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The prevalence and variation patterns of corona mortis: A fresh cadaveric study

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Abstract

Corona mortis (CM) is an anastomotic vessel that crosses behind the superior pubic ramus. The presence of the anastomoses is not persistent and has many variations of patterns, and locations. The aim of this study was to provide prevalence and the anatomical details of CM. This study was performed on fresh cadavers. The number and patterns of CM were recorded, consisting of the lengths, diameters, and distances, which were measured from anatomical landmarks of interest. Sixty-eight hemipelvises were studied. The CM were found in 24 (35.29%) hemipelvises. The arterial corona mortis (ACM) presented in 10 hemipelvises. Seven ACM were the anastomoses between the external iliac artery (EIA) and the obturator artery (OA), 4 were OA, which originated from EIA or the inferior epigastric artery (IEA). The venous corona mortis (VCM) was found in 13 (19.12%) hemipelvis. Eleven VCM were anastomoses between external iliac vein (EIV) and obturator vein (OV), 3 were OV drained to EIV or inferior epigastric vein (IEV), and in 4 (5.8%), the hemipelvises had multiple CM. The mean diameters, lengths, and distances from the symphysis of CM were 2.98, 33, and 45 mm, respectively. In this study, the Prevalence of CM was 35.29%. Twenty-eight percent of CM were aberrant obturator vessels, which originated from external iliac system. Six percent of hemipelvis had 2 or more anastomoses. During surgery, great care should be taken to identify all vessels traversing behind the superior pubic ramus in the retropubic space in order to prevent catastrophic hemorrhage.

Keywords: Aberrant obturator vessels, Acetabulum fracture, CM, Ilioinguinal approach, Pelvic injury

1. Introduction

Corona mortis (CM) is the vascular connection between the obturator system and the external iliac system [1] behind the superior pubic ramus in the retropubic space. This communicating vessel has been named as Corona mortis or 'Crown of Death' because significant hemorrhage can occur if the anastomoses have been torn from injury or during the operation in the retropubic space [2].

Although CM has been defined as the anastomosis between the external iliac artery (EIA) and the obturator artery (OA), several studies have shown a high variation in prevalence, patterns, and locations. The prevalence of CM ranges from 28-96% [3,4] and can be arterial, venous, or both arterial and venous communications. From the study by Rusu MC, et al [5], the vascular anastomoses behind superior pubic ramus can be divided into 3 groups as follows (Figure 1).

However, there have been some reports of another variation of CM [6,7]. Kawai K, et al. [8] found and reported IEA arising from the OA as a terminal branch of the internal iliac artery. Therefore, having knowledge of anatomy will aid in defining the location and type of CM to avoid complications and to improve surgical outcomes in the retropubic space.

The aim of this study was to identify prevalence, locations, and patterns of CM in fresh cadavers.

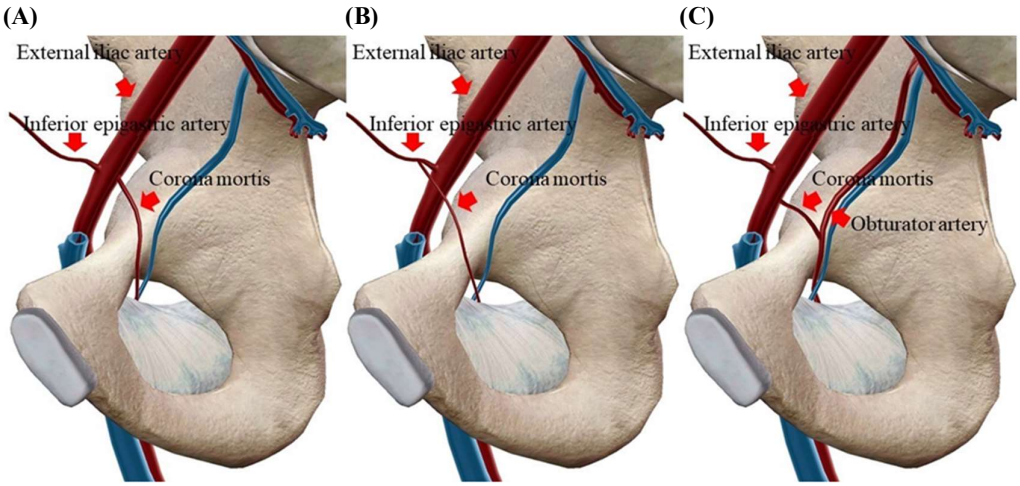

Figure 1 Morphological variations of corona mortis; (A) The obturator vessel originates from or drains to the external iliac vessel, (B) The obturator vessel originates from or drains to the inferior epigastric vessel, and (C) The vessel connects between the obturator and the external iliac vessel based on [5].

2. Materials and methods

The present study was conducted on fresh adult cadavers. The dissections of the hemipelvises were performed by using medial and middle window of the ilioinguinal approach on each side of the hemipelvises to access the retropubic space. The external oblique aponeurosis was incised from the anterior superior iliac spine (ASIS) to the lateral border of rectus abdominis muscle proximal to the external inguinal ring to expose the inguinal ligament. The inguinal ligament was incised from the ASIS to the pubic tubercle. The medial window was performed by splitting the linea alba. The rectus abdominis muscle bellies were laterally retracted. The anatomical landmarks of interest were identified, including the pubic symphysis, the pubic tubercle, and the medial edge of rectus abdominis muscle as the lateral border of the medial window. The middle window of the ilioinguinal approach was performed by identifying the space between the psoas muscle laterally and the femoral artery medially. The dissection was performed down to the pelvic brim by releasing the iliopectineal fascia from the iliopectineal eminence. The femoral artery was identified as the medial border of the middle window of the ilioinguinal approach.

All vessels, which were located on the posterior surface of superior pubic ramus, were preserved. The vascular connections between the obturator system and the external iliac system were identified and recorded. Patterns of vascular connections were recorded and classified according to Rusu MC, et al [5]. classification. The diameters and lengths of the connecting vessels were measured by using vernier calipers (reading error: 0.02 mm/resolution: 0.01 mm). The distances from the connecting vessels to the anatomical landmarks of interest were recorded.

Descriptive data was presented in means and SD's. The Chi-square test was used to compare the nominal data. The T test was used to compare the continuous data. The level of significance was set at a $p< 0.05$. The Spearman's Rho was used to measure the strength of association between two variables.

3. Results

This study was performed on 34 adult fresh cadavers (20 males and 14 females) with 68 hemipelvises. The mean age of the cadavers was 71 years old.

The CM was present in 24 (35.29%) hemipelvises. There were multiple vascular connections in 4 (5.8%) hemipelvises. Three of the hemipelvises had 2 the venous corona mortis (VCM) and one hemipelvis had 1 the arterial corona mortis (ACM) and 2 VCM. The prevalence of CM in the cadavers was 58.82%, while 47.05 % of the cadavers had had unilateral CM and 11.76% had bilateral CM. The prevalence of CM in females (55%) was found to be higher than males (27%). This denotes a statistically significant difference between the genders.

The ACM presented in 11 (16.17%) hemipelvises. The most common pattern was an anastomosis between OA and EIA (7 hemipelvises). There was OA that had originated from EIA in 2 hemipelvises, and OA that had originated from the inferior epigastric artery (IEA) in 2 hemipelvises. The average diameters and lengths of the ACM were 2.73 and 30.55 mm, respectively. The distance from ACM to the anatomical landmarks of interest shown in table 1.

Table 1 Anatomical data of ACM.

Arterial corona mortis	Mean ±SD (range) (mm)
Diameter	2.73±1.13 (1.25-4.4)
Length	30.55±10.92 (12.3-43.05)
Distance from pubic symphysis	46.81±8.51 (33.3-62.25)
Distance from pubic tubercle	37.55±8.09 (29-56.3)
Distance from lateral border of medial window of ilioinguinal approach	27.32±6.04 (18.45-35.75)
Distance from medial border of middle window of ilioinguinal approach	28.06±9.18 (14.15-41.15)

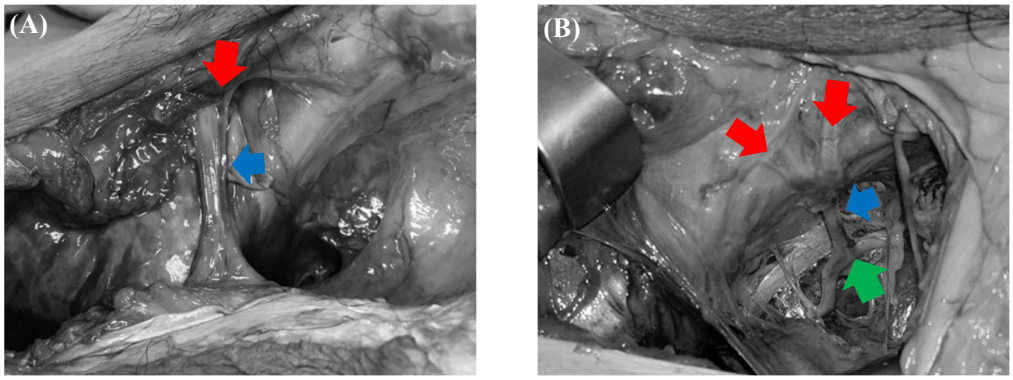

Figure 2 (A) The ACM (red arrow) connected between EIA (blue arrow) and OA, and (B) the ACM (blue arrow) connected between two branches of vessel from the EIA (blue arrow) and the OA (green arrow).

The ACM was identified in 8 right hemipelvises (Figure 2). The average diameters and lengths of the ACM in the right hemipelvises were 2.8 and 29.25 mm. The average distances from the ACM to the pubic symphysis, the pubic tubercle, the lateral border of the medial window, and the medial border of the middle window of the ilioinguinal approach were 47.35, 36.5, 26.4, and 27.85 mm, respectively. The ACM presented in 3 left hemipelvises. The average diameters and lengths of the ACM in the left hemipelvises were 2.55 and 34 mm. The average distances from the ACM to the pubic symphysis, the pubic tubercle, the lateral border of the medial window and the medial border of the middle window of the ilioinguinal approach were 45.4, 40.3, 29.8 and 28.6 mm, respectively. There were no significant statistical differences in the sizes, lengths, or distances from the CM to the anatomical landmarks of interest between the ACM in the right and left hemipelvises.

The VCM was identified in 14 (20.58%) of hemipelvises, which was higher than the prevalence of ACM. Eleven VCM were vascular anastomoses between OV and external iliac vein (EIV). It was found that OV had drained to EIV in 2 hemipelvises and that OV had drained to IEV in 1 hemipelvis. The average diameters and lengths of the VCM were 3.16 and 34.74 mm, respectively. The distance from VCM to the anatomical landmarks of interest shown in table 2

Table 2 Anatomical data of VCM.

Venous corona mortis	Mean ±SD (range) (mm)
Diameter	3.16±1.05 (1.15-4.9)
Length	34.74±10.48 (20.45-65.3)
Distance from pubic symphysis	44.04±10.55 (31-73.3)
Distance from pubic tubercle	37±9.85 (24.3-59.45)
Distance from lateral border of medial window of ilioinguinal approach	31.9±8.07 (20-49.45)
Distance from medial border of middle window of ilioinguinal approach	26.48±14.08 (3.1-59.4)

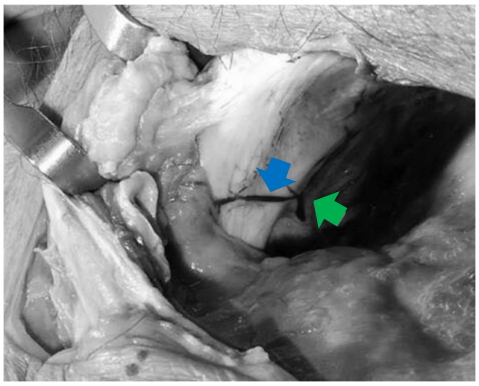

Figure 3 The small VCM (blue arrow) connected between the EIV and the OV (green arrow).

The VCM was identified in 9 right hemipelvises (Figure 3). The average diameters and lengths of the ACM in the right hemipelvises were 3.3 and 32.4 mm (Figure 4). The average distance from the ACM to the pubic symphysis, the pubic tubercle, the lateral border of the medial window, and the medial border of the middle window of the ilioinguinal approach were 43, 37.3, 34.2, and 27.5 mm, respectively. The ACM presented in 5 left hemipelvises. The average diameters and lengths of the ACM in the left hemipelvises were 2.7 and 39.85 mm. The average distance from the ACM to the pubic symphysis, the pubic tubercle, the lateral border of the medial window, and the medial border of the middle window of the ilioinguinal approach were 46.3, 36.3, 25.8, and 24.3 mm, respectively. There were no significant statistical differences between the sizes, lengths, and distances from the CM to the anatomical landmarks of interest between the ACM in the right and left hemipelvises. No correlation between the presence of ACM and VCM was found.

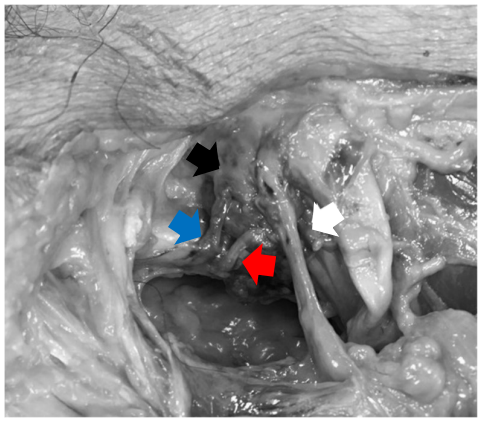

Figure 4 The ACM (red arrow) from the EIV (white arrow) and the VCM (blue arrow) from the EIV (black arrow) in single hemipelvis.

4. Discussion

The injury to the CM can occur after pelvic injuries, especially in cases of superior pubic ramus fractures. Gómez GJ, et al. [9] reported that ACM avulsion can cause severe hemorrhage that needs embolization in patients with stable pubic ramus fractures. Broek T, et al. [10] also reported 4 cases of elderly patients, who had had massive hemorrhages following pubic ramus fractures. The iatrogenic injury of CM during operations in the retropubic space is another possible cause of severe hemorrhage. Larsson PG, et al [11] and Gobrecht U, et al. [12] reported about patients with severe hemorrhages, who were in shock after operations had been performed in the retropubic space and noted that surgical revision had been required to stop the bleeding. From the original description in Gray's Anatomy, the CM is abnormal anastomosis between obturator and external iliac vascular system and can be either an arterial or a venous connection. However, there is still some controversy about its definition. Some authors [5] have stated that any form of anastomosis that is present between the internal iliac system and external iliac system, which traverses behind the superior pubic ramus, is CM due to the fact that there is a similar risk of bleeding if damaged. Meanwhile, others have argued that it is only the anastomosis of the obturator vessel and inferior epigastric vessel [13]. Therefore, having anatomical knowledge of these

anastomoses is necessary in order to avoid iatrogenic vascular complications in the surgical procedure in the retropubic space.

From the literature review, the prevalence of CM is variously reported. The lowest prevalence of CM was reported by Deli Sa, et al [3] at 29% of the hemipelvises. Moreover, it was found to be as high as 96% as reported in a study of Berberoglu et al. [4] In our study, the CM was present in 35.29% of hemipelvises, which was comparable to most studies. The prevalence of ACM was reported to have ranged from 8 to 65 % of hemipelvises. The VCM presented more frequently from 14 to 96%. In this study, the prevalence of VCM was 20.58%, which was higher than 16.17% of ACM. Kashyap S, et al. [14] showed that the prevalence of ACM had been 8.3%, while the prevalence of VCM had been 58.3%. In the cadaveric study by Du MM, et al [15], the results showed a similar prevalence of ACM and VCM at 31.25% and 56.25%, respectively. These results were consistent with our observations. The multiple CM presented in a far less frequent range from 8-15 % compared to our study at 5.8%. The prevalence of corona mortis from other studies were summarized in table 3.

Table 3 Prevalence of CM reported in the literature.

Type of study	Hemipelvises (n)	CM (%)	ACM (%)	VCM (%)	Reference
Cadaver	79	73	43	59	[16]
Cadaver	100	42	34	70	[17]
Cadaver	12	50	--		[18]
Cadaver	14	-	-	96	[4]
Angiogram	98	-	29		[13]
Opearation	142	40	22	27	[19]
Cadaver	54	-	-	20.40	[2]
Cadaver	150	61	19	52	[20]
Cadaver	50	72	34	-	[21]
Cadaver	66	77.30	-	-	[22]
Cadaver	204	76	22.50	70.60	[23]
Cadaver	80	83	36	60	[1]
Cadaver	560	-	21.60	-	[8]
Ct angiogram	100	-	29	-	[24]
Cadaver	50	62	-	40	[25]
Cadaver	40	80	65	55	[5]
Cadaver	10	40	-	-	[26]
Cadaver	70	28.57	11.42	14.28	[3]
Operation	50	52	8	48	[27]
Cadaver	20	-	60	80	[28]
Operation	391	-	28.40	-	[29]
Cadaver	22	-	22.72	-	[30]
Ct angiogram	200	-	33	-	[31]
Ct angiogram	660	-	14.1	51.10	[32]
Cadaver	60	-	45	-	[33]
Cadaver	48	83.58	12.50	60.70	[34]
Ct angiogram	300	-	30	-	[35]
Cadaver	24	79.20	8.30	58.30	[14]
Cadaver	16	75	18.75	43.75	[15]
Cadaver	68	35.29	16.17	20.58	Present study

The presence of CM is very important when performing surgery in the retropubic space. The surgical treatment of the anterior ring of pelvis or anterior column of acetabulum fracture commonly uses the ilioinguinal or modified Stoppa approach to access the retropubic space. It has been recommended that when performing operations in this area, surgeons need to identify the location of the CM before beginning bony work in order to prevent uncontrollable hemorrhage, which can take place when the vessel is ruptured. In the case of rupture, it can retract back through the obturator foramen, which can make it difficult to find and can result in a life-threatening situation. However, the anatomical patterns of CM are highly varied. A study from Talalwah WA, et al. [6] showed that in 1.1% of population, the OA arose from the femoral artery and passed over the superior pubic ramus. Pinochet J, et al. [7] noted that the vein emerged from the obturator foramen and connected to EIV without having an OV connection. From our study, most of vascular traversing posterior to superior pubic ramus had been anastomoses between external iliac and obturator system (72%). However, 28 % of vessels were aberrant obturator vessels that had not connected to internal iliac system, but had originated from external iliac or inferior epigastric vessel. Because these aberrant OA had supplied blood to the obturator externus, pectineus, adductors, and gracilis muscles, the ligation of this type of vessel should be done with caution. Our result was

different from the study of Rusu MC, et al. [5], in which it was found that the aberrant obturator vessel had been found in 50% of vessels, which were located behind the superior pubic ramus.

The distance between the bony landmark and the CM will guide surgeons to identify this anastomosis for the sake of surgical safety. The average distances from the CM to the pubic symphysis and the pubic tubercle were 45.17 and 37.22 mm, respectively. The distance from the anatomical landmark in our study was also consistent with previous reports that the distance from the CM to the pubic symphysis almost always exceeds 30 mm. While the shortest average distances from the CM to the pubic symphysis was reported by Karakurt L, et al [13] at 33.4 mm Surgeons can perform dissections in this surgical safety limit without risk of vascular injury. In cases of the pubic symphysis fracture or dislocation, the bony landmark may be distorted from the displaced fragment. The distance from the border of the surgical approach may be used to identify the location of the CM. The medial window of the ilioinguinal approach is normally used to access the pubic symphysis, pubic ramus, and the quadrilateral surface. The lateral border of this window is the insertion of the rectus abdominis muscle at pubic crest. The average distance from this point to CM was 29.86 mm. The middle window of ilioinguinal approach was used to access the pelvic brim, the quadrilateral surface, and the sacroiliac joint. The average distance from the medial border of middle window to the CM was 27.12 mm.

The average diameter and length of the ACM from our study was 2.73 and 30.55 mm, respectively. The VCM diameter and length were 3.16 and 34.74 mm. Because the VCM was larger and longer, it would be more susceptible to injury. A bleeding vein would be difficult to cauterize or ligate because of its fragile vascular wall. The ACM could also cause severe hemorrhage, especially when it arises from EIA due to high pressure and rapid blood flow. To prevent catastrophic bleeding, we recommend identifying and ligating any vessel on the posterior surface of the superior pubic ramus.

The strength of our study arises from the fact that the study was performed with fresh cadavers and that the characteristics of the studied vessels were close to the situations found in clinical practice. However, the weakness of this study stems from the fact that the mean age of cadavers was slightly high and that abnormal vessels, such as those with arterial atherosclerosis or venous thrombosis were frequently found, and there were more collateral branches of the vascular system.

5. Conclusion

In our study, the prevalence of CM was 35.29%. The prevalence of VCM was higher than ACM. The most common pattern of CM was the anastomosis between the external iliac and the obturator system (72%). Most of the hemipelvises had only one anastomosis per side. Only 5.8% of them had 2 or more anastomosis. It is important to note that great care should be taken to identify all vessels traversing behind the superior pubic ramus during the surgery in the retropubic space so that catastrophic hemorrhage can be prevented.

6. Ethical approval

The study protocol was approved by the Khon Kaen university ethics committee for human research, Faculty of Medicine, Khon Kaen University,Thailand (HE591360).

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