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The Anatomical Characteristics of Corona Mortis: A Systematic Review of the Literature and Its Clinical Importance in Hernia Repair

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Abstract

Background: Inguinal hernia repair is one of the most common daily operations in general surgery. However, the anatomical structures of the region, such as the corona mortis (the crown of death), make this procedure quite challenging. A comprehensive knowledge of its anatomy is essential, since massive hemorrhage may occur if the vessel is injured. The current review of the literature aimed to report the frequency and anatomical variations of vascular corona mortis.

Methods: A substantial study was coordinated through PubMed, Scopus and Google Scholar. The Prisma guidelines were used for the systematic review of the articles found. A total of 13 studies and 1,455 patients were included for the statistical analysis.

Results: The results showed that corona mortis was present in about half the hemi-pelvises, and to be more accurate, the prevalence was 46%. Venous corona mortis was more frequent than the arterial type (42% vs. 25%).

Conclusions: Considering the percentages mentioned above, every surgeon who schedules an operation on the retro-pubic area, especially during a hernioplasty procedure, should evaluate the possibility of the presence of corona mortis. Anatomical knowledge of the region is vital for attempting to eliminate the risk of injuring the corona mortis during surgery.

Keywords: Corona mortis; Inguinal hernia; Hemorrhage; Anatomical variations

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Introduction

The corona mortis (CMOR), also known as the "crown of death", is a horrifying name that serves to represent the high risk of hemorrhage that may occur if this anatomical variant is injured and the difficulty of achieving hemostasis. CMOR is the vascular anastomosis between the obturator and external iliac or inferior epigastric vessels (Fig. 1); this connection is usually regarded as arterial, but it may be venous or both venous and arterial [1-7]. It has been found that, sometimes, an enlarged pubic branch of the inferior epigastric artery that descends into the obturator foramen may replace the obturator artery, and an enlarged pubic vein that joins the iliac vein may replace the obturator vein [8, 9]. Most of the studies included in the current meta-analysis identify the presence of an arterial CMOR; in those in which venous CMOR is recognized, the incidence of venous anatomical variation is higher. These divergent vessels cross the superior pubic ramus, making them prone to injury during a laparoscopic hernia repair or the placement of a mesh during open surgery.

Materials and Methods

Search method

A comprehensive search was administered through the PubMed, Scopus and Google Scholar search engines to identify the number of articles that met the inclusion criteria for analysis. The search terms that were used were as follows: CMOR, crown of death, hernia, complications, hemorrhage and anatomical variations. No review protocol existed. The references of all the included articles were searched to identify if any further relevant articles existed. For the analysis, we included only original articles written in English during the last 15 years. Case reports, conference abstracts, letters to the editor and studies reporting incomplete or irrelevant data were excluded from the study. Any differences of opinion among the authors were solved through consultation. The authors followed the Prisma guidelines for the analysis, which was conducted by two separate reviewers independently, and the reviewers were also responsible for the extraction of the data. The data included the origin of the patients, gender and CMOR prevalence (arterial, venous or both)

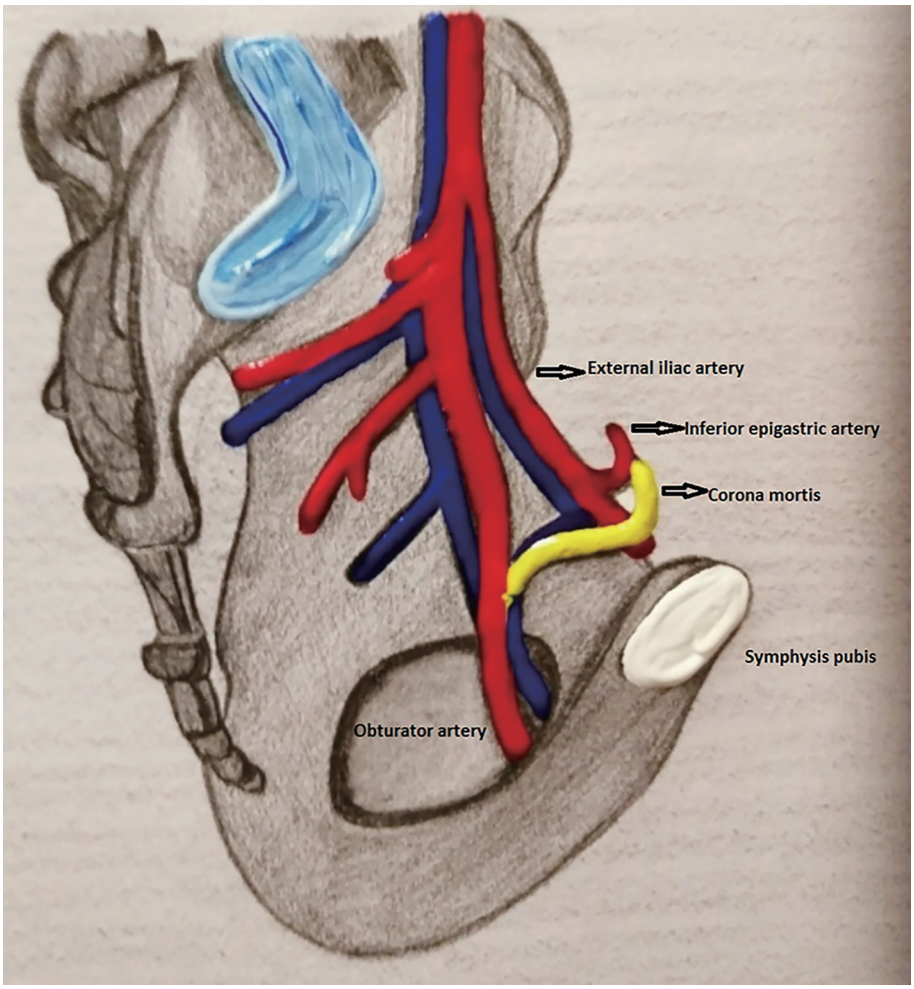

Figure 1. Drawing demonstrating corona mortis which connects the obturator with the inferior epigastric vessels (created by Eva Filo).

and location (right, left or bilateral). Further statistical consultation was conducted if there was any disparity regarding the data.

Statistical analysis

The pooled data were examined for heterogeneity using the random effects model, more specifically, MetaXL 5.3, the freely available software for meta-analysis in Microsoft Excel. The pooled prevalence and Cochran's Q test were estimated to identify heterogeneity among studies. If the confidence intervals (CIs) of the pooled prevalence estimate (PPE) overlapped poorly, this was strong evidence of statistical heterogeneity. The I^2 statistics (Higgins statistics) were also calculated, describing the percentage of the variability in effect estimates that was due to heterogeneity rather than sampling error.

Results

After an extensive search of the databases, a total of 465 records were identified. Of those, 451 articles did not meet the inclusion criteria or were duplicates, and 14 full-text articles were assessed for eligibility. Finally, 13 articles were included in the qualitative and quantitative synthesis, and one study was excluded due to statistical issues (Fig. 2). Most of the included studies, a total of nine, were performed on cadavers; of the others, two reported radiological results and two dealt with intraoperative findings (Table 1) [3, 6-8, 10-18].

A total of 1,455 hemi-pelvises were assessed for the statistical analysis; the PPE for the full sample was 0.46 (95% CI: 0.34 - 0.58), as shown in Table 2. In terms of the geographical distribution, the PPE of the sample from the America's was 45.66 (95% CI: 26.04 - 65.96), which was close to the total result, while a higher result was found in Europe, at 53.79 (95% CI: 22.55 - 83.67), and a lower one in Asia, at 41.52 (95% CI: 23.95 - 60.20).

There was no difference in the PPE regarding the presence of CMOR on the sides of the hemi-pelvises (right vs. left), while the PPE for bilateral presence was half of the previous values, at 0.08 (95% CI: 0.09 - 0.22; Table 2). In all the above

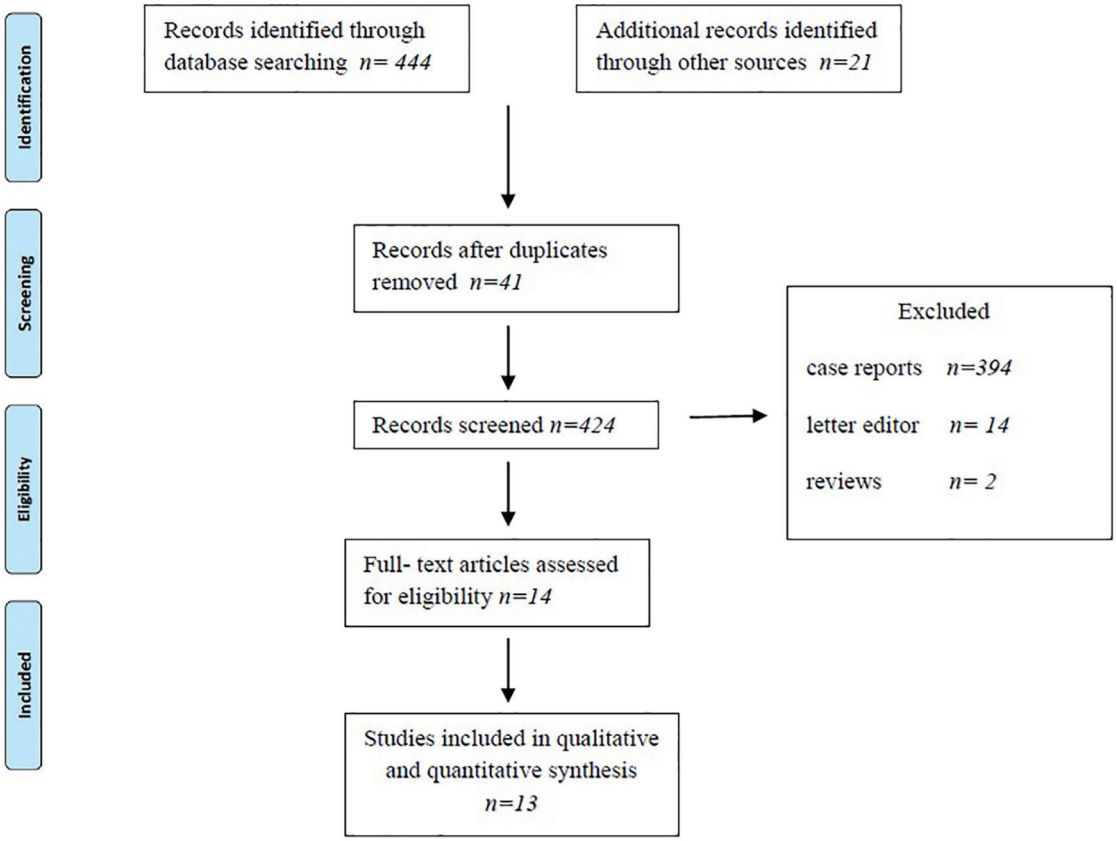

Figure 2. Flow diagram of included studies according to Prisma guidelines.

cases, according to the Higgins I^2 statistics, the heterogeneity was quite high, except in the results from the imaging, where the relatively small sample size suggested that more studies should be conducted to generate more reliable conclusions

Table 1. The Included Studies, Their Country of Origin, Type of Study and Prevalence of CMOR

Study	Country	Type of study	No. of patients	No. of hemi-pelvises	Reported CMOR prevalence (%)
Stavropoulou-Deli and Anagnostopoulou, 2013 [11]	Greece	Cadaveric	35	70	20 (28.5%)
Rusu et al, 2010 [7]	Romania	Cadaveric	20	40	32 (80%)
Smith et al, 2009 [12]	USA	Imaging	50	100	29 (29%)
Leite et al, 2017 [13]	Brazil	Cadaveric	60	60	27 (45%)
Okcu et al, 2009 [3]	Turkey	Cadaveric	75	150	91 (61%)
Nayak et al, 2016 [14]	India	Cadaveric	73	73	37 (51%)
Steinberg et al, 2017 [15]	Israel	Imaging	100	200	66 (33%)
Talalwah, 2016 [16]	Saudi Arabia	Cadaveric	104	208	21 (10%)
Ates et al, 2015 [10]	Turkey	Intraoperative	321	398	113 (28.4%)
Baena et al, 2015 [17]	Colombia	Cadaveric	14	28	22 (78.6%)
Pillay et al, 2017 [18]	India	Cadaveric	24	48	37 (77.08%)
Pellegrino et al, 2015 [6]	Italy	Intraoperative	25	50	26 (52%)
Drewes et al, 2005 [8]	USA	Cadaveric	15	30	10 (33.3%)

CMOR: corona mortis.

Table 2. The Total PPE and the Statistical Heterogeneity (Higgins I^2 Statistics) of CMOR as Well as the PPE and I^2 According to the Continent, the Type of Study and the Location of CMOR

Category	No. of studies (no. of hemi-pelvises)	PPE (95% CI)	I^2 (95% CI)	P value
Overall	13 (1,455)	45.55 (33.62 - 57.73)	94.99 (92.93 - 96.44)	0.000
Europe	3 (160)	53.79 (22.55 - 83.67)	93.17 (83.39 - 97.19)	0.000
Asia	6 (1,077)	41.52 (23.95 - 60.20)	97.03 (95.35 - 98.11)	0.000
America	4 (218)	45.66 (26.04 - 65.96)	87.47 (70.12 - 94.75)	0.000
Imaging	2 (300)	31.71 (26.57 - 37.10)	0 (0 - 0)	0.493
Intraoperative	2 (448)	38.41 (16.20 - 63.22)	90.51 (65.69 - 97.38)	0.002
Cadavericor cadavers	9 (707)	50.90 (30.75 - 70.91)	96.27 (94.54 - 97.46)	0.000
Left-sided	4 (443)	14.96 (9.23 - 21.76)	68.65 (9.25 - 89.17)	0.023
Right-sided	4 (443)	15.83 (7.39 - 26.52)	85.71 (64.91 - 94.18)	0.000
Bilateral	4 (443)	7.91 (5.57 - 10.62)	0 (0 - 43.49)	0.846

PPE: pooled prevalence estimate; CMOR: corona mortis; CI: confidence interval.

(Figs. 3-5).

Discussion

The presence of CMOR can complicate fractures in the pubic ramus, as well as several surgical procedures. The open or laparoscopic technique is used, and inguinal hernia repair - one of the most common operations in general surgery daily practice - belongs to these operations. The high prevalence of CMOR in the population makes it clinically important. The exact definition of CMOR remains controversial until today. First, in their study, Damanis et al stated that there are three anatomical structures that cross the pubic ramus on its posterior area, namely, an artery or a vein and an aberrant obturator artery [19]. Today, most anatomical textbooks support that CMOR is an anastomotic vessel between the obturator and external iliac or inferior epigastric vessels. There are also some authors suggesting that CMOR is a clinical rather than anatomical structure [10]. Rusu and co-authors have categorized the venous CMOR into three types based on the drainage arrangement of the obturator vein [7]. It is type I when it drains to the external iliac vein, type II when draining into the inferior epigastric vein and type III when the obturator vein and inferior epigastric vein anastomose.

The goal of our review was determining the true prevalence of CMOR among the population, as well as its variations and anatomical characteristics, to diminish the possibility of iatrogenic perforation or cross-section of the vessel during hernia repair. When CMOR is present, it can be damaged during the laparoscopic procedure from the tacks used during the fixation of the mesh into the Cooper's ligament. This can cause severe bleeding, which is difficult to control and often results in conversion to open surgery or retroperitoneal hematoma and

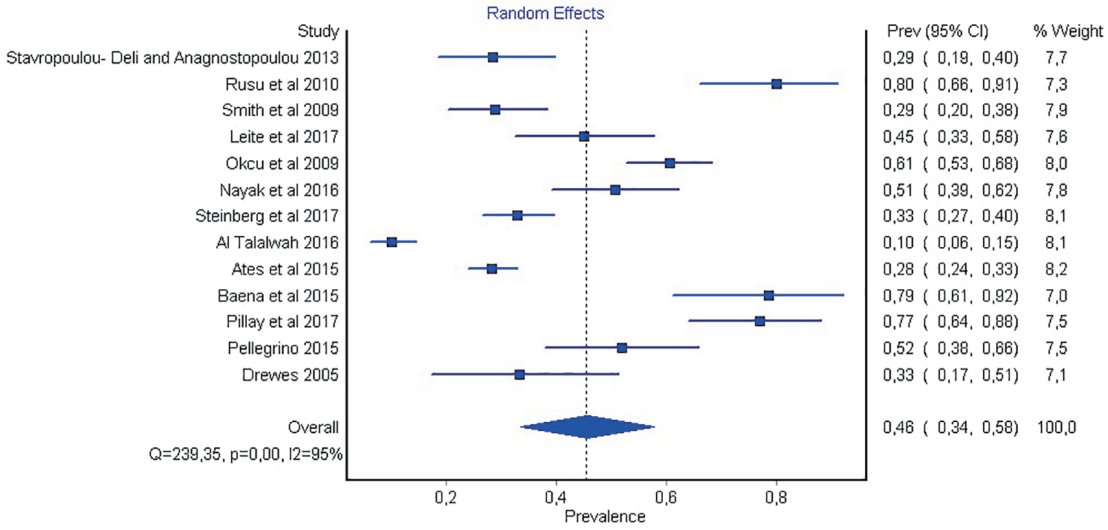

Figure 3. Forest plot of the total prevalence of corona mortis.

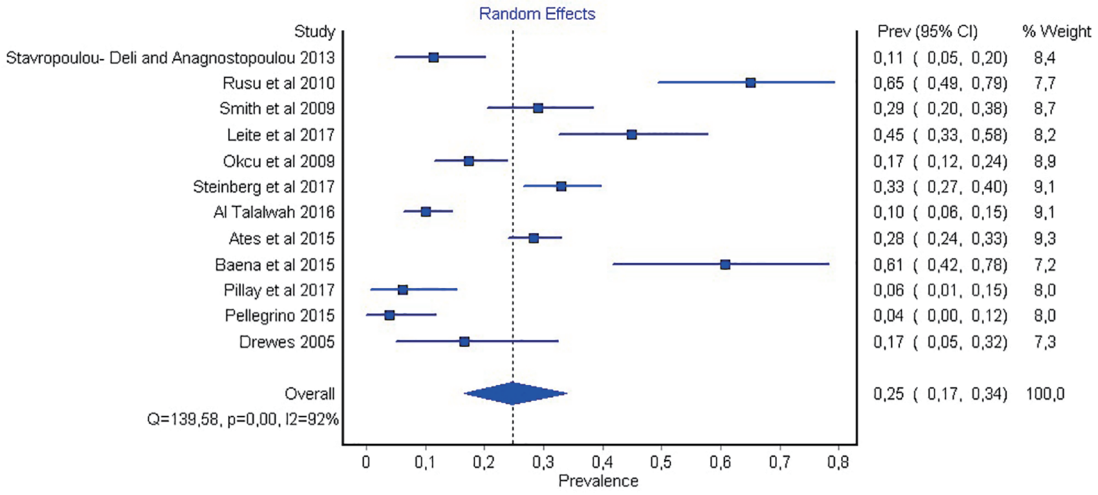

Figure 4. Forest plot of the prevalence of an arterial only corona mortis.

reoperation. In addition, surgeons should be aware that injury of the artery can cause greater hemodynamic instability and hemorrhage, but venous CMOR is more difficult to diagnose and control. Beyond the anatomic variations of CMOR, another issue is the distance of the vessel from the pubis symphysis. Karakurt et al first reported that the distance can be 21.4 - 41 mm; however, most authors have concluded that the distance almost always exceeds 30 mm [20-23]. In addition, the diameter of the vessel is most often more than 3 mm and cannot be easily ignored, because in conventional surgery, vessels of a diameter less than 2 mm can be missed [11, 24].

In our study, the overall prevalence of CMOR in the population was relatively high, and more specifically, it was found in half of all the hemi-pelvises, with a predominance of 46%. Venous CMOR was more frequent than arterial CMOR was (42% vs. 25%). The heterogeneity of the studies included was not enough to extract safe results regarding the location of the vessel (left vs. right hemi-pelvis), as well as the presence of both the artery and vein. CMOR was more prevalent in patients from Europe than those from Asia (48.75% vs. 34.09%); concerning the patients from America, the PPE was very close to the overall one (Table 2).

Regarding the type of studies included into the study, the deviation of the PPE from the overall value was high for the cadaveric and low for the intraoperative and imaging (Table 2).

The main limitation of our analysis was the heterogeneity among the studies, which probably arose due to the anatomical differences among the continents regarding the development of the vascular system. In addition, most of the studies were performed on cadavers, possibly because the researchers had the advantage of three-dimensional vision and direct examination by hand without the risk of hemorrhage. To properly compare cadaveric with intraoperative or imaging studies, more of the latter are necessary. However, the large sample sizes included in our analysis and the statistical methods employed represent the strengths of this research. From a statistical point of view, it is necessary to organize and conduct large multicenter studies based mainly on living subjects, confined to one continent to reduce heterogeneity and bias.

In conclusion, our main results revealed that CMOR was present in nearly half the population, and it is more common

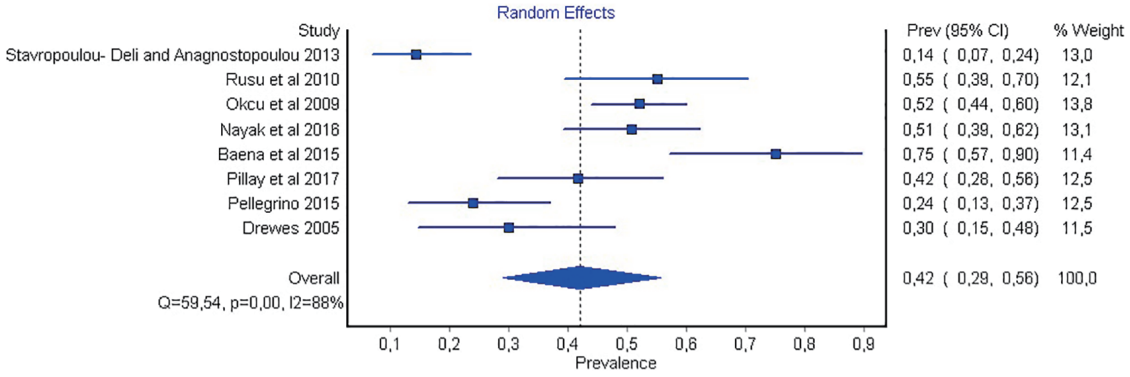

Figure 5. Forest plot of the prevalence of a venous only corona mortis.

in patients from Europe than from Asia, with the venous being more frequent than the arterial type. Considering its prevalence and anatomical variations, the CMOR, or crown of death, should be recognized during the hernia repair and treated with the respect the name indicates.

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There was no funding for this study.

Conflict of Interest

All authors declare that they have no conflict of interest.

Informed Consent

Not applicable.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Anastasios Katsourakis and Sergios Konstantinidis. The first draft of the manuscript was written by George Noussios and Anastasios Katsourakis, and all the authors commented on previous versions. All the authors approved the final manuscript.

Data Availability

The authors declare that data supporting the findings of this study are available within the article.

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