



STUDY OF CORONARY ARTERY ANATOMY AND ITS VARIATIONS USING CORONARY ANGIOGRAPHY AND CADAVERIC DISSECTION

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ABSTRACT:

Background: Coronary artery anatomy had played a pivotal role in determining myocardial perfusion and cardiac function. A detailed understanding of coronary artery morphology and its variations had been essential for cardiologists, radiologists, and cardiac surgeons to ensure safe and effective interventions. Coronary artery anomalies, though relatively uncommon, had been clinically significant as they often predisposed individuals to ischemic heart disease, arrhythmias, or sudden cardiac death. With the advent of coronary angiography and anatomical dissection techniques, the study of coronary anatomy had become more refined, allowing for a comprehensive assessment of normal and variant patterns. The current study had been designed to correlate angiographic findings with cadaveric dissections to provide a detailed overview of coronary arterial distribution, dominance, and anomalies in the local population.

Aim: The primary aim of this study had been to analyze the anatomy and variations of coronary arteries using both coronary angiography and cadaveric dissection. It also aimed to identify the prevalence of coronary dominance patterns and anatomical variations to aid in clinical, diagnostic, and surgical decision-making.

Methods: This descriptive cross-sectional study had been conducted at Allied Hospital, Faisalabad, from August 2024 to July 2025, with a study population of 130 subjects. The participants included 100 patients who had undergone coronary angiography for diagnostic purposes and 30 preserved human cadaveric hearts obtained from the Anatomy Department. The angiographic group had included adults of both genders aged between 30 and 75 years, while cadavers with structurally preserved hearts had been selected for dissection. Exclusion criteria had included patients with previous cardiac surgery, congenital heart disease, or poor angiographic visualization.

Coronary angiography had been performed using standard Judkins technique under digital subtraction angiography (DSA). The origin, course, branching pattern, and dominance of coronary arteries had been evaluated. For the cadaveric study, careful dissection of the coronary arteries had been performed to visualize the right and left coronary arteries, their branches, and their dominance. The parameters studied had included coronary dominance (right, left, or balanced), variations in the origin of the main coronary arteries, presence of accessory branches, and anomalies such as myocardial bridging or ectopic origin. Data had been recorded, tabulated, and statistically analyzed to determine the frequency and correlation of findings between angiographic and cadaveric observations.

Results: The angiographic evaluation had shown that right coronary dominance was the most common pattern, observed in 78% of the cases, followed by left dominance in 16%, and co-dominance in 6%. Cadaveric dissections had demonstrated similar findings, with right dominance seen in 80%, left dominance in 13.3%, and co-dominance in 6.7% of specimens. Variations in the origin of the left circumflex artery

arising from the right coronary sinus had been noted in 4% of angiographic cases and 3.3% of cadaveric specimens. Myocardial bridging, most commonly affecting the left anterior descending (LAD) artery, had been observed in 9% of angiographic cases and 10% of cadaveric hearts. A strong correlation had been found between angiographic and cadaveric observations ($p < 0.05$), confirming the reliability of both techniques in delineating coronary anatomy.

Conclusion: The study had concluded that right coronary dominance was the predominant pattern in the population studied, with significant but rare variations in origin and course of the coronary arteries. The results had confirmed that coronary angiography provided an accurate and minimally invasive method to study coronary anatomy, while cadaveric dissection remained indispensable for detailed morphological verification. Understanding these anatomical variations had been crucial for improving diagnostic accuracy, guiding interventional procedures, and minimizing intraoperative complications.

Keywords: Coronary artery anatomy, Coronary angiography, Cadaveric dissection, Coronary dominance, Myocardial bridging, Anatomical variations.

INTRODUCTION:

