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An anatomical study on the variations and clinical significance of the corona mortis within a South African sample

Jade Naicker [a,*], Zithulele Nkosinathi Tshabalala [b], Andries Masenge [c], Obakeng Modisane [a], Steven Matshidza [a,1], Nkhensani Mogale [a]

[a] Department of Anatomy, Faculty of Health Sciences, School of Medicine, University of Pretoria, Gauteng, 9 Bophela Road, South Africa
[b] Department of Human Anatomy, Faculty of Health Sciences, School of Medicine, Nelson Mandela University, Eastern Cape, Old Uitenhage Road, South Africa
[c] Department of Statistics, Faculty of Natural and Agricultural Sciences, University of Pretoria, Gauteng, Lynwood Road and Roper Street, South Africa

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ABSTRACT

Introduction: Anterior orthopaedic approaches, much like the Modified Stoppa approach, target fractures of the anterior column of the pelvis and acetabulum. The approach is described as a minimally invasive technique that may lead to iatrogenic haemorrhage and fatality in patients. Such mortality is due to the inadvertent severing of the corona mortis vessels, a clinical term referring to the anastomosis between the obturator vessels and the external iliac vessels typically via an accessory obturator vessel that courses over the pelvic brim. Knowledge regarding the prevalence and clinical significance of the corona mortis, especially within the South African population is lacking, and therefore further investigation of this anomaly is necessary.

Materials and methods: This study investigated the incidence and variations of the corona mortis vessels in a South African sample using 63 adult cadavers obtained from the Department of Anatomy, University of Pretoria. After careful dissection of the blood supply to the pelvis, the prevalence of corona mortis was investigated. Variations regarding the composition of the corona mortis and the incidence of aberrant obturator vessels were documented.

Results: The incidence of corona mortis was observed in 67.5% of the study sample, with 91.6% being venous and 8.4% being arterial in composition. An incidence of 26.0% of aberrant obturator arteries and 8.1% of aberrant obturator veins were observed originating or draining directly into the external iliac system, respectively. A single rare instance of corona mortis was observed and involved an anastomosis with the superior vesical vein rather than the typical obturator vein. While variations amongst anomalous accessory vessels were observed which resulted in as many as 3 aberrant vessels coursing over the pelvic brim. No significant difference was concluded for the incidence of corona mortis between the left and right sides or between males and females.

Conclusion: Mapping out the parameters of the corona mortis and examining the variation linked with the anomaly will aid orthopaedic surgeons in implementing anterior approaches with reduced vascular damage and iatrogenic deficit. Further understanding of its incidence in the South African population will in turn assist in interpreting its clinical significance.

1. Introduction

Corona mortis or the 'crown of death' is a clinical term that traditionally describes the anomalous communication between the obturator artery, which originates from the anterior division of the internal iliac artery, and the external iliac artery or its branch, the inferior epigastric artery [1]. Corona mortis anastomoses are typically completed via the accessory obturator vessel, an atypical branch of the external iliac vessels or its branches that communicates with the typical obturator vessel [1]. The corona mortis is an inter–individual variant, located posterior

* Corresponding author. Dr Savage Road, Prinshof 349-Jr, Pretoria, 0084, Basic Medical Sciences building, Room 3-17, Prinshof Medical Campus, University of Pretoria, South Africa.

E-mail addresses: Naicker.Jade@up.ac.za (J. Naicker), Zithulele.Tshabalala@mandela.ac.za (Z.N. Tshabalala), Andries.Masenge@up.ac.za (A. Masenge), obakengc.modisane@gmail.com (O. Modisane), MatshidzaS@ufs.ac.za (S. Matshidza), Nkhensani.Mogale@up.ac.za (N. Mogale).

[1] Permanent addressDepartment of Orthopaedics, Faculty of Health Sciences, School of Medicine, University of Free State, Free State, 3 Budget Avenue, South Africa.

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to the superior pubic ramus within the retropubic space, while the accessory obturator vessel crosses over the superior pubic ramus [2].

The variations associated with the corona mortis include the anastomosis of the obturator artery directly with the external iliac artery or indirectly via an accessory obturator artery or the inferior epigastric branch, respectively [3]. Cases can include arterial or venous vasculature, or in some cases both, however, a prominent incidence of venous anastomoses has been reported in previous literature [4–11]. The corona mortis is reported to be an extremely variant anomaly which may influence its clinical implications. The investigation of the anatomy and significance of the anastomosis is key in decreasing iatrogenic injury to the corona mortis during pelvic ring and acetabular fractures.

The locality of the corona mortis is known to range from the superior iliac crest to the pubic symphysis and can therefore be easily ligated when accessing the pelvis during various intraoperative approaches. These procedures include the repair of inguinal, obturator, or femoral hernias and Tension-free Vaginal Tape secure, for the treatment of stress urinary incontinence [10,12]. However, orthopaedic procedures which aim to repair the anterior column of the pelvis (iliopubic column) and acetabulum utilising the anterior and lateral approaches pose the most concern [8]. The anterior approach of interest is called the Modified Stoppa approach which is sometimes applied in conjunction with the lateral approach to the iliac crest [13]. The considerable risk and threat associated with the potential damage of the corona mortis vessels include spontaneous vascular spasms and retraction into the pelvis, which may be encountered during the Modified Stoppa approach [7]. Therefore, documenting the incidence and variations of the corona mortis within a South African sample will assist practitioners in avoiding the threat of corona mortis injury. These reports are key in decreasing iatrogenic injury to the corona mortis during pelvic ring and acetabular fracture repair. The current study investigated the frequency and variations of this anastomosis and the constituent vessels, which may lead to intraoperative bleeding. This knowledge will increase awareness of the vasculature intercepting anterior approaches to the pelvis [12].

2. Materials and Methods

2.1. Materials

A total of 63 adult cadavers, 34 males and 29 females, with an intact pelvis (123 hemipelves) between the ages of 22–95 years (mean age: 68, SD ± 16.66) were obtained from the Department of Anatomy, Faculty of Health Sciences, University of Pretoria. Any cadaver which presented evidence of surgery, injury or pathology to the pelvis was excluded.

Ethical clearance was obtained from the University of Pretoria, Faculty of Health Sciences Research Ethics Committee (Ethical clearance number: 259/2020) and research was conducted in accordance with the South African National Health Act 61 of 2003, Chapter 8.

2.2. Methods

With the cadaver in the supine position, a midsagittal incision was made between the umbilicus and the palpated pubic symphysis; and the anterior abdominal wall was reflected laterally towards the mid-axillary line. The small and large intestines were then resected at the junction between the sigmoid colon and the rectum for better exposure of the true pelvis. To visualise the branches of the internal iliac artery and the quadrilateral plate of the pelvic bone, the medial surface of the true pelvis was exposed by removing the peritoneal covering of the pelvis and reflecting the bladder posteriorly, away from the pubic symphysis.

The anterior division of the internal iliac artery and vein were identified, while the obturator vessels were traced to the obturator canal, accompanied by the obturator nerve. Any anastomosing vessels which communicated with the obturator artery or vein before passing through the obturator canal, were further investigated. These vessels were followed to their drainage (veins) or origin (arteries) from the external iliac vessels or its branches, in order to identify the corona mortis and document its prevalence.

In any instance where anastomosis between the obturator and accessory obturator vessels was not evident, the obturator canal was dissected further to ensure that anastomosis did not occur distally. Cases where anastomosis between the accessory obturator and obturator vessels was confirmed, were classified as a corona mortis. The incidence of the accessory obturator artery and vein and their origin or drainage pattern, respectively, were recorded. Variations in the origin and drainage of the obturator artery and vein were identified and documented, as well as variations in the anastomosing components of the corona mortis. The comparison of the prevalence of corona mortis between male and females and right and left sides were statistically analyzed using a chi-squared test.

3. Results

The current study exhibited a 67.5% (n = 83/123) incidence of corona mortis amongst the sample of 123 cadaveric hemi-pelves. Table 1 shows the respective incidences of bilateral and unilateral cases of corona mortis for both venous and arterial anastomoses.

The anastomoses consisted of communication of both arterial and venous vessels, while venous corona mortis exhibited the most variation in its anastomotic and drainage patterns. Most of the venous anastomoses consisted of communication involving an obturator vein. However, disparities in the drainage of the obturator vein were observed, with 8.1% (n = 10/123) of obturator veins draining into the external iliac vein (Fig. 1) or superior vesical vein (Table 2). This vessel was classified as an aberrant obturator vein and coursed over the superior pubic ramus, in a similar manner in comparison to the accessory obturator vein.

In two instances, an aberrant obturator vein was seen splitting into two vessels before coursing over the superior pubic ramus and draining into the external iliac vein separately. In one of these two cases, an additional aberrant obturator artery was observed to have accompanied the two aberrant obturator veins, accounting for three abnormally coursing vessels in a single hemi-pelvis (Fig. 2). However, these aberrant vessels were not considered corona mortis as they did not display signs of anastomosis between the internal and external iliac veins.

Venous anastomoses consisted of the obturator vein which communicated with either an accessory obturator vein and/or a second accessory obturator vein. The accessory obturator vein was identified as the additional obturator vessel which coursed from the entrance of the obturator canal, or the point of anastomosis before its drainage into the external iliac vein or its tributaries. The accessory obturator vein presented with an incidence of 77.2% (n = 95/123), and the second accessory obturator vein presented an incidence of 15.5% (n = 19/123). The accessory obturator vein predominantly drained into the external iliac vein in 71.6% (n = 68/95) of cases (Figs. 3–5). Although, additional variations in the 'common' drainage pattern of the accessory obturator vein, as described in literature, also occurred with 5.3% (n = 5/95) of accessory obturator veins draining into the internal iliac vein, 6.3% (n = 6/95) displayed drainage into the transverse branch of the inferior epigastric vein, and 16.8% (n = 16/95) having drained into the inferior

Table 1
The incidence of corona mortis on the left and right sides, including bilateral cases for all corona mortis cases as well as all venous and arterial cases. (***Key: CM:*** *Corona mortis)*.

Incidences	Left side	Right side	Bilateral	Overall
CM (n)	55.4% (46)	44.6% (37)	26.5% (22)	67.5% (83)
Venous CM (n)	53.9% (41)	46.1% (35)	23.7% (18)	61.8% (76)
Arterial CM (n)	71.4% (5)	28.6% (2)	–	5.7% (7)
CM in females (n)	57.1% (20)	42.9% (15)	20.0% (7)	42.2% (35)
CM in males (n)	54.2% (26)	45.8% (22)	31.3% (15)	57.8% (48)

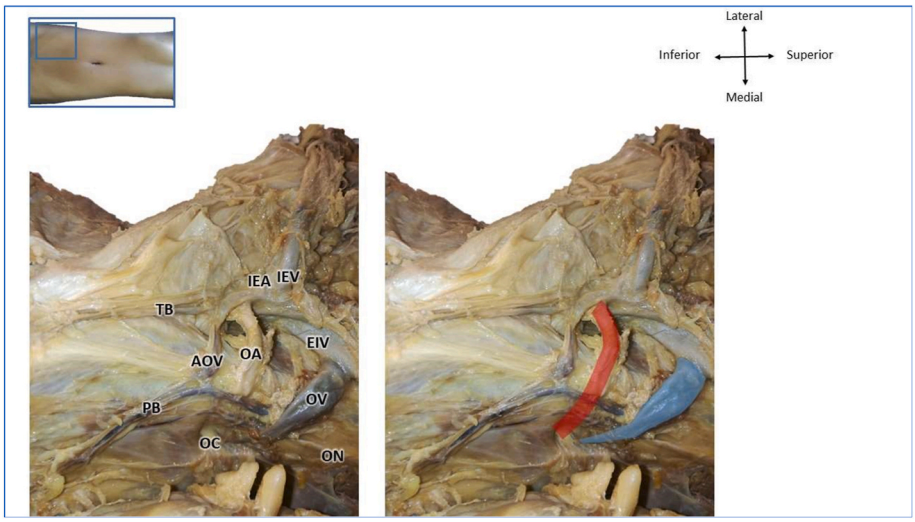

Fig. 1. Lateral view of the right pelvis showing an aberrant obturator vein (OV) which drained into the external iliac vein (EIV) as highlighted in blue and an aberrant obturator artery (OA) as highlighted in red, both of which crossed over the superior pubic ramus. ***Key***: ***PB***: *Pelvic branches,* ***AOV***: *Accessory obturator vein draining into* ***IEV***: *Inferior epigastric vein,* ***IEA***: *Inferior epigastric artery,* ***ON***: *Obturator nerve,* ***TB***: *Transverse branch draining into inferior epigastric vein,* ***OC***: *Obturator canal.* (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
The incidence of aberrant obturator arteries and obturator veins.

Aberrant vessel	Incidence (n)
Aberrant obturator artery	11.2% (32)
Aberrant obturator vein	0.08% (10)
Aberrant obturator veins draining into the external iliac vein	6.5% (8)
Aberrant obturator veins draining into the superior vesical vein	1.6% (2)
Aberrant obturator arteries originating from the inferior epigastric artery	8.9% (11)
Aberrant obturator arteries originating from the external iliac artery	17.1% (21)

epigastric vein.

Arterial corona mortis consisted of an anastomosis between the accessory obturator artery and the obturator artery and presented an incidence of 6.5% (n = 8/123). All accessory obturator arteries were observed originating from the inferior epigastric artery and communicated with an obturator artery in cases of corona mortis. Variations in the origin of the obturator artery were detected; as the obturator artery was observed originating from the external iliac or inferior epigastric artery in 26.0% (n = 32/123) of cases. These vessels were classified as aberrant obturator arteries, relative to the classification of the aberrant obturator vein which is documented in Table 2 (Figs. 1, 2, 4 and 5). In most of the arterial corona mortis cases where an accessory obturator artery was present, the obturator artery was notably smaller in diameter than usual.

Three unusual anastomotic patterns were observed which present with multiple accessory obturator veins and a unique drainage pattern thereof. The first rare variation was observed in 1.6% (3/123) of cases and included an accessory obturator vein and a second accessory obturator vein, both of which anastomosed with a single obturator vein. This resulted in two corona mortis anastomoses forming, with one lying anteriorly and the other posteriorly along the lateral pelvic wall (Fig. 3).

Another unusual pattern was observed in five cases, where the obturator vein was accompanied by a secondary obturator vein, which

Fig. 2. Lateral view of the right pelvis showing the obturator vein (OV) splitting into two vessels within the obturator canal (OC) before draining into the external iliac vein (EIV) as highlighted in blue while an aberrant obturator artery (OA) courses in between, as highlighted in red. ***Key***: ***EIA***: *External iliac artery*, ***ON***: *Obturator nerve*, ***UB***: *Urinary bladder.* (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

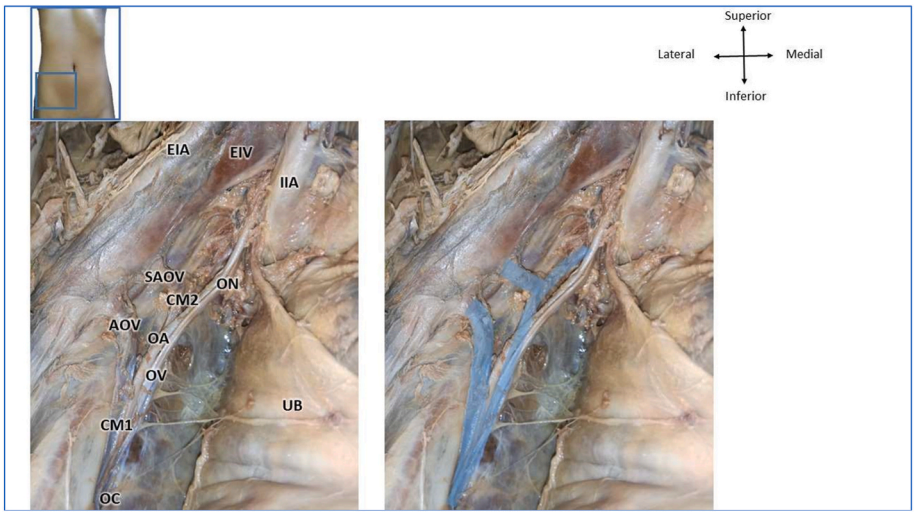

Fig. 3. Lateral view of the right pelvis displaying an accessory obturator vein (AOV) and second accessory obturator vein (SAOV) draining into the external iliac vein (EIV) and communicating with obturator vein (OV) creating two corona as highlighted in blue. ***Key***: ***CM1***: *Corona mortis one,* ***CM2***: *Corona mortis two,* ***OA***: *Obturator artery,* ***IIA***: *Internal iliac artery.* ***EIA***: *External iliac artery,* ***OC***: *Obturator canal*, ***UB***: *Urinary bladder*. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

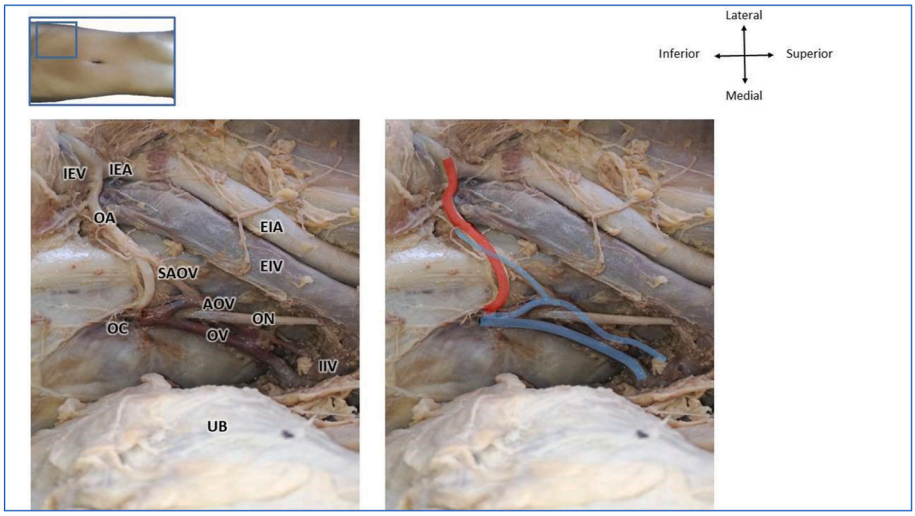

Fig. 4. Lateral view of the right pelvis showing an obturator vein (OV) and accessory obturator vein (AOV) anastomosing with each other and an additional second accessory obturator vein (SAOV) communicating with the AOV forming a corona mortis as highlighted in blue. An aberrant obturator artery (OA) is highlighted in red which originates from the inferior epigastric artery (IEA). ***Key***: ***IIV***: I*nternal iliac vein,* ***IEV***: *Inferior epigastric vein,* ***EIV***: *External iliac vein,* ***EIA:*** *External iliac artery*, ***ON***: *Obturator nerve*, ***OC***: *Obturator canal,* ***UB***: *Urinary bladder*. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

coursed parallel and lateral to the first, as they exited the obturator canal. The vessels would anastomose with each other once or twice, as the obturator artery or nerve coursed between these two vessels, before draining into the internal iliac vein separately or as a common trunk. The more lateral of the two obturator veins was noted to have contributed to the corona mortis anastomoses and was classified in the current study as an accessory obturator vein and presented with an incidence of 5.3% (n = 5/95) (Fig. 4).

The third rare case would be the anastomosis between the accessory obturator vein and the superior vesical vein over the obturator internus muscle. This formed a single case of corona mortis which did not involve an obturator vein (Fig. 5). This case was classified as a corona mortis case due to the communication between the external and internal iliac veins, despite the involvement of 'non-traditional' corona mortis components.

No statistical difference was concluded for the prevalence of corona mortis between male and female which accounted for a p-value of 0.48 with a 95% confidence interval of −0.7735–0.3638) and an incidence rate difference of −0.2049. This result was consistent with the analysis of the prevalence of corona mortis between left and right sides, with a p-value of 0.44, a 95% confidence interval of −0.4039–0.1769) and incidence rat difference of −0.1135.

4. Discussion

The prevalence and variations of the corona mortis anastomosis will assist in increasing the awareness of the anomaly and its clinical implications during orthopaedic procedures. The high rate of intercepting vessels and rare cases seen in this study exhibit how unpredictable the anastomosis and pelvic blood supply are and the significance of investigating these variations to decrease the threat of injury.

In the current study, a 67.5% (n = 83/123) incidence was observed

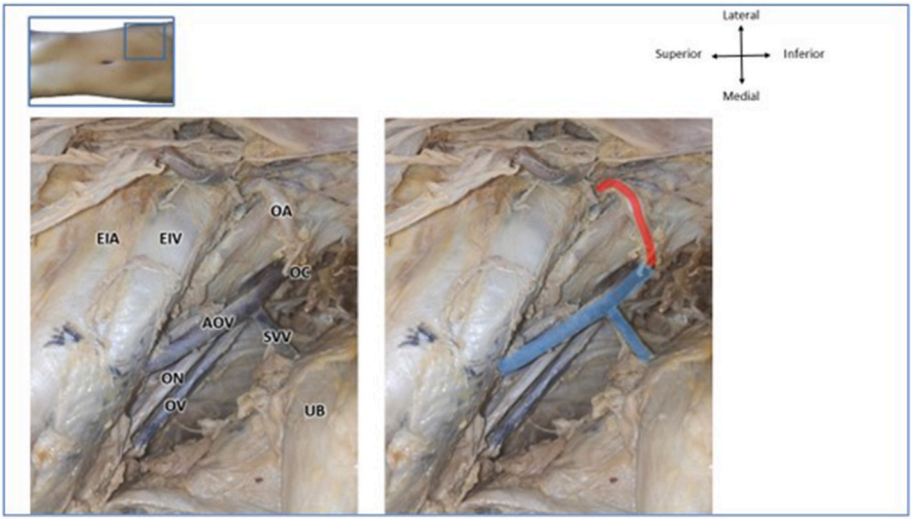

Fig. 5. Lateral view of the left pelvis showing an accessory obturator vein (AOV) anastomosing with a superior vesicle vein (SVV) before draining into the external iliac vein (EIV) as highlighted in blue and an aberrant obturator artery (OA) as highlighted in red. ***Key***: ***OV***: *Obturator vein,* ***EIA***: *External iliac artery,* ***ON:*** *Obturator nerve,* ***OC***: *Obturator canal,* ***UB***: *Urinary bladder*. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

for the presence of corona mortis anastomosis amongst 123 cadaveric hemi-pelves of a South African adult sample. These findings are analogous to the study by Okcu et al. [7] who presented a 61% (n = 91/150) incidence and Namking et al. [14] with a reported incidence of 70.6% (n = 144/204). The incidence of venous anastomoses reported by Darmanis et al. [8] and Tornetta et al. [5] consisted of 60% (n = 48/80) and 70% (n = 35/50) respectively. These findings share a similar incidence with the current study which resulted in 61.8% (n = 76/123) of the sample. Although this prevalence may correlate with previously reported incidences in Asian and European populations, a significantly high prevalence has not been previously documented in a South African population.

Previous literature has defined the corona mortis as any vessel that crowns the superior pubic ramus, posing a similar threat of injury as the traditional anastomosis between the obturator and accessory obturator vessels. This definition of the corona mortis aligns with the system of classification for these aberrant vessels in several studies [3,9,12]. In these studies, the corona mortis included aberrant obturator vessels or accessory obturator vessels regardless of their communication with obturator vessels or lack thereof. However, the current study classified corona mortis cases as any anastomoses between the internal and external iliac systems via an accessory or second accessory obturator vessel, as initially described by Letournel and Judet [1]. Obturator vessels of variant origin or drainage, specifically involving the external iliac system, were classified as aberrant obturator vessels. These varying descriptions may lead to discrepancies in the incidence of corona mortis between studies and ultimately, methods of classification.

In 91.6% (n = 76/83) of all corona mortis cases, the constituent vessels were venous, which was initially expected considering the high prevalence of venous corona mortis previously recorded compared to arterial cases as seen in Table 3. This was consistent with a study conducted by Berberoğlu et al. [6] who reported a high incidence of 100% venous constituents amongst their cadaver sample.

Previous literature has noted possible reasons for the presence of corona mortis anastomoses particularly in those samples where there is a correlation between the increased incidence of the corona mortis and increasing age [17]. Individuals of an older age are more susceptible to cardiovascular diseases such as arteriosclerosis and deep vein thrombosis which occlude vessels and create alternative circulatory routes [17]. The high incidence of corona mortis would correlate with this hypothesis as the current cadaver sample comprised mostly of senior individuals (mean age = 68).

Table 3
Incidences of venous and arterial corona mortis. (***Key: CM****: Corona Mortis*).

Author (year)	Incidence venous CM (n)	Incidence arterial CM (n)
Teague et al. [4]	59% (47)	43% (34)
Tornetta et al. [5]	70% (29)	34% (13)
Berberoğlu *et al.* (2001)	100% (14)	85.7% (12)
Okcu et al. [7]	52% (78)	19% (29)
Darmanis et al. [8]	60% (48)	36% (29)
Pillay et al. [15]	60.7% (34)	12.5% (7)
Wada et al. [16]	76.1% (88)	28.3% (32)
Current study (2024)	94.6% (76)	8.4% (7)

Even though venous corona mortis is a prevalent finding, it is discordant with the traditionally described anomaly which is typically arterial (Jastschinski, 1891). Although an artery can have more threatening implications once severed due to the higher pressure within arterial vessels, however, the retraction of the severed vein can also deter haemostasis of the vessel leading to haemorrhage [5,18]. The accessory obturator vein which resulted in an incidence of 77.2% (n = 95/123) was categorized as an additional obturator vein that drained mostly into the external iliac, or less so into the inferior epigastric vein in 16.8% (n = 16/95) of cases. This drainage pattern was commonly observed in numerous studies as seen in Table 4 below. A study by Stavrouplou-Deli and Anagnostopoulou [10] reported an incidence of 66.7% (n = 8/12) of the accessory obturator veins draining into the external iliac vein, which is closely related to findings concluded in the current study. Findings by Laccarino et al. [19] and Pillay et al. [15] had

Table 4
Incidences of accessory obturator veins draining into the external iliac vein and inferior epigastric vein.

Author (year)	Incidence draining into the external iliac vein (n)	Incidence draining into the inferior epigastric vein (n)
Rusu et al. [9]	–	3.75% (3)
Stavropoulou-Deli and Anagnostopoulou [10]	66.7% (8)	33.3% (4)
Laccarino et al. [19]	23.6% (17)	12.5% (9)
Pillay et al. [15]	42.9% (21)	20.4% (10)
Current study (2024)	71.6% (68)	16.8% (16)

the closest comparable results to the current study with regards to drainage of the accessory obturator vein into the inferior epigastric vein.

An incidence of 6.5% (n = 8/123) of accessory obturator arteries was observed in the current study, all of which originated from the inferior epigastric artery. Similarly, the origin of the accessory obturator arteries is consistent with the observations made in studies by Berberoğlu et al. [6], Rusu et al. [9], Stavropoulou-Deli and Anagnostopoulou [10], Talalwah [3], Laccarino et al. [19] and Luna [20], who reported on the origin of the accessory obturator artery as solely being the inferior epigastric artery. Corona mortis anastomoses which involve the inferior epigastric vessels, are located in close relation to the femoral ring and may therefore pose a threat during procedures within this region. One of these procedures includes femoral hernia repair, therefore, surgeons should consider the aberrant drainage or origin of accessory obturator vessels during pre-operative preparations [9].

Table 5 reports incidences of the variant origins of the obturator artery from the external iliac and inferior epigastric arteries from various authors and suggests that the inferior epigastric artery is the common source for the origin of the aberrant obturator artery [9,15,19,21]. These findings are comparable to the results of the current study. It should be noted that these aberrant obturator vessels course almost identically to the accessory obturator vessels although larger in diameter in most cases. Therefore, caution should be taken during anterior approaches to the pelvis, to inspect for an additional obturator vessel in the region of the obturator canal or the presence of these crossing vessels prior to their safe ligation to avoid impairment to the primary blood supply.

In 4.1% (n = 5/123) of cases, the obturator vein was accompanied by an additional vein coursing lateral it, as both vessels exited the obturator canal and drained into the internal iliac vein separately or as a common trunk. The more lateral of the two vessels were found to form part of the corona mortis anastomoses. This is similar to findings made by Missankov et al. [22] who described a "double obturator vein" in 37% of venous corona mortis cases. Although the frequency of the parallel vein or 'double obturator vein' was lower in the current study, the existence is corroborated by the Missankov et al. [22] study. The current study also identified rare cases of two aberrant obturator veins draining into the external iliac vein, similar to Tantchev et al. [25], who mentioned two obturator veins draining into the inferior epigastric and external iliac vein, separately. These numerous variations prove that the pelvic blood supply can be inconsistent and the incidence of these lesser-known aberrant vessels may pose a greater risk during approaches to the pelvis. Fig. 6 depicts the various deviations of the corona mortis anastomosis found in the current study. Variations include the presence of both venous and arterial anastomoses (Fig. 6a) and parallel obturator veins (Fig. 6b). Additionally, two accessory obturator veins, which in some instances created a 'double corona mortis' were also observed (Fig. 6c).

Table 5
Incidences of aberrant obturator arteries originating from the external iliac artery and inferior epigastric artery.

Author (year)	Incidence originating from the external iliac artery (n)	Incidence originating from the inferior epigastric artery (n)
Missankov et al. [22]	44% (43)	25% (24)
Mahato [23]	10% (5)	8% (4)
Rusu et al. [9]	1.3% (1)	3.8% (3)
Laccarino et al. [19]	1.4% (1)	13.9% (10)
Talalwah [3]	9.8% (20)	1.1% (2)
Leite et al. [21]	–	6.7% (4)
Pillay et al. [15]	18.2% (4)	68.2% (15)
Granite et al. [24]	5.6% (1)	33.3% (6)
Current study (2024)	8.9% (11)	17.1% (21)

In other instances, the second accessory obturator vein acted as a communicating branch between the accessory obturator and obturator veins (Fig. 6d). A single case of the corona mortis which did not incorporate an obturator vein was also noted (Fig. 6e) as well as the splitting of accessory obturator veins (Fig. 6f).

Sañudo et al. [26] theorized an ontogenetic cause for variations and anomalous anastomoses of the obturator vessel. Such causation is reported to result from the differentiation of the vessels from the primitive rete femorale and rete pelvicum. Vascular channels are established from this network and either enlarge or dissipate resulting in a variable pelvic blood supply. The embryology of the pelvic vasculature explains the high rate of variability of the blood supply and anastomoses that occur, especially amongst those vessels that originate from the internal iliac artery. A meta-analysis by Zarzecki et al. [27] discusses the variable origin and anastomoses of the middle anorectal artery and reports a rate of 78.1% of anastomoses amongst surrounding vessels. Similarly, Shafarenko et al. [28] reported an overall prevalence of 45.20% of anastomoses between the Prostate artery and adjacent vessel based on a meta-analysis involving 7421 prostate arteries.

The number of vessels observed coursing over the superior pubic ramus was much greater than anticipated or reported in previous literature. Tornetta et al. [5] noted a relatively high incidence in 84% of crossing communications over the superior pubic ramus in their study sample. However, the current study noted up to four vessels passing over the bony landmark in a single instance, consisting of both venous and arterial components. This concluded an incidence of 135.8% (n = 167/123) of crossing vessels and an average of 3 crossing vessels per cadaver (Table 6). These aberrant vessels exhibited a similar locality to the corona mortis vessels as they too cross the pelvic brim. Therefore, each of these vessels can be detrimental to the health of an individual if severed, as injury to aberrant vessels can lead to vascular spasm and potential haemorrhage.

Due to the high rate of aberrant vessels crossing the pelvic brim and the exposure of this bony landmark during anterior orthopaedic approaches to the pelvis, like the Modified Stoppa approach, the clinical implications related to the corona mortis is suspected to be significant. Jenson et al. [29] reported a mortality of 6.2% (n = 8/130) during anterior approaches as a result haemorrhage and further sourced the cause of such cases of bleeding to a pelvic or cancellous bone origin. It was concluded that the risk associated with the presence of the corona mortis is minimal and of little concern to surgeons when approaching the pelvic region, as it is a controllable anomaly that can be readily amended if damaged [29]. Darmanis et al. [8] noted the lack of correlation between the presence of the corona mortis and cases of haemorrhage during pelvis surgery. This can be explained due to the level of experience of a surgeon and their susceptibility to the anomaly. Although, extreme caution should be taken when dealing with the anastomosis especially in trauma cases as the spasm of the vessel wall may lead to the source of bleeding going undetected [4,7,8].

5. Limitations

Anastomoses that occurred distal to the obturator canal could not be followed as it would disturb the intra-pelvic blood supply and additional observations occurring in the region. Therefore, this may affect the prevalence of corona mortis reported in the current study. Some vessels were compromised due to previous dissectors working in the same area which may cause disturbances in the pelvic blood supply or associated structures.

6. Conclusion

We can conclude that the incidence of the corona mortis within the South African population based on the sample resulted in 67.5% (n = 83/123). There was a high number of variations amongst venous anastomosis and the presence of vessels crossing the pelvic brim was higher

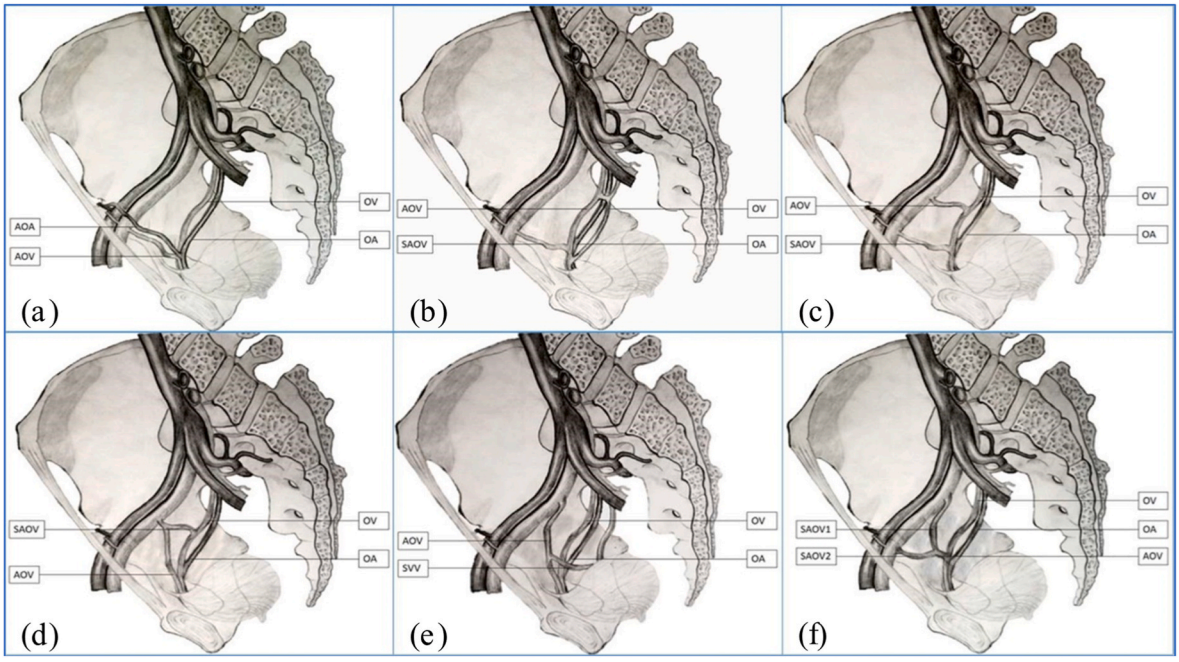

Fig. 6. (a): Normal arterial and venous corona mortis between accessory obturator and obturator vessels, (b): venous corona mortis variation consisting of two obturator veins, (c): double venous corona mortis variation consisting of two accessory obturator veins, (d): venous corona mortis variation consisting of a connecting branch, (e): venous corona mortis consisting of the superior vesicle vein instead of the obturator vein, (f): venous corona mortis variation consisting of a split accessory obturator vein. ***Key: AOA:*** *Accessory obturator artery,* ***AOV:*** *Accessory obturator vein,* ***OV:*** *Obturator vein,* ***OA:*** *Obturator artery,* ***SAOV:*** *Second accessory obturator vein,* ***SVV:*** *Superior vesicle vein.*

Table 6
The incidence of crossing vessels that coursed over the superior pubic ramus.

Crossing vessels	n (Total = 167)	Incidence
Obturator artery	32	26.0%
Accessory obturator artery	8	6.5%
Obturator vein	5	4.1%
Accessory obturator vein	88	71.5%
Second accessory obturator vein	15	17.7%
Venous pelvic branches	18	12.2%
Arterial pelvic branches	1	0.8%

than expected. Therefore, further investigation needs to occur on the clinical implication of these vessels and how to avoid them during anterior approaches to the pelvis.

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CRediT authorship contribution statement

Jade Naicker: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Zithulele Nkosinathi Tshabalala:** Writing – review & editing, Supervision. **Andries Masenge:** Formal analysis. **Obakeng Modisane:** Writing – review & editing. **Steven Matshidza:** Validation, Supervision, Investigation, Data curation, Conceptualization. **Nkhensani Mogale:** Writing – review & editing, Validation, Supervision, Methodology, Investigation.

Declaration of Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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