Research Article

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Morphometric study of Assessment of Coronary Ostia in human cadavers by dissection method: A Morphometric Study

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ABSTRACT

Background: The coronary ostia are the primary gateways for blood supply to the myocardium. Variations in their number, location, and morphometry are clinically significant, influencing the approach and success of invasive cardiac procedures like coronary angiography and aortic valve surgery. Precise cadaveric data from specific populations are essential to supplement angiographic findings.

Materials and Methods: This descriptive cross-sectional study was conducted on 38 formalin-fixed adult human hearts (24 male, 14 female) obtained during routine dissection. The hearts were meticulously dissected to expose the ascending aorta and locate the coronary ostia. The number of ostia, their anatomic position relative to the sinotubular junction (STJ) and aortic valve cusps, their shape, and their transverse diameter were recorded using a digital vernier calliper.

Results: The classic two-ostia pattern (left and right) was observed in 86.8% (33/38) of specimens. Multiple ostia were present in 13.2% (5/38), with three specimens having an additional right coronary ostium and two having a separate posterior aortic sinus ostium. The left coronary ostium (LCO) was predominantly located within the sinus of Valsalva (92.1%), while the right coronary ostium (RCO) was more frequently found at the sinotubular junction (57.9%). The mean transverse diameter of the LCO (3.82 ± 0.51 mm) was significantly larger ($p < 0.05$) than that of the RCO (3.21 ± 0.48 mm). Oval was the most common shape for both ostia (LCO: 63.2%, RCO: 55.3%).

Conclusion: This study confirms the high prevalence of the classic bilateral coronary ostia pattern but also highlights a significant incidence of anatomic variations. The LCO is typically larger and situated lower within the sinus than the RCO. These morphometric data are crucial for clinicians to minimize iatrogenic injuries and improve the safety and efficacy of coronary interventions.

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INTRODUCTION

The human heart, a relentless muscular pump, is itself dependent on a robust and precisely orchestrated blood supply delivered by the coronary circulation. This system originates at the coronary ostia, the primary gateways situated within the aortic sinuses (sinuses of Valsalva) at the root of the ascending aorta. These ostia are the sole inlets for oxygenated blood to perfuse the vast network of coronary arteries, making their patency, location, and morphology fundamental to cardiac function and survival [1].

The classic anatomical textbook description posits a configuration of two ostia: the left coronary ostium (LCO), emerging from the left posterior (or left coronary) aortic sinus, and the right coronary ostium (RCO), originating from the anterior (or right coronary) aortic sinus [2]. This seemingly simple arrangement, however, belies a significant potential for variation. The development of the coronary arteries is a complex embryological process involving the ingrowth and remodeling of vascular plexuses from the epicardium and the subsequent formation of connections with the aortic sinuses [3]. It is during this intricate process that deviations can occur, leading to anomalies in the number, location, shape, and size of the coronary ostia [4].

These variations are far more than academic curiosities; they hold profound and direct clinical implications. In the realm of interventional cardiology, coronary angiography is a cornerstone procedure for diagnosing and treating coronary artery disease. An anomalous ostium—whether it be an abnormally high take-off, a separate accessory ostium, or a slit-like configuration—can pose significant challenges to catheter engagement, leading to prolonged procedure times, failed cannulation, misdiagnosis, or even iatrogenic dissection of the aortic root [5, 6]. Furthermore, the rise of transcatheter aortic valve implantation (TAVI) has brought these anatomical nuances into sharper focus, as the prosthesis deployment can potentially occlude or impinge upon a coronay ostium, particularly if it is situated unusually low [7].

In cardiac surgery, the stakes are equally high. During aortic valve replacement, especially with a stentless bioprosthesis or an aortic homograft, and during root replacement procedures (e.g., the Bentall procedure), the surgeon must meticulously identify and often reimplant the coronary ostia. An inaccurate understanding of their precise location relative to the sinotubular junction (STJ) and the valve commissures can result in kinking, torsion, or excessive tension on the coronary arteries, precipitating catastrophic peri-operative myocardial infarction [8, 9]. Similarly, during coronary artery bypass grafting (CABG), an anomalous ostium can complicate the creation of a proximal anastomosis or the interpretation of graft function.

While modern imaging modalities like multidetector computed tomography (MDCT) and angiography provide dynamic, in-vivo data, they have inherent limitations in precisely defining the ostial relation to the STJ and accurately characterizing its exact shape and circumferential anatomy [10]. Cadaveric dissection remains the indispensable gold standard for obtaining detailed, three-dimensional, and tactile morphometric data, allowing for direct measurement and observation without the constraints of flow dynamics or radiation exposure [11].

Numerous morphometric studies on coronary ostia have been conducted globally, revealing population-specific trends and variations [12, 13]. However, anatomical norms can exhibit regional and ethnic variations, and a continuous influx of data from diverse populations is necessary to refine our understanding of human anatomical diversity. This study, therefore, aims to conduct a comprehensive morphometric analysis of the coronary ostia in a sample of 38 human cadaveric hearts. Our objectives are to meticulously document the number, anatomic location, shape, and transverse diameter of the coronary ostia. The findings from this investigation are anticipated to provide a valuable anatomical database that will be of paramount importance to anatomists, interventional cardiologists, and cardiothoracic surgeons, ultimately contributing to enhanced procedural safety and efficacy.

MATERIALS AND METHODS

Research Design

This study employed a descriptive cross-sectional research design. The morphometric parameters of the coronary ostia were observed and measured at a single point in time in a sample of cadaveric hearts. The study was conducted in the Department of Anatomy at [Institution Name]. The target population for this study consisted of all formalin-fixed adult human hearts available in the department's cadaveric collection.

Inclusion and Exclusion Criteria for Sample Selection

- **Inclusion Criteria:**
    1. Formalin-fixed adult human hearts (age > 18 years at the time of death).
    2. Hearts with intact aortic root and clearly identifiable aortic sinuses.
    3. Specimens without any prior dissection that damaged the region of interest.
- **Exclusion Criteria:**
    1. Hearts with obvious congenital malformations (e.g., septal defects, transposition).
    2. Hearts showing severe atherosclerosis, calcification, or aneurysmal dilation at the aortic root that could distort ostial anatomy.
    3. Hearts with evidence of trauma or surgical intervention in the aortic or coronary regions.

Sample Size Calculation

Due to the descriptive and morphometric nature of this anatomical study and the finite number of available specimens meeting the inclusion criteria, a convenience sampling method was employed. The final sample size was determined to be 38 hearts, which is considered adequate for providing preliminary descriptive data and is comparable to sample sizes in similar previously published morphometric studies. A formal power calculation, typically used for hypothesis-testing studies, was not applicable.

Procedure for Data Collection

1. **Specimen Preparation:** Thirty-eight formalin-fixed human hearts were selected based on the inclusion and exclusion criteria.
2. **Dissection:** The ascending aorta was carefully opened using a longitudinal incision from the arch proceeding downwards towards the aortic valve, taking extreme care to avoid the sinuses of Valsalva.
3. **Exposure and Identification:** The aortic valve cusps and the prominent ridge of the sinotubular junction (STJ) were clearly identified.
4. **Morphometric Assessment:**

- The number of ostia present in the aortic root was recorded.
- The location of the center of each primary ostium was determined relative to the STJ.
- The shape of each ostium was visually assessed and categorized.
- The transverse diameter of each primary ostium was measured using a digital vernier caliper (Mitutoyo, Japan; precision 0.01 mm). Two measurements were taken for each ostium by a single observer to ensure consistency, and the average was recorded in a pre-designed proforma.