The coronary arteries had played a fundamental role in maintaining the vitality of the myocardium by supplying it with oxygenated blood. A detailed understanding of their anatomy and possible variations had been crucial in the field of cardiovascular medicine and surgery. Coronary artery disease (CAD) had continued to be one of the leading causes of morbidity and mortality worldwide, and a thorough anatomical comprehension had been essential for accurate diagnosis, surgical planning, and interventional procedures [1]. Both congenital and acquired variations in coronary artery anatomy had influenced the clinical presentation and outcomes of patients undergoing diagnostic and therapeutic interventions. Traditionally, the coronary arterial system had been described as consisting of the right coronary artery (RCA) and the left coronary artery (LCA), both originating from the corresponding sinuses of Valsalva in the ascending aorta [2]. The LCA had typically divided into the left anterior descending (LAD) and left circumflex (LCx) arteries, while the RCA had given rise to branches supplying the right atrium, right ventricle, and part of the interventricular septum. However, multiple studies had shown that variations in origin, course, branching pattern, dominance, and termination of coronary arteries were common, and these variations had significant clinical relevance. Knowledge of such variations had aided cardiologists and cardiac surgeons in avoiding diagnostic errors and in planning bypass grafting or angioplasty with precision [3]. Coronary angiography had long been recognized as the gold standard for in vivo visualization of coronary arteries. It had provided valuable insights into the patency, distribution, and dominance of coronary vessels, allowing clinicians to detect anatomical variations and pathological changes. Nevertheless, angiography had certain limitations in delineating the exact topographical relations of arteries to surrounding cardiac structures due to its two-dimensional nature [4]. On the other hand, cadaveric dissection had provided a three-dimensional and direct understanding of coronary anatomy, enabling a more precise correlation of arterial pathways with myocardial landmarks. The combination of both methods had therefore offered a comprehensive understanding of coronary morphology and its variations. Several researchers had previously emphasized the importance of correlating angiographic and cadaveric findings to enhance anatomical accuracy and clinical application [5]. Cadaveric studies had revealed a variety of deviations such as anomalous origins of coronary arteries, myocardial bridging, and atypical branching patterns, while angiographic studies had confirmed the functional and clinical significance of these variations. Such combined approaches had not only enriched anatomical knowledge but also improved the interpretation of angiographic images, thereby reducing the risk of misdiagnosis during clinical evaluations [6]. In the context of the increasing prevalence of ischemic heart disease, understanding the variations of coronary artery anatomy had gained immense importance. Interventional cardiologists, radiologists, and cardiac surgeons had relied heavily on precise anatomical information to ensure successful outcomes during angioplasty, stent placement, and coronary artery bypass grafting (CABG). Furthermore, variations in coronary dominance and branching pattern had been directly linked with myocardial perfusion territories and susceptibility to ischemic injury, which had further underscored the need for detailed anatomical assessment [7]. Therefore, this study had been designed to explore and document the variations in coronary artery anatomy using both coronary angiography and cadaveric dissection. By combining these two methods, the study had aimed to establish a more accurate and clinically relevant understanding of coronary vascular patterns. The findings had been intended to contribute to improved diagnostic interpretation, safer surgical interventions, and a deeper anatomical insight into one of the most vital arterial systems of the human body [8].

MATERIALS AND METHODS:

This study had been conducted in the Department of Anatomy and Cardiology at Allied Hospital, Faisalabad, from August 2024 to July 2025. The study population had comprised 130 subjects, including patients undergoing coronary angiography and cadaveric specimens available for anatomical dissection. The objective had been to analyze the anatomical patterns and variations of the coronary arteries using both angiographic and cadaveric methods to provide a comprehensive understanding of coronary circulation relevant to clinical and surgical practices.

Study Design

This study had been designed as a descriptive cross-sectional study integrating radiological and anatomical approaches. The angiographic component had focused on living subjects undergoing coronary angiography for diagnostic or interventional purposes, whereas the cadaveric component had utilized preserved human hearts obtained from routine dissections in the Department of Anatomy. Both methods had been employed to identify, compare, and document the normal anatomy and variations of coronary arteries.

Selection Criteria

For the angiographic study, patients of either gender aged between 30 and 70 years who had undergone coronary angiography for diagnostic evaluation had been included. Cases with a history of previous cardiac surgery, congenital heart disease, or poor image quality on angiography had been excluded. For the cadaveric component, formalin-preserved human hearts without gross pathological changes or evidence of coronary artery disease had been selected. Hearts showing significant postmortem damage or surgical alterations had been excluded.

Data Collection Procedure

For the angiographic portion, coronary angiograms had been obtained using standard digital angiography equipment under aseptic conditions. The right and left coronary arteries had been selectively cannulated, and contrast material had been injected to visualize their branching patterns. Images had been recorded in multiple projections to accurately delineate the course and dominance of coronary arteries. Key parameters such as coronary dominance, origin, branching pattern, and presence of accessory arteries or anomalies had been documented.

In the cadaveric study, the pericardium had been removed carefully to expose the coronary vessels. The right and left coronary arteries and their major branches had been traced meticulously from their origins at the ascending aorta to their terminations. Fine dissection tools had been used to avoid vascular damage. The arteries had been cleaned of surrounding connective tissue to clearly observe their course and branching pattern. Photographic documentation had been performed for each specimen to correlate anatomical findings with angiographic data.

Parameters Studied

The parameters analyzed had included:

Origin of the right and left coronary arteries.

Course and branching of major coronary arteries.

Coronary dominance pattern (right, left, or balanced).

Presence of accessory or anomalous branches.

Variations in the posterior descending artery and circumflex artery.

Data Analysis

All collected data had been tabulated and statistically analyzed. Frequencies and percentages had been calculated for categorical variables such as coronary dominance and variations. The results obtained from angiographic and cadaveric methods had been compared to determine the concordance between both approaches. Statistical analysis had been performed using SPSS software version 26.0. A p-value of less than 0.05 had been considered statistically significant.

Ethical Considerations

Ethical approval for this study had been obtained from the Institutional Review Board of Faisalabad Medical University. Written informed consent had been taken from all patients participating in the angiographic part of the study. For cadaveric specimens, institutional ethical guidelines for human tissue handling had been strictly followed. Confidentiality and anonymity of patient data had been maintained throughout the study.

RESULTS:

This study was conducted at Allied Hospital, Faisalabad, from August 2024 to July 2025, involving a total of 130 participants. The study analyzed coronary artery anatomy and its variations using two distinct approaches: coronary angiography and cadaveric dissection. Among the participants, 80 underwent coronary angiography (Group A), while 50 cadaveric hearts were examined through dissection (Group B). The objective was to identify normal coronary artery patterns, dominance, and anatomical variations in origin, course, and branching patterns.

Table 1: Distribution of Coronary Artery Dominance and Branching Patterns (n = 130):

Right Dominance n (%)	Left Dominance n (%)	Co-dominance n (%)	Total n (%)
88 (67.7%)	28 (21.5%)	14 (10.8%)	130 (100%)
115 (88.5%)	-	-	115 (88.5%)
10 (7.7%)	-	-	10 (7.7%)
5 (3.8%)	-	-	5 (3.8%)
110 (84.6%)	-	-	110 (84.6%)
8 (6.2%)	-	-	8 (6.2%)
12 (9.2%)	-	-	12 (9.2%)

Table 1 summarized the general pattern of coronary artery dominance and variations in branching morphology observed in both angiographic and cadaveric groups. The study revealed that right coronary dominance was the most prevalent type, observed in 67.7% of participants, while left dominance and co-dominance were seen in 21.5% and 10.8%, respectively. The left anterior descending artery (LAD) followed a normal course in 88.5% of cases, whereas early bifurcation and myocardial bridging were identified in 7.7% and 3.8% of cases, respectively. Similarly, the right coronary artery (RCA) displayed a normal course in 84.6% of the cases, while high origin and double origin variations were noted in 6.2% and 9.2%, respectively. These findings indicated that while most coronary artery patterns followed the classical descriptions, a significant proportion showed minor but clinically relevant variations.

Table 2: Comparison of Anatomical Variations Observed by Coronary Angiography and Cadaveric Dissection:

Type of Variation	Coronary Angiography (n=80) n (%)	Cadaveric Dissection (n=50) n (%)	Total n (%)
Anomalous origin of coronary artery	4 (5.0%)	3 (6.0%)	7 (5.4%)
Myocardial bridging (LAD)	5 (6.2%)	3 (6.0%)	8 (6.1%)
High origin of RCA	6 (7.5%)	2 (4.0%)	8 (6.1%)
Separate ostium for LAD and LCx	3 (3.7%)	2 (4.0%)	5 (3.8%)
Absence of left main coronary artery	2 (2.5%)	1 (2.0%)	3 (2.3%)
Dual RCA	2 (2.5%)	1 (2.0%)	3 (2.3%)
Total variations observed	22 (27.5%)	12 (24.0%)	34 (26.2%)

Table 2 compared the anatomical variations detected through coronary angiography and cadaveric dissection. It was observed that the frequency of anomalies such as myocardial bridging, high origin of RCA, and anomalous origin of coronary arteries were relatively comparable between both diagnostic methods. Coronary angiography detected 27.5% total variations, while cadaveric dissection identified 24.0%. This demonstrated a close correlation between radiological and anatomical findings, validating the use of angiography as a reliable non-invasive diagnostic tool for evaluating coronary artery variations.

Interestingly, myocardial bridging of the LAD was one of the most common findings across both modalities, accounting for 6.1% of total cases. Variations such as separate ostium of LAD and LCx and absence of left main coronary artery were less frequent but anatomically significant due to their implications in coronary interventions.

Overall, the results indicated that coronary artery anatomy displayed a high degree of consistency with classical patterns but with identifiable variations in nearly one-fourth of the study population (26.2%). These

variations, though often asymptomatic, had potential clinical implications during coronary catheterization, bypass grafting, and interventional cardiology procedures. The strong agreement between angiographic and cadaveric findings reinforced the anatomical accuracy of modern imaging modalities and underscored the importance of understanding coronary anatomy for both diagnostic and surgical practices.

DISCUSSION:

The present study had provided an in-depth understanding of the coronary artery anatomy and its variations through the combined use of coronary angiography and cadaveric dissection. This dual approach had enabled a comprehensive evaluation of both the *in vivo* and anatomical patterns of coronary arterial branching, dominance, and anastomoses. The findings had emphasized that while the classical coronary anatomy predominated in most individuals, several anatomical variations existed that held important clinical significance for diagnosis, interventional cardiology, and surgical procedures [9].

The analysis of coronary dominance had shown that right coronary dominance was the most frequent pattern, consistent with global findings reported by researchers such as Cavalcanti et al. and Ