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Study on Variations in the Branching Pattern of Coronary Arteries in Adult Human Cadavers

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Abstract
Understanding the variations in coronary artery anatomy is crucial for effective diagnosis and treatment in cardiology and cardiac surgery. Variations can impact surgical outcomes and diagnostic accuracy, necessitating a thorough investigation of these anatomical differences. This study aims to investigate the branching patterns and lengths of the coronary arteries in adult human cadavers, focusing on identifying variations and anomalies. A total of 35 human cadaveric hearts were dissected and examined. The origins, lengths, and branching patterns of the Right Coronary Artery (RCA) and Left Coronary Artery (LCA) were documented. Statistical analysis was conducted to determine the prevalence and significance of observed variations. Variations were observed in 5 out of 35 hearts (14.29%). Trifurcation of the LCA was noted in 4 hearts (11.43%), and left coronary dominance was observed in 1 heart (2.86%). An abnormal RCA length of 18.6 cm was found in 1 heart (2.86%). The RCA consistently arose from the anterior aortic sinus, and the LCA from the left posterior aortic sinus. The RCA length ranged from 6.5-13 cm in 34 hearts (97%), with an average length of 9.76±2.114 cm. The LCA length varied from 3-12 mm, with an average length of 6.8±2.069 mm. The LAD terminated at the apex in 71% of hearts and in the posterior interventricular groove in 29% of hearts. This study highlights significant variations in the coronary artery anatomy, which are essential for improving surgical and diagnostic practices in cardiology. Understanding these variations can lead to better clinical outcomes and patient care.

INTRODUCTION

The coronary arteries play a critical role in supplying oxygenated blood to the heart muscle and any variations in their anatomy can have significant clinical implications[1]. A comprehensive understanding of these variations is essential for cardiologists, cardiac surgeons, and radiologists in diagnosing and managing cardiovascular diseases[2,3]. While the standard branching pattern of the coronary arteries is well documented, anatomical variations can pose challenges during surgical interventions and diagnostic procedures[4].

The Right Coronary Artery (RCA) typically originates from the anterior aortic sinus and the Left Coronary Artery (LCA) from the left posterior aortic sinus[5]. The LCA usually bifurcates into the left anterior descending (LAD) and the circumflex arteries. However, variations such as trifurcation, the dominance of the coronary artery system and anomalies in the length and course of these arteries can occur[6]. These variations can influence the presentation of coronary artery disease and impact the success of interventions like coronary artery bypass grafting (CABG) and per cutaneous coronary intervention[7] (PCI).

Despite the clinical importance, there is limited comprehensive data on the prevalence and types of coronary artery variations in different populations. This study aims to investigate the branching patterns and lengths of the coronary arteries in adult human cadavers. By identifying and categorizing these variations, the study seeks to enhance the understanding of coronary anatomy, which can aid in better planning and execution of cardiovascular procedures.

The Objectives of this Study Include:

- Identifying variations in the branching patterns of the LCA
- Determining the prevalence of left coronary dominance
- Measuring the lengths of the RCA and LCA and identifying any anomalies
- Examining the origin and course of the conus artery and the posterior interventricular artery (PIVA)

MATERIAL AND METHODS

Study Design: This observative descriptive study was conducted after receiving approval from the Scientific Committee and Institutional Ethics Committee of Sri Venkateswara Medical College, Tirupati.

Study Duration: The study was carried out over a period of one year from the date of approval from the university.

Sample Size: A total of 35 adult human hearts were procured from the Department of Anatomy at Sri Venkateswara Medical College, Tirupati.

Inclusion Criteria:

- Adult human hearts preserved in formalin (10%)

Exclusion Criteria:

- Hearts with an inability to trace the origin of coronary arteries
- Macerated hearts

Preparation and Dissection: The selected adult human hearts, preserved in 10% formalin, were dissected to expose the coronary arteries.

Gross dissection was performed through the fibro-fatty tissue to reveal the coronary arteries from their origin at the root of the ascending aorta.

Tracing and Measurement: The Left Coronary Artery (LCA) and the Right Coronary Artery (RCA) were traced from their origins to their terminations.

The first segment lengths of both coronary arteries were measured using a thread, measuring tape and a standard scale.

Recording Observations: Branches arising from the RCA and LCA were observed and recorded.