Data Analysis

All morphometric data were systematically recorded in a pre-designed data collection sheet. This data was subsequently transferred to a Microsoft Excel spreadsheet (Microsoft Corp., USA) for organization and preliminary calculations. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean, standard deviation, frequency, percentage) were calculated. An independent samples t-test was used to compare the mean diameters of the LCO and RCO, with a p-value < 0.05 considered statistically significant.

RESULTS

The distribution of the number of coronary ostia is summarized in Table 1. The classic anatomical pattern of two coronary ostia was observed in the vast majority of specimens, accounting for 33 out of 38 hearts (86.8%). Conversely, multiple ostia, defined as more than two, were present in 5 specimens, constituting 13.2% of the sample. **(Table 1)**

A detailed breakdown of these variations, provided in Table 2, shows that the most frequent anomaly was the presence of two distinct right coronary ostia, found in 3 hearts (7.9% of the total sample). Furthermore, 2 specimens (5.3%) exhibited a separate third ostium in the posterior aortic sinus, representing the independent origin of the conus artery**. (Table 2)**

The anatomical position of the primary ostia relative to the sinotubular junction (STJ) revealed a distinct differential pattern between the left and right sides, as detailed in Table 3. The Left Coronary Ostium (LCO) was predominantly located within the sinus of Valsalva, below the STJ, in 35 specimens (92.1%). The remaining 3 LCOs (7.9%) were situated at the level of the STJ, with none found above it. In contrast, the Right Coronary Ostium (RCO) was most frequently located precisely at the sinotubular junction, observed in 22 hearts (57.9%). Only 14 RCOs (36.8%) were found below the STJ, and a notable 2 specimens (5.3%) exhibited a high take-off, with the RCO located above the STJ in the tubular ascending aorta. **(Table 3)**

The morphological configuration of the ostial orifices was categorized, and the results are presented in Table 4. The oval shape was the most common morphology for both the Left and Right Coronary Ostia. It was observed in 24 LCOs (63.2%) and 21 RCOs (55.3%). The circular shape was the second most prevalent, found in 10 LCOs (26.3%) and 12 RCOs (31.6%). A slit-like configuration was the least common, identified in 4 LCOs (10.5%) and 5 RCOs (13.1%). **(Table 4)**

The transverse diameters of the primary coronary ostia were measured, and the descriptive statistics are reported in Table 5. The mean transverse diameter of the Left Coronary Ostium was 3.82 ± 0.51 mm, with a range from 2.8 mm to 4.9 mm. The mean diameter for the Right Coronary Ostium was 3.21 ± 0.48 mm, with a range from 2.3 mm to 4.1 mm. Statistical comparison using an independent samples t-test confirmed that the Left Coronary Ostium was significantly larger in diameter than the Right Coronary Ostium ($p < 0.001$). **(Table 5)**

Table 1: Distribution of the Number of Coronary Ostia

Number of Ostia	**Frequency (n)**	**Percentage (%)**
Two (Classic)	33	86.8%
Multiple (>2)	5	13.2%
Total	**38**	**100.0**

Table 2: Detailed Breakdown of Specimens with Multiple Ostia

Variation Type	**Frequency (n)**	**Percentage of Total Sample (%)**
Two Right Coronary Ostia	3	7.9%
Separate Posterior Sinus Ostium	2	5.3%
Total with Variations	**5**	**13.2%**

Table 3: Location of the Primary Coronary Ostia Relative to the Sinotubular Junction (STJ)

Ostium	Below STJ (Within Sinus)	At the STJ	Above STJ
Left Coronary Ostium (LCO)	35 (92.1%)	3 (7.9%)	0 (0%)
Right Coronary Ostium (RCO)	14 (36.8%)	22 (57.9%)	2 (5.3%)

Table 4: Shape Distribution of the Primary Coronary Ostia

Ostium	Circular	Oval	Slit-like
Left Coronary Ostium (LCO)	10 (26.3%)	24 (63.2%)	4 (10.5%)
Right Coronary Ostium (RCO)	12 (31.6%)	21 (55.3%)	5 (13.1%)

Table 5: Transverse Diameter of the Primary Coronary Ostia (in mm)

Ostium	Mean ± Standard Deviation	Range (Min - Max)
Left Coronary Ostium (LCO)	3.82 ± 0.51 mm	2.8 - 4.9 mm
Right Coronary Ostium (RCO)	3.21 ± 0.48 mm	2.3 - 4.1 mm

DISCUSSION

This morphometric study provides a detailed analysis of the coronary ostia in 38 human cadaveric hearts, revealing key anatomical patterns and significant variations that are of considerable clinical importance. The findings affirm several established anatomical norms while also highlighting the prevalence of variations that demand clinical vigilance.

The discovery that the classic two-ostia pattern was present in 86.8% of our specimens serves as a fundamental benchmark and is consistent with the findings of larger anatomical studies. For instance, a comprehensive study by **Saremi et al. (2008)** using CT angiography reported a similar incidence of the standard pattern, noting variations in approximately 10-15% of cases [9]. The 13.2% incidence of multiple ostia in our series, primarily represented by accessory right coronary ostia (7.9%), aligns with this range. These accessory ostia, often supplying the conus artery, are a well-documented variant. Their clinical significance is paramount during coronary angiography, as they can be easily overlooked or be challenging to cannulate selectively, potentially leading to an incomplete diagnostic assessment or missed pathology in the conus branch [5].

Perhaps one of the most clinically salient findings of this study is the distinct difference in the location of the left and right coronary ostia. Our data clearly demonstrate that the LCO is consistently situated deep within the sinus of Valsalva (92.1%), a position that may offer some protection during catheter manipulation. In stark contrast, the RCO was most frequently found at the delicate sinotubular junction (57.9%), with two cases (5.3%) observed above it. This higher take-off of the RCO has been consistently observed in other morphological studies. **Cavalcanti et al. (2003)**, in their cadaveric study, also reported a higher frequency of the RCO being located at or near the STJ compared to the LCO [10]. This anatomical predisposition makes the RCO particularly vulnerable to iatrogenic injury during surgical procedures such as aortic root replacement or the placement of an aortic cross-clamp, where a misplaced suture can easily compromise the ostium, leading to catastrophic myocardial ischemia [6, 8].

The morphological assessment revealed that the oval shape was the most common configuration for both ostia. This non-circular shape has implications for coronary blood flow dynamics, potentially creating flow vortices that may influence shear stress and endothelial function. The smaller, but statistically significant, diameter of the RCO (3.21 mm) compared to the LCO (3.82 mm) is a consistent finding in anatomical literature and reflects the typically larger myocardial territory and flow demands supplied by the left coronary system [1, 10]. This size discrepancy is a critical consideration for interventional cardiologists when selecting guide catheters and for cardiac surgeons when creating anastomoses during coronary artery bypass surgery, as the smaller ostial size may necessitate more delicate techniques to avoid trauma or restenosis.

Limitations

It is important to acknowledge the limitations of this study. The sample size of 38, while adequate for a descriptive morphometric analysis, may limit the generalizability of the exact prevalence rates for rarer variations. Furthermore, the use of formalin-fixed tissues, a standard in anatomical studies, may introduce some degree of tissue shrinkage, potentially affecting the absolute diameter measurements. However, the comparative relationship between the LCO and RCO is likely preserved.

CONCLUSION

In conclusion, this study reinforces that while the classic two-ostia pattern is the norm, a significant minority of the population possesses anatomical variations that can profoundly impact clinical procedures. The consistent finding of a higher and more variable RCO location, coupled with its smaller diameter, underscores its status as a potential anatomical "hotspot" for complications. These findings provide an essential anatomical framework that can enhance the pre-procedural planning of cardiologists and surgeons, ultimately contributing to improved patient safety and procedural success in diagnostic and therapeutic cardiac interventions.

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