Original Article

Anomalous Origin of the Obturator Artery in a Goan Population: A Study Linked with Hernia Reduction Surgery

Abstract

Context: "Corona mortis" or "crown of death" occurs when an accessory obturator artery (OA) is also present, having rich anastomosis with the normal OA around the obturator canal. The OA can take origin from various arteries such as the common iliac, anterior or posterior divisions of the internal iliac, inferior epigastric, superior or inferior gluteal, internal pudendal, or even external iliac arteries. Accessory OA has an incidence of 30%–40% in earlier studies. **Aims:** To find out the incidence, location, and dimensions of aberrant, retropubic, anastomosing vessels and the corona mortis that connects the external iliac and obturator vessels and to determine their interference with various surgical approaches. **Subjects and Methods:** Twenty-five cadaveric pelvises were dissected in the pelvic and retropubic inguinal regions. The origin and course of the OA and the presence of venous plexuses were recorded. We studied the frequencies of occurrence of abnormal obturator vessels and also their variant patterns of origin from and drainage into the iliac vessels. **Statistical Analysis Used:** Student's *t*-test. **Results:** We found a higher incidence, i.e., 44% of internal iliac artery branching pattern as Group Ia. Vasa corona mortis was seen in two pelvises showing an arterial connection around the superior pubic ramus, whereas venous corona mortis was seen in twenty pelvises and five hemipelvises showing an aberrant OA. **Conclusions:** Cadaveric dissections have shown a vascular connection between the obturator, external iliac, and inferior epigastric vessels, and these variations are important specially when doing pelvic and groin surgeries.

Keywords: *Aberrant obturator artery, corona mortis, inferior epigastric artery, internal iliac artery, obturator artery*

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Introduction

Hemorrhage involving the branches of the internal iliac artery (IIA) is a well-known possibly lethal complication in pelvic injuries;[1] hence, a comprehensive knowledge of vascular anatomy of the pelvis is much needed for successful endoscopic total extraperitoneal inguinal hernioplasty and laparoscopic herniorrhaphy.[2]

The obturator artery (OA) is usually a branch of the anterior division of IIA and courses forward on the pelvic wall, along with the obturator vein (OV) below it and the obturator nerve above it, and then enters the obturator foramen. Normally, there is no venous plexus on the anterolateral walls of the pelvis.[3]

The OA can take origin from various arteries such as the common iliac artery, anterior or posterior divisions of IIA, inferior epigastric artery (IEA), superior gluteal artery (SGA) or inferior gluteal artery (IGA), internal pudendal artery (IPA), IIA, or external iliac artery (EIA).[4,5]

An additional OA is sometimes seen supplementing the normal OA and when present, is called the accessory OA and has an incidence of 30%–40%. "Corona mortis," sometimes known as "crown of death," is a concept described when both the normal and accessory obturator arteries are present with rich anastomoses between the pubic ramus of the IEA and OA.[6] The significance of this is that if the corona mortis is accidentally cut, hemorrhage may occur, which leads to complications in achieving hemostasis.[7,8] The corona mortis has been said to cause massive uncontrolled bleeding,[8] significant bleeding,[9] profuse bleeding,[10] pelvic bleeding,[11] or life-threatening hemorrhage.[12]

In this context, knowledge of the presence of accessory OA is important as it may be accidentally cut when enlarging the femoral ring during reduction surgery for

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a strangulated hernia as it can lie along the edge of the lacunar ligament, in close relationship to the neck of the hernial sac.[13]

According to Bendavid, "the trans-abdominal approach is an approach to hernia repair that is unfamiliar to most surgeons and the ideal reconstruction of the floor of the inguinal canal during a herniorrhaphy needs good anatomic dissection and exposure."[14] It is the need of the hour for surgeons to take precautions to avoid injury to such unexpected sources of hemorrhage, such as aberrant obturator vessels.[15] Due to the dearth of available data on such anastomotic variations regarding the OA in the Goan population, this study was undertaken. The aims and objectives of this study are to find out the incidence, location, and dimensions of aberrant, retropubic, anastomosing vessels and the corona mortis that connects the external iliac and obturator vessels and to determine their interference with various surgical approaches.

Subjects and Methods

This study was performed in the Anatomy Department of the Goa Medical College, after taking the necessary permission from the Institutional Ethics Committee. Twenty-five cadavers, i.e., 50 hemipelvises, were used in our study, of which 22 were male and three were female with a mean age of 44.8 years and were dissected in the pelvic and retropubic inguinal region with great care taken at the superior pubic ramus to preserve as many vessels as possible, especially those >1–2 mm in diameter. We also dissected the branches of the IIA and EIA and then traced the OA from its origin to its exit, when observing its course and relations to surrounding structures. Any vessels connecting the obturator vessels with the external iliac or inferior epigastric systems as well as any aberrant vessels, including their courses and branches, were observed. The external diameter of all vessels as well as their distance from the symphysis pubis and the lacunar ligament was measured with calipers. Venous plexuses on the lateral pelvic walls were also observed. Photographs were taken using a Sony Alpha Single-lens Reflex camera with a zoom lens. Variations observed were statistically assessed using the Student's *t*-test (two-sample assuming equal variances).

Results

Normal obturator artery

Out of 50 hemipelvises, the OA mostly arose as shown in Table 1.

The average length of the normal OA was 44.56 ± 6.59 mm (range, 25.15–60.08 mm), and the average diameter was 2.53 ± 0.56 mm (range, 25.15–60.08 mm). A vascular communication more than 1–2 mm diameter was observed in 20 hemipelvises (40%). Eight hemipelvises showed communicating vessels with larger diameter (>4 mm in diameter); in all, the vessel was a vein draining into the external iliac vein (EIV) with an average diameter of 3.81 ± 1.27 mm, out of which two of the same hemipelvises also showed an artery as the communicating vessel with an average diameter of 3.54 ± 0.09 mm [Figures 1 and 2].

Arterial corona mortis

Out of the total 50 hemipelvises, only two showed an arterial connection (4%) at an average distance of 42.76 ± 7.77 mm from the symphysis pubis. In all the hemipelvises, the connecting artery formed a "vascular arch" around the superior pubic ramus with a mean distance of 5 mm from the lacunar ligament [Figure 1].

Venous corona mortis

Venous anastomoses were much more common than arterial and were observed in 20 (40%) out of 50 hemipelvises. The connecting vein was at an average distance of 41.53 ± 9.29 mm from the symphysis pubis and passed over the superior pubic ramus close to the femoral ring and lacunar ligament, then passed medial to the iliopectineal eminence and iliopsoas muscle and coursed vertically downward along with the artery when present to the obturator foramen and connected to the normal OV [Figures 2 and 3].

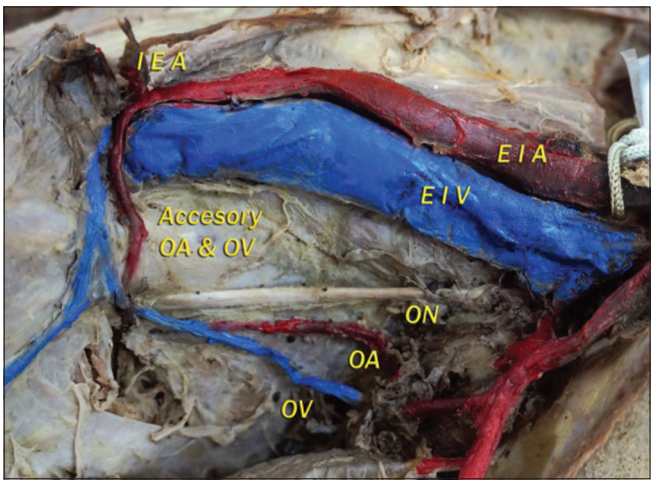

Figure 1: Accessory obturator artery from the inferior epigastric artery and accessory obturator vein draining into the inferior epigastric vein

Table 1: Origin of obturator artery

Origin	Male	Female	Total	Percentage
Ant Div IIA	20	2	22	44
SGA	1	-	1	2
IEA	3	2	5	10
IGA and IPA	15	1	16	32
IPA	3	1	4	8
IIA and EIA	2	-	2	4

IIA: Internal iliac artery, Ant Div IIA: Anterior divisions of IIA, SGA: Superior gluteal artery, IEA: Inferior epigastric artery, IGA: Inferior gluteal artery, IPA: Internal pudendal artery, EIA: External iliac artery

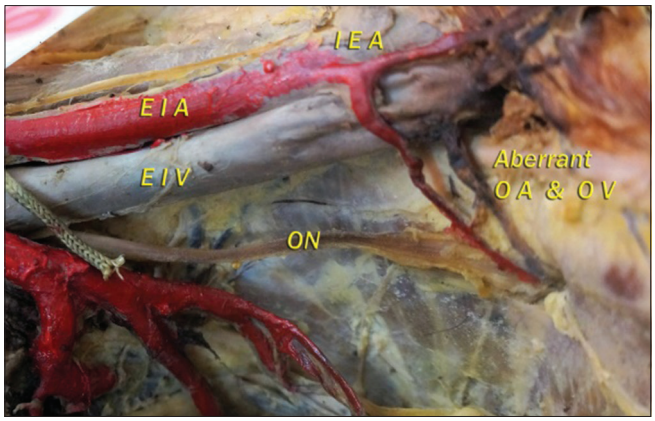

Figure 2: Aberrant obturator artery from the inferior epigastric artery and aberrant obturator vein draining into the external iliac vein

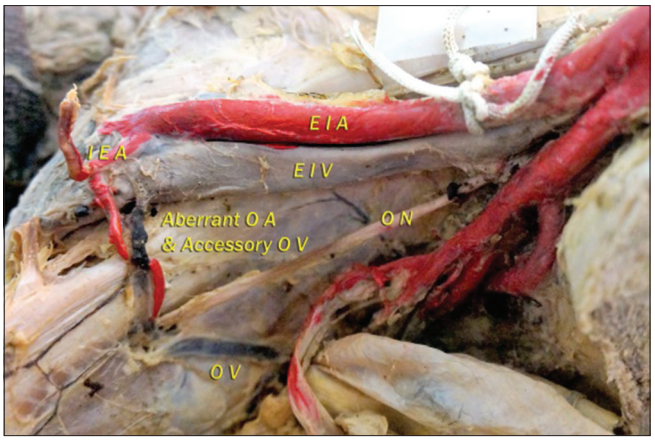

Figure 3: Aberrant obturator artery from the inferior epigastric artery and accessory obturator vein draining into the external iliac vein

Aberrant obturator vessels

In five hemipelvises, an aberrant OA arose from the IEA and in three hemipelvises an aberrant OV drained into the EIV. In one side, there were two veins draining into the EIV, one of which passed medial to the lacunar ligament.

Both connecting artery and vein were found in one specimen and 14 sides had more than one anastomotic vessel. Eight sides also had multiple venous anastomoses: two sides with three venous branches and six sides with two venous branches.

Five out of 25 cadavers had bilateral variations, of which one female cadaver showed bilateral symmetrical aberrant OA and OV. Overall, the average diameter of the anastomotic vessels was 3.58 ± 1.22 mm, although in eight hemipelvises, we found nine vessels >4 mm diameter.

Table 2 summarizes the vascular distribution in our study.

Table 2: Vascular details

Incidence-arteries and veins	Sides (%)
Vessel crossing the pubic ramus	21/50 (42)
Vessel >4 mm diameter	8/50 (16)
Aberrant OA from EIA	5/50 (10)
Aberrant OV draining into EIV	3/50 (6)
Arterial anastomoses	2/50 (4)
Venous anastomoses	20/50 (40)
Multiple venous anastomoses	8/50 (16)
Less than one vessel present	14/50 (28)
Both artery and vein present	1/50 (2)
Bilateral vascular anomalies	5/25 (20)
Bilateral symmetry in vascular distribution	10/25 (40)

EIA: External iliac artery, EIV: External iliac vein, OV: Obturator vein, OA: Obturator artery

Discussion

Normal obturator artery

Yamaki *et al*. dissected 645 cadaveric hemipelvises and classified the branching of the IIA according to Adachi's classification (1928), and they reported that 80% of their specimens belonged to Group Ia, i.e., two main branches – the SGA and a common trunk for IGA and IPA from the IIA.[16,17] In our study, we found a high incidence of 44% of this same IIA branching pattern.

Bergman *et al*. found in 23% of cases a similar origin of OA on both sides of the body.[18] In our study, we found bilateral symmetry in vascular distribution in 40% of our sample.

Cloquet's study (1817) showed that the frequency with which the OA arose from the IIA rather than from the IEA/EIA was 3:1; Monro found this ratio to be 20:1; Manec as 6:1; and Scarpa et al. as 15:1 as cited by Bergman *et al*.[18] With regard to the OA arising from the IEA, we found a ratio of 1 in 10, which is midway between the findings of Manec and Scarpa. Many other studies found variations in branching of OA as shown in Table 3.[19-24]

Li and Zeng studied 148 specimens and found the incidence of abnormal OA to be 9.5% ± 2.4%, average length of the artery 42.3 ± 7.1 mm, and the outer caliber 1.7 ± 0.7 mm, but they found no significant difference between sides or sexes (P = 0.05).[25] We found the incidence of abnormal OA to be 17.64%, with the length of the artery being 34.02 ± 4.62 mm and the external caliber being 2.4 ± 0.59 mm. No significant difference was found between the sides or sexes (P = 0.46).

Arterial corona mortis

Abnormal anastomotic vessels between the external iliac and the obturator systems have been referred to as the corona mortis, and this connection can be arterial or venous or both (Letournet, 1993; Letournet and Judet, 1993; Tornetta *et al*., 1996; Karakurt *et al*., 2002; and Okcu *et al*., 2004).[26-30]

Karakurt *et al*. found arterial incidence at 29%;[29] Tornetta *et al*. in 50 pelvic halves found anastomosis in 84%, of which only 34% were arterial;[28] Teague *et al*. in 78 pelvic halves

Table 3: Percentage of vascular distribution in previous studies and the present study

Author and date	OA branch from internal iliac artery							Branch from external iliac artery			Total sample
	ADIIA	PDIIA	IGA IPA	IGA	IPA	SGA	ILA	Dir br	IEA	IIA + EIA	
Braitwaite 1952[19]	41.4	-	10	4.7	3.8	10	3.5	1.1	19.5	6.5	169
Bergman *et al*., 1988[18]	41.4	0	10	4.7	3.8	10	0	1.1	25	20–30	-
Missankov *et al*., 1996[20]	-	-	-	-	-	-	-	25	-	-	-
Jakubowicz *et al*., 1996[21]	-	-	-	-	-	-	-	1.3	-	2.6	-
Pai *et al*., 2009[15]	60.2	7.14	-	-	-	10.2	1	5.1	14.2	2	98
Biswas *et al*., 2010[22]	44.6	12.5	0	0	0	16	-	3.5	23.2	0	56
Thirupathi *et al*., 2013[4]	35.55	0	13.33	4.44	4.44	4.44	2.22	8.88	26.66	0	45
Pavan *et al*., 2014[5]	40	18	0	6	4	0	10	2	6	0	50
Mamatha *et al*., 2015[23]	24	14	-	-	-	-	-	-	-	12	50
Rajive and Pillay 2015[24]	54	0	0	2	2	2	0	0	22	0	50
Present study	44	0	32	0	8	2	0	0	10	4	50

EIA: External iliac artery, IIA: Internal iliac artery, IEA: Inferior epigastric artery, SGA: Superior gluteal artery, IPA: Internal pudendal artery, OA: Obturator artery, IGA: Inferior gluteal artery, ADIIA: Anterior division Internal Iliac artery, PDIIA: Posterior division internal iliac artery, ILA: Ilio-lumbar artery, Dir br: Direct Branch

found 73% anastomosis, of which 43% were arterial;[9] Okcu *et al*. found arterial anastomosis in 19% of all anastomoses;[30] and Hong *et al*. found anastomosis in 72% of 50 pelvic halves, of which 34% were arterial.[10] We found arterial anastomosis much lower as in 4% of our specimen.

Venous corona mortis

In most previous studies, venous corona mortis has shown a higher incidence than arterial corona mortis.[8] Tornetta *et al*. found venous anastomosis in 70%;[28] Teague *et al*. found it in 59%;[9] Okcu *et al*. found it in 61%;[30] Hong *et al*. found it in 62%;[10] and Darmanis *et al*. found it in 83%.[7] The highest incidence ever reported was that of Berberoğlu *et al*., who found 96% venous anastomosis.[12] Letournel and Letournet and Judet found an incidence of 10%–15% corona mortis in 150 cases.[26,27] In our study, we found venous anastomosis in 40% of our specimen.

Rusu *et al*. have classified the venous corona mortis into three types: "Type I-OV drains into EIV, Type II-OV drains into inferior epigastric vein (IEV), and Type III-OV anastomoses with IEV."[31] In our study, we found type II in 32% and type III in 68% of venous corona mortis.

Aberrant obturator vessels and corona mortis

Berberoğlu *et al*. found 14% aberrant OA;[12] Lau and Lee found 22% aberrant OA and 27% aberrant OV;[2] and Hong *et al*. found 22% anomalous OV and 24% anomalous OA.[10] We found aberrant OA in 10%. Sarikcioglu *et al*. found the average distance between the anastomotic vessels and the lacunar ligament to be 12.18 ± 3.55 mm.[8] Sakthivelavan *et al*. reported an arterial corona mortis having an average distance from the lacunar ligament as 13.1 mm.[32] In our study, we found this distance to be 5 ± 7.07 mm.

The variant patterns of origin and course of the obturator arteries are due to the fact that the OA appears late as an uneven growth of anastomosis of EIA and IIA, which relies on organogenesis, and either the artery could be normal or can be completely replaced by the pubic anastomosis and if both the rami are enlarged it is called as corona mortis.[33] During a transabdominal preperitoneal repair, IEA is one among the four important landmarks that should be seen at initial laparoscopic inspection of the inguinal region.[34]

Sabuncuoglu *et al*. described a triangle of dissection which includes the triangle of pain, the triangle of doom, and the corona mortis, and they stated that "when the lacunar ligament is opened the vascular branch behind the lacunar ligament passes over Cooper's ligament and causes an anastomosis between the obturator and EIA or IEA and can lead to life threatening haemorrhage particularly during surgical femoral hernia repair."[35]

Conclusions

Cadaveric dissections have shown a vascular connection between the OA and the IEA overlying the superior pubic ramus, wherein the diameter as well as the course of these vessels varies. Inexperience with laparoscopic inguinal anatomy can lead to vascular injuries occurring during surgery in this case involving the inferior epigastric and obturator vessels which even can result in life-threatening hemorrhage. In our study, we found a higher incidence, i.e., 44% of IIA branching pattern as Group Ia. Vasa corona mortis was well documented, with two pelvises showing an arterial connection around the superior pubic ramus, but venous corona mortis was found to have a higher significance and was seen in twenty pelvises. Five hemipelvises showed aberrant OA, with more pelvises shoring an aberrant anastomosis. Hence, knowledge of the variations in the origin of the OA with special reference to the accessory and/or aberrant obturator vessel is important when performing any surgery in the pelvic and groin regions.

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Conflicts of interest

There are no conflicts of interest.

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