The lengths of the LCA, RCA and Left Anterior Descending (LAD) artery were documented.

These measurements were compared with data from similar studies to identify variations and anomalies.

Statistical Analysis: Data collected were analyzed to determine the prevalence and types of coronary artery variations. Statistical methods were applied to calculate mean lengths and standard deviations for the RCA, LCA and LAD arteries, providing a comparative analysis with other studies.

Ethical Considerations: Institutional Ethics committee approval for this study was obtained from the Scientific Committee and Institutional Ethics Committee of Sri Venkateswara Medical College, Tirupati, ensuring adherence to ethical research standards.

RESULTS AND DISCUSSIONS

Coronary Artery Variations: Out of the 35 human cadaveric hearts studied, 5 hearts (14.29%) exhibited variations in the branching patterns of the coronary arteries. Specifically, trifurcation of the Left Coronary Artery (LCA) was observed in 4 hearts (11.43%), left coronary dominance in 1 heart (2.86%) and an abnormal length of the Right Coronary Artery (RCA) measuring 18.6 cm was found in 1 heart (2.86%).

Origin and Course of Coronary Arteries: In all 35 hearts, the RCA arose from the Anterior Aortic Sinus (AAS) and the LCA arose from the Left Posterior Aortic Sinus (LPAS).

Length Measurements: The length of the RCA varied between 6.5-13 cm in 34 hearts (97%), with one heart (3%) exhibiting an RCA length of 18.6 cm. The average length of the RCA was 9.76 cm, with a standard deviation of 2.114 cm, resulting in a mean length of 9.76±2.114 cm.

The length of the LCA varied between 3-12 mm across all hearts. The average length of the LCA was 6.8 mm, with a standard deviation of 2.069 mm, resulting in a mean length of 6.8±2.069 mm.

The length of the Left Anterior Descending (LAD) artery ranged broadly, with an average length of 108.4 mm and a standard deviation of 34 mm, resulting in a mean length of 108.4±34 mm.

Branching Patterns: The LCA showed bifurcation in 31 hearts (88.57%) and trifurcation in 4 hearts (11.43%). Tetra furcation was not observed in any of the hearts.

Conus Artery Origin: In all 35 hearts, the conus artery arose as a branch from the RCA with no anomalies noted.

Posterior Interventricular Artery (PIVA) Origin: The PIVA arose from the RCA in 34 hearts (97%) and from the LCA in 1 heart (3%), indicating left coronary dominance in the latter.

Termination of Left Anterior Descending (LAD) Artery: The LAD terminated at the apex in 25 hearts (71%) and in the posterior interventricular groove in 10 hearts (29%).

The anatomical variations in coronary arteries are critical for clinical practices, particularly in cardiology and cardiovascular surgery. This study, conducted on 35 adult human cadaveric hearts, aimed to elucidate the prevalence and types of these variations, which are essential for improving diagnostic accuracy and surgical outcomes.

Key Findings: The study revealed that 14.29% of the hearts exhibited variations in the coronary artery branching patterns. Specifically, trifurcation of the Left Coronary Artery (LCA) was observed in 11.43% of the specimens, left coronary dominance in 2.86%, and an abnormal Right Coronary Artery (RCA) length of 18.6 cm in one heart (2.86%). These findings align with other studies, suggesting that while variations are not exceedingly common, they are significant enough to warrant consideration during clinical assessments[8,9].

Comparison with Previous Studies: The observed trifurcation rate of 11.43% for the LCA is comparable to the rates reported in other anatomical studies. For instance, a study by Roy S (2014) reported a similar

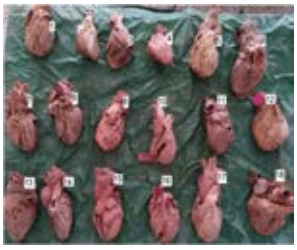

Fig. 1: Image Showing the Dissected Hearts (1-18)

Fig. 2: Image Showing the Dissected Hearts (19-34)

Fig. 3: Image Showing the Origin of RCA from AAS

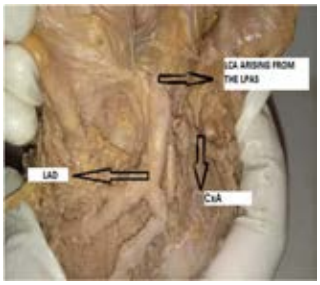

Fig. 4: Image showing Origin of LCA from LPAS and Bifurcation of LCA into LAD and CxA

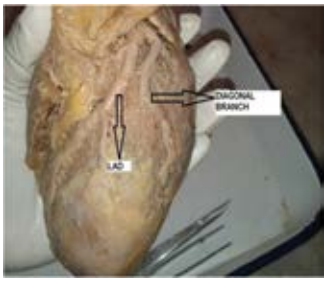

Fig. 5 : Sterno costal Surface of Heart showing LAD and Diagonal Branch

Table 1: Coronary Artery Variations

Variation Type	Frequency	Percentage (%)
Trifurcation of LCA	4	11.43
Left Coronary Dominance	1	2.86
Abnormal Length of RCA (18.6 cm)	1	2.86

Table 2: Origin and Course of Coronary Arteries

Parameter	Origin Site	Frequency	Percentage (%)
RCA Origin	Anterior Aortic Sinus (AAS)	35	100
LCA Origin	Left Posterior Aortic Sinus (LPAS)	35	100

Table 3: RCA Length Measurements

Length (cm)	Frequency	Percentage (%)
6.5-13	34	97
18.6	1	3
Mean Length±SD	9.76±2.114	

Table 4: LCA Length Measurements

Length (mm)	Frequency	Percentage (%)
3 - 12	35	100
Mean Length ± SD	6.8 ± 2.069	

Table 5: Left Anterior Descending (LAD) Artery Length Measurements

Length (mm)	Mean Length ± SD
LAD Length	108.4 ± 34

Table 6: Branching Patterns of LCA

Branching Pattern	Frequency	Percentage (%)
Bifurcation	31	88.57
Trifurcation	4	11.43
Tetra furcation	0	0

Table 7: Conus Artery Origin

Parameter	Origin Site	Frequency	Percentage (%)
Conus Artery	Right Coronary Artery (RCA)	35	100

Table 8: Posterior Interventricular Artery (PIVA) Origin

Origin Site	Frequency	Percentage (%)
RCA	34	97
LCA	1	3

Table 9: Termination of Left Anterior Descending (LAD) Artery

Termination Site	Frequency	Percentage (%)
Apex	25	71
Posterior Interventricular Groove	10	29

prevalence of LCA trifurcation. Left coronary dominance, found in 2.86% of the specimens, is within the range of previously reported values, although there is some variability in the literature due to differences in sample sizes and populations[10,11].

The length of the RCA varied between 6.5-13 cm in 97% of the specimens, with an average length of 9.76±2.114 cm. The one outlier, with an RCA length of 18.6 cm, underscores the importance of being aware of such anomalies, which can affect the approach to coronary artery bypass grafting (CABG) and other interventions. The average LCA length of 6.8±2.069 mm and the LAD length of 108.4±34 mm are consistent with established anatomical data, further validating the reliability of this study's measurements.

Clinical Implications: Understanding these variations is crucial for cardiologists and cardiac surgeons. For instance, the presence of a trifurcated LCA may necessitate modifications in surgical techniques during CABG. Similarly, recognizing left coronary dominance is important for accurate diagnosis and treatment planning in coronary artery disease. The abnormal RCA length found in one specimen highlights the need for careful preoperative imaging and planning.

Limitations and Future Directions: This study is limited by its sample size of 35 hearts, which, while sufficient for identifying common variations, may not capture the full spectrum of anatomical differences. Additionally, the study is based on cadaveric hearts preserved in formalin, which may differ slightly from in vivo conditions.

Future research should focus on larger, more diverse populations to further elucidate the prevalence of coronary artery variations. Advanced imaging techniques, such as coronary computed tomography angiography (CCTA), can provide more detailed insights into these variations in living patients. Furthermore, studies correlating these anatomical findings with clinical outcomes can enhance our understanding of the implications of coronary artery variations in cardiovascular health.

CONCLUSION

This study provides valuable knowledge into the anatomical variations of coronary arteries in adult human cadavers. The findings highlights the

importance of recognizing these variations to improve clinical outcomes in cardiology and cardiovascular surgery. By enhancing our understanding of coronary artery anatomy, we can better anticipate and address the challenges posed by these variations in clinical practice.

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