator artery is the presence of an extra obturator artery in addition to the normal counterpart. An accessory obturator artery pierces the obturator membrane, not participating in anastomosis [1, 4, 18]. We propose a simple classification of the aberrant and accessory obturator arteries with clinical significance [10) (Figure 3).

In Figure 3, we divide Type I and Type II regarding the AOA location to the deep femoral ring, as an AOA medial to the deep femoral ring is closer to the urogynecological field during surgery. An AOA lateral to the deep femoral ring is closer to the operative field during oncogynecological procedures. Therefore, the probability of intraoperative injury depends on the locations of the AOA and the type of surgery. Type IV is included as it is of clinical significance in oncogynecology. Clinical applications of an AOA are described below. The accessory obturator artery classification is the same as the AOA one, except that there is a normal obturator artery, arising from the IIA.

OBTURATOR VEIN (OA) ANATOMY AND VARIATIONS

The OV arises in the adductor region and passes through the obturator foramen. It then proceeds posteriorly and superiorly on the lateral pelvic wall below the obturator artery and drains into the internal iliac vein [7-13]. As mentioned above the obturator nerve (ON), OA, and OV run in that order, from above to below, in the lateral pelvic wall and piercing the obturator foramen. However, in medical literature different order in the neurovascular bundle has been described. In a study of one hundred and fifty hemipelvises of 84 embalmed adult Korean cadavers, Won et al. described the order ON- OV- OA in 5 cadavers and OA-ON-OV in 3 cadavers. In 25 of the specimens, two of these three structures (ON, OA, and OV) were twisted around each other in the lateral pelvic wall [9].

Classic anatomy texts pay less attention to the variations of veins than arteries. There are many reports of the OA origin variations, but less importance is given to the OV drain variations. It is believed that venous anomalies are more probable than an arterial one [3, 19].

We define an aberrant obturator vein as vein, that passes through the obturator foramen and drains in the external iliac vein or its tributaries, not participating in anastomosis. There is no other obturator vein.

An accessory obturator vein is the presence of an extra obturator vein in addition to the normal counterpart. An accessory obturator vein passes through obturator membrane, not participating in anastomosis. We propose simple classification with a clinical significance of the aberrant and the accessory obturator veins [9, 20]. (Figure 4).

In Figure 4, we divide Type I and Type II regarding location to the deep femoral ring. An aberrant obturator vein medial to the deep femoral ring is most likely to be injured during urogynecology operations, whereas an aberrant obturator vein lateral to the deep femoral ring during oncogynecology procedures. Type IV is included, as the chance of damaging double aberrant obturator vein is greater during pelvic lymphadenectomy. A double aberrant obturator vein is located lateral to the deep femoral ring. Missankov et al. reported in a cadaveric study, 2 % of type IV of all specimens. The accessory obturator vein classification is the same as the aberrant obturator vein one, except that there is a normal obturator vein, draining in the IIV.

CMOR

In medical literature, there is no consensus on CMOR terminology [21]. Nyhus clarified CMOR as pubic branch of the obturator artery. Berberoglu et at. stated that some authors referred to the term “Corona Mortis’’ as the anastomosis between the obturator artery and the pubic branch of the inferior epigastric artery, whereas others defined CMOR as the pubic branch of the obturator artery [19]. Moreover, terms such as aberrant, accessory, communicating, variant obturator vessels were used to clarify CMOR [1, 21, 22, 23]. Additionally, some authors termed CMOR as any vessel coursing over the superior pubic branch, regardless whether it is a vascular anastomosis, an obturator vessel related to the external iliac system or a terminal small vessel [2, 3].

We prefer to keep the description by Darmanis et al., Sanna et al. and Drewes at al., as the term “Corona mortis “is any abnormal anastomotic vessel, located behind the superior pubic ramus and on the posterior aspect of the lacunar ligament, between an obturator vessel (part of to the internal iliac system) and an external iliac vessel [1, 4, 23].CMOR should measure 2 mm or more [24, 25]. CMOR could be in close relationship with the loose edge of the lacunar ligament and the neck of the femoral hernia sac [4, 17, 21, 25]. The close relation between CMOR, lacunar ligament and femoral ring could become a matter of great concern to the orthopedic surgeon, urologist, gynecologist and general surgeon [25]. Sarikcioglu et al. measured the average distance between the arch of the lacunar ligament and the CMOR and found this average to be 12.18mm – 3.55mm [21]. Accessory obturator and aberrant obturator vessels are excluded as these originate from the external iliac or inferior epigastric system and pierce the obturator membrane, not participating in anastomosis [1]. Our concept of separation is that CMOR is an anatomical term that reflects a clinical situation rather than an anatomical structure [2]. Therefore, CMOR, AOVs and ACOVs are at various risk of damage during different surgical procedures. We proposed a clinical classification of CMOR (Figure 5). Type III CMOR is shown in Figure 6.

CLINICAL APPLICATIONS OF AOVS, ACOVS AND CMOR IN GYNECOLOGY

In oncogynecology, Selcuc et al. reported that the term "Corona mortis'' is questionable. They concluded that the retro-pubic vascular anastomoses are easily seen after a careful and tiny dissection over the external iliac artery below the inguinal ligament. In their opinion, an injury to CMOR rarely occurs during pelvic lymphadenectomy as they had only 6 CMOR injuries among 96 pelvic lymphadenectomies. The bleeding was easily controlled [26]. According to other authors CMOR is exposed and at risk of injury during pelvic lymphadenectomy [6, 25]. In our opinion, there is a low risk of damaging CMOR during pelvic lymphadenectomy at the external iliac region for endometrial, ovarian and cervical cancer. Anatomical landmarks for performing systematic oncogynecological pelvic lymphadenectomy in the external iliac region are: ventrally – drain of deep circumflex iliac vein (DCIV) , dorsally – common iliac artery bifurcation, laterally- genitofemoral nerve on the iliopsoas muscle, medially - obliterated umbilical artery[26, 27].DCIV is ventral border as removal of circumflex iliac nodes distal to the DCIV in external iliac region for cervical cancer (FIGO stage Ia, IIa) is not necessary for three reasons – might not be regional lymph nodes, greater risk of lymphedema and low metastatic rate[38]. Studies reported similar findings for endometrial and ovarian cancer [28 -30]. Therefore, visualization of DCIV is enough to complete ventral dissection in the external iliac region. The DCIV drains in the external iliac vein, approximately 1 cm proximal to the inferior epigastric vein, so injury to CMOR should be avoided (Figure 7, 8).

As shown in Figure 7, the DCIV is proximal to the inferior epigastric vein. The distance between vessels was measured – 11 mm (Figure 7) .Consequently, during pelvic oncogynecological lymphadenectomy at the external iliac region, injury to the CMOR distal to the DCIV is less likely to occur, especially for anastomotic vessels between the obturator and the inferior epigastric system. In medical literature, there are no studies comparing the frequency of AOVs, ACOVs, and CMOR distal or proximal to the DCIV. However, figures from the majority of studies showed CMOR, AOVs, ACOVs to be distal to the DCIV [6, 13, 21, 22]. Nevertheless, meticulous dissection should be performed until the level of the DCIV is reached (Figure 8).

The risk of injury of AOVs, ACOVs and CMOR is high during pelvic lymphadenectomy in the obturator region. Anatomical landmarks for performing pelvic lymphadenectomy in the obturator region are: cranially – caudal wall of the external iliac vein, caudally – the obturator vessels, ventrally – the pubic bone together with the levator ani and the obturator muscle, where the obturator nerve leaves the pelvis through the obturator canal, dorsal – the common iliac vessels bifurcation, medial – the urinary bladder, lateral – the obturator internus muscle [27]. Meticulous and careful lymph node dissection is required in the ventral and caudal border of obturator region in order to preserve AOVs, ACOVs, and CMOR. As shown in Figure 8, the risk of damaging CMOR is elevated in the obturator and external iliac region during pelvic lymphadenectomy. CMOR is proximal to the deep circumflex iliac vein, as the anastomosis is between obturator and external iliac system.

The origin of an AOA from the femoral artery is rare and no prevalences have been established [15]. However, studies reported the rate of AOA arising from the femoral artery to be between 0.15% and 1.66% [5,8, 12, 15]. In Figure 3 we included an AOA arising from the femoral artery (Type IV), as it is of major clinical significance in two oncogynecological procedures: inguinofemoral lymphadenectomy and sentinel lymph node biopsy in the inguinofemoral region [7]. The lymphatic system in the inguinal region can be divided into two distinct groups: superficial and deep inguinal lymph nodes. The superficial inguinal lymph nodes are located beneath the Camper fascia and superficial to the fascia lata of the thigh, whereas the deep inguinal nodes lie beneath the fascia lata along the femoral vein [31]. An AOA arising from the femoral artery is at high risk of injury during superficial and deep inguinal lymph nodes dissection. The uppermost deep inguinal lymph node located within the femoral canal and under the inguinal (Poupart) ligament is called Cloquet’s node [32]. Cloquet’s node was believed to be the link between inguinal and iliac/obturator nodes and the sentinel lymph node for vulvar cancer [33]. Currently, studies report that Cloquet's node has no particular surgical relevance and is considered an inconstant lymph node, being absent in approximately 50% of the cases and, when present, unilateral in approximately 30% [34, 35]. Although Cloquet's node is not consistently present, an examination for its presence should be performed by cranial retraction of the inguinal region over the femoral canal [36]. A Cloquet's node dissection carries the risk of injuring an AOA arising from femoral artery, medial circumflex femoral artery or profunda femoral. Although the node is medial to an AOA arising from femoral artery, the surgeon should be familiar with obturator artery origin anomalies in the region.

In our opinion, ACOVs and AOVs are at higher risk of injury than CMOR in the external iliac region, as they are more likely to occur proximal to the DCIV and lateral to the deep femoral ring. AOVs cross the superior pubic ramus more obliquely and at a posterior position compared to CMOR [4]. Moreover, damage to ACOV and AOVs could be more precarious than CMOR. In the majority of cases, the average diameter of AOVs is greater than CMOR [4, 9, 37]. ACOVs, AOVs and CMOR lateral to the deep femoral ring are at major risk of damage during pelvic lymphadenectomy, as they are in the surgical field.

In urogynecology, AOVs, ACOVs and CMOR are at risk of injury during stress urinary incontinence procedures - minimally invasive midurethral sling - the tension-free vaginal tape (TVT), Transobturator tape (TOT), TVT Secur (a single-incision sling device) and retropubic colposuspension -Burch procedure.

For many years, Burch colposuspension (first introduced in 1961) was a well-accepted technique for surgical management of stress urinary incontinence (SUI), especially when it was associated with urethral hypermobility. It was considered as the "gold standard" for the treatment of SUI [38]. Burch procedure surpassed in popularity in the early 2000s after the advent of the minimally invasive midurethral sling [51]. Although antimesh media and statements by the Us Food and Drug Administration in recent years have led to some patients requesting mesh-free surgery, Burch procedure remains an option for secondary treatment of SUI [38, 39]. Burch colposuspension is performed through laparotomy or laparoscopy [38].

The Retzius (retropubic) space is dissected. Once the retropubic space is dissected, the bladder neck and the pubocervical fascia are identified. The surgeon places 2 bilateral nonabsorbable sutures through the pubocervical fascia and vaginal muscularis, without passing through the vaginal epithelium—one at the level of the midurethra and other at the urethrovesical junction. Sutures are fixed to the Cooper's pubic ligament [39, 40].

Cooper originally described Pectineal ligament or Cooper's pubic ligament. He stated that the Cooper's ligament was a ligamentous expansion, which formed a remarkably strong ridge above the iliopectineal line [41-42]. There is no consensus about the origin of pectineal ligament. Faure et al. reported that the pectineal ligament adheres to the periosteum of the superior pubic ramus, covers the pectineal line of the pubis, and stretches dorsally from the pubic tubercle and the iliopubic eminence [42-43]. The pectineal ligament forms the dorsal border of the deep femoral ring and the lacunar (Gimbernat) ligaments is the medial border [44]. Steinke et al. reported that the pectineal ligament is attached ventrally to the pectineus muscle and it attaches to both the iliopsoas fascia, obturator fascia, whereas dorsally both fascia are free of the pectineal ligament. Cranially, the pectineal ligament is connected to the inguinal ligament by the lacunar ligament [42]. Faure et al. concluded that the mean length of pectineal ligament is 53 mm. It was thicker in two regions – at its medial insertion or between the external iliac vessels and the pubic spine [43].They reported that during Burch colposuspension stitches should be located near to the iliac vessels and 4 cm lateral to the medial insertion of the ligament, where it has its greatest thickness [43]. According to other study, the medial part of pectineal ligament close to the pubic tubercle was the thickest section and it became thinner while extending laterally [44]. In a study of 11 female unembalmed female cadavers, Kinman et al. reported that the mean distance from the most lateral stitch in Cooper's pubic ligament to the obturator bundle was 25.9 ± 7.6 mm and to the external iliac vessels was 28.9 ± 9.3 mm, and in some instances, these structures were less than 15 mm away [39]. Pulatoglu et al. measured the total length of the pectineal ligament - 5.9±0.76 cm on the left and 6.5±1.14 cm on the right side. From the midpoint of the right pectineal ligament, the mean distance to the right CMOR was 2.37±0.63 cm and the mean distance to the left CMOR was 2.15±0.48 cm [44].

From these studies, we can conclude that during Burch colposuspension, AOVs, ACOVs and CMOR are at great risk of injury, especially if they pass medial to the deep femoral ring (Figure 9).

In figure 9, CMOR is located medial to the deep femoral ring and in close proximity to the most lateral stitch in the pectineal ligament. The incidence of AOVs, ACOVs and CMOR medial to the deep femoral ring varies in medical literature (5%-42,5%). Last reported that the AOA lay medial to the deep femoral ring in 10 % of cases [16]. Skandalakis et al. stated 40 %

percentage of AOA passing medial to the deep femoral ring [45]. Another study reported an artery, which passed through the medial side of the deep femoral ring in 5% of the specimens observed. Moreover, there were comparatively larger veins, which ran medially to the deep femoral ring and opened into the external iliac vein (found in 42.5%) [10]. Injury of AOVs, ACOVs and CMOR lateral to the deep femoral ring during Burch colposuspension is possible, but less likely to occur. In the majority of cases AOVs, ACOVs and CMOR are located lateral to the deep femoral ring (60% - 90%) [8 , 16, 45].

Furthermore, AOVs, ACOVs and CMOR are at risk of damaged during operations for vaginal wall descent, uterovaginal prolapse and neovaginal reconstruction [42, 44]. Studies reported that pectopexy for pelvic organ prolapse is feasible procedure because the surgeon used a wide area in the pelvis and the strong nature of the pectineal ligament would decrease the postoperative recurrence rates [44, 46]. The pectineal ligament is the target for neovaginal attachment in Mayer–Rokitansky–Küster–Hauser syndrome. The syndrome is related with uterus aplasia and variable degrees of vaginal hypoplasia of its upper portion. Although different materials are used for creation of neovaginal, sigmoid grafts are most common [42, 47].

Minimally invasive procedures, such as the TVT sling (introduced in 1998), the TOT sling (2002) and the TVT-Secur are used for treatment of SUI [24]. They involve the placement of slings under the midurethra through a retropubic (TVT) or transobturator (TOT) approach [24]. The TVT is considered a minimally invasive procedure that involved passage of needles through small vaginal and suprapubic skin incisions [48]. The TOT is a minimally invasive procedure, based on an entirely new concept of positioning of tape under the middle urethra horizontally through the obturator foramen [49]. The TVT- Secur is less invasive short tape method as anchoring the minitape in the obturator muscle avoids a full needle passage. The TVT-Secur has two suggested approaches – U-retropubic and lateral Hammock (obturator) [50]. In the U-Approach, the tape is pushed along the periost behind the arc of the pubic bone at an angle of 45°, whereas in the Hammock Approach, the tape is pushed towards the obturator foramen [51]. Although TOT (the retropubic space is not entered, the needle tip penetrates the obturator externus muscle, the obturator membrane, and then rotates around the medial aspect of the pubic ramus) is associated with lower rate of AOVs, ACOVs and CMOR injury, studies reported damage to these vessels in all type of sling procedures [24, 48-52]. Montoya et al. stated that during TVT- Secur procedure, the closest distance from the 45° and 90° anchor points to the ACOV was 1.6 and 1.5 cm, respectively [48]. They described ACOV and CMOR as the same structure [62]. In a cadaveric study, Stavropoulou stated that the average distance from the symphysis pubis to arterial CMOR was 52.4mm and venous CMOR was 46.7 mm [48]. Darmanis et al. reported an average distance between the CMOR and the symphysis pubis 40 mm – 96 mm, while Tornetta et al reported 30mm- 90 mm [3, 4, 53]. The majority of authors concluded that average distance from the symphysis pubis to AOVs, ACOVs and CMOR exceeds 30 mm [24, 34]. Consequently, during TVT and TVT-Secur (U approach) the tape is placed at a distance of 25mm- 30mm from the symphysis pubis [24, 51]. Larsson et al. reported a complication of CMOR during TVT- Secur procedure [50]. Authors commented Larsson et al. case and concluded that the injury of the CMOR happened in the attempt to place the TVT-Secur™ more upwardly, similar to the tape applied in the U position [50, 51, 54]. Gobrecht et al. stated that the 45°-angle insertion could damage the AOVs, ACOVs and CMOR. Injuring the AOVs, ACOVs and CMOR could be avoided by inserting the tape in either a 0° angle (classic retropubic TVT) or a 90° angle (TVT-O, obturator) [51]. In our opinion, injury to AOVs, ACOVs and CMOR during TVT- sling procedures is more likely to occur if they are located medial to the deep femoral ring, as the closer proximity to the symphysis pubis (Figure 10).

CONCLUSIONS

AOVs, ACOVs and CMOR are encountered during different types of gynecological operations. Intraoperative injury to AOVs, ACOVs and CMOR depends on type of surgery and vessels location behind the superior pubic ramus, and posterior aspect of the lacunar ligament. Our new clinical classification might help gynecologist to be familiar with AOVs, ACOVs, CMOR variations and to avoid injury during surgery.

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Table 1. OA origin variations [5, 7-17].

Origin from internal iliac artery (IIA)

OA arises separately from IIA before bifurcation

OA arises from the anterior division of IIA

OA arises from inferior gluteal artery

OA arises from internal pudendal artery

OA arises from posterior division of IIA

Origin from external iliac artery (EIA)

OA arises directly from EIA

OA is a branch of inferior epigastric artery

OA arises as a double root from both IIA and EIA

Figure 1. Obturator nerve, artery and vein topographical anatomy – open surgery (right pelvic side wall). ON – obturator nerve, OA – obturator artery, OV – obturator vein, IIV – internal iliac vein, IIA – internal iliac artery, UMA – umbilical artery

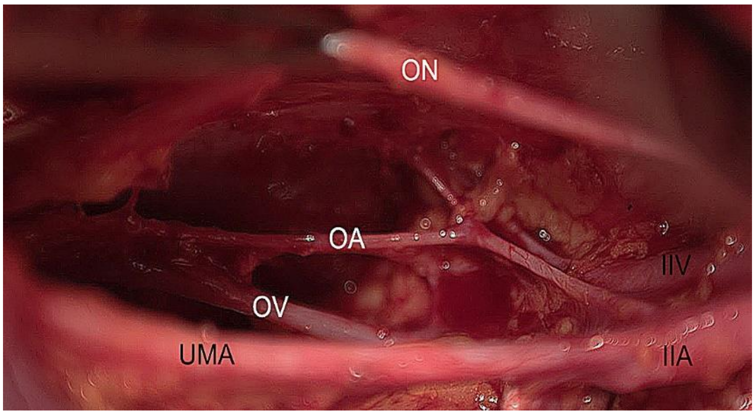

Figure 2. **Obturator fossa anatomy – open surgery (right pelvic side wall).** EIA – external iliac artery, EIV – external iliac vein, IIV – internal iliac vein, IIA – internal iliac artery, UA – uterine artery (cut and ligated), UR – ureter, UMA – umbilical artery, ON – obturator nerve, OA – obturator artery, OV – obturator vein, OF – obturator foramen, OIM – obturator internus muscle, BOIM – branch of obturator artery for obturator internus muscle.

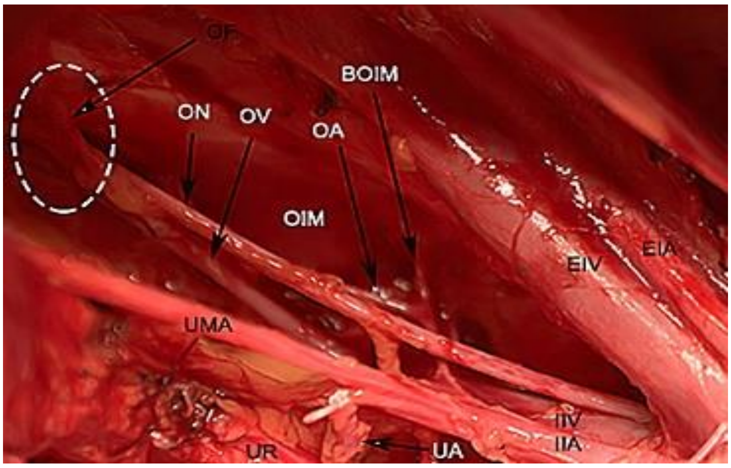

Figure 3. Aberrant obturator artery (AOA) classification. **Type I** – AOA arising from the inferior epigastric artery. AOA is located medial to the deep femoral ring. **Type II** – AOA arising from the inferior epigastric artery. AOA is located lateral to the deep femoral ring. **Type III** – AOA arising from the external iliac artery. **Type IV** – AOA arising from the femoral artery.

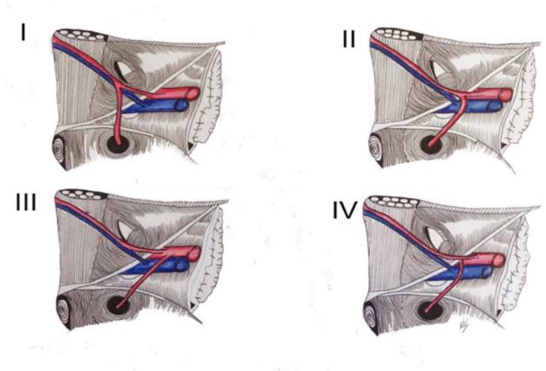

Figure 4. Aberrant obturator vein classification. Type I – aberrant obturator vein drains in the inferior epigastric vein. Aberrant obturator vein is located medial to the deep femoral ring. **Type II** – aberrant obturator vein drains in the inferior epigastric vein. Aberrant obturator vein is located lateral to the deep femoral ring**. Type III** – aberrant obturator vein drains in the external iliac vein**. Type IV** – double aberrant obturator vein drains in the external iliac vein.

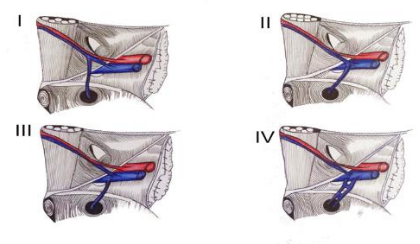

Figure 5. CMOR classification. **Type I** – CMOR between obturator artery (OA) and external iliac artery**. Type II** – CMOR between obturator vein (OV) and external iliac vein**. Type III** – CMOR between both obturator vessels and external iliac vessels. **Type IV** – CMOR between inferior epigastric artery and OA**. Type V** - CMOR between inferior epigastric vein and OV**. Type VI** – CMOR between both obturator vessels and inferior epigastric vessels. **Type IV, V and VI** anastomotic vessels are located lateral to the deep femoral ring**. Type VII** – CMOR between OA and inferior epigastric artery. **Type VIII** – CMOR between OV and inferior epigastric vein. **Type IX** – CMOR between both obturator vessels and inferior epigastric vessels. **Type VII, VIII and IX** anastomotic vessels are located medial to the deep femoral ring.

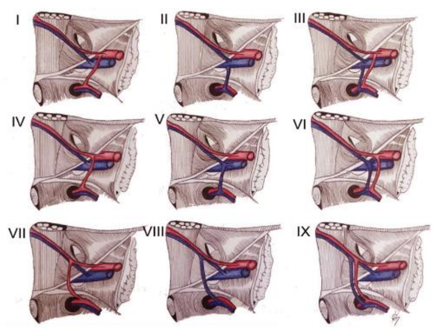

Figure 6. Arterial CMOR and venous CMOR between obturator artery/vein and external iliac artery/vein. Fresh cadaver. Type III. PMM – psoas major muscle, EIA – external iliac artery, EIV – external iliac vein, gGFN- genital branch of genitofemoral nerve, fGFN – femoral branch of genitofemoral nerve, DCIV – deep circumflex iliac vein, IEV- inferior epigastric vein, IEA – inferior epigastric artery, IL – inguinal ligament, FR –deep femoral ring, OF – obturator foramen, ON – obturator nerve, OA- obturator artery(severed during dissection), OV- obturator vein, aCMOR – arterial Corona mortis, vCMOR – venous Corona mortis, SPS – superior pubic ramus

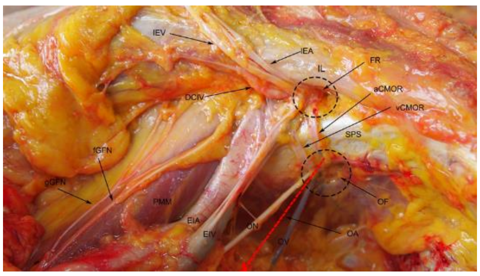

Figure 7. Venous Corona mortis between obturator vein and inferior epigastric vein. (right pelvic side wall). The distance between deep circumflex iliac vein and inferior epigastric vein is measured – 11 mm. **Embalmed cadaver**. **Type V.** EIA – external iliac artery, EIV – external iliac vein, PMM – psoas major muscle, OIM – obturator internus muscle, IIA – internal iliac artery, UA – uterine artery, UMA – umbilical artery, ON – obturator nerve, OA - obturator artery, OV – obturator vein, B – bladder, PS – pubic symphysis, IEV – inferior epigastric vein, DCIV – deep circumflex iliac vein, vCMOR – venous Corona mortis.

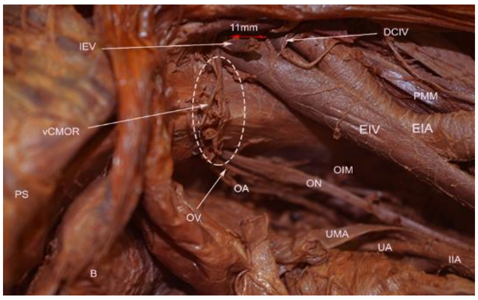

Figure 8. Arterial and venous Corona mortis between external iliac and obturator vessels (left pelvic side wall). Rare case of CMOR proximal to the deep circumflex iliac vein. **Fresh cadaver. Type III.** EIA – external iliac artery, EIV – external iliac vein, PMM – psoas major muscle, PMIM – psoas minor muscle, FN – femoral nerve, IIN – ilioinguinal nerve, gGFN – genital branch of genitofemoral nerve, fGFN – femoral branch of genitofemoral nerve, DCIV – deep circumflex iliac vein, ON – obturator nerve , 0A - obturator artery, OV – obturator vein, OF – obturator foramen, FR – deep femoral ring, aCMOR – arterial Corona mortis, vCMOR – venous Corona mortis, IL – inguinal ligament, PL – pectineal ligament, IEV – inferior epigastric vein, IEA - inferior epigastric artery.

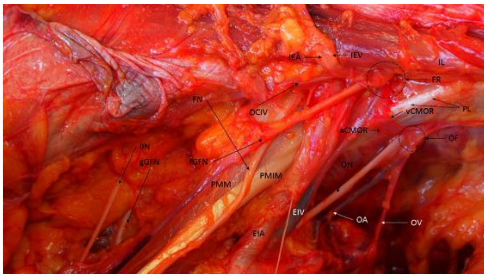

Figure 9. Arterial and venous Corona mortis between inferior epigastric and obturator vessels (left pelvic side wall). **CMOR is located medial to the deep femoral ring**. **Fresh cadaver. Type IX**. CIA – common iliac artery, PMM – psoas major muscle, IIA – internal iliac artery, EIV – external iliac vein, EIA – external iliac artery, IIN – ilioinguinal nerve, FN – femoral nerve, gGFN – genital branch of genitofemoral nerve, fGFN – femoral branch of genitofemoral nerve, ON – obturator nerve, OA – obturator artery, OV – obturator vein, OF – obturator foramen, PL – pectineal ligament, FR – deep femoral ring , vCMOR – venous Corona mortis, aCMOR – arterial Corona mortis, IL – inguinal ligament, DCIV – deep circumflex iliac vein.

Figure 10. Venous CMOR between OV and inferior epigastric vein. The anastomosis is located medial to the deep femoral ring – open surgery. Type V. EIV – external iliac vein, EIA – external iliac artery, IIA – internal iliac artery, UR – ureter, UMA – umbilical artery, ON – obturator nerve, OA – obturator artery, OV – obturator vein, OIM – obturator internus muscle, FR – deep femoral ring, vCMOR – venous Corona mortis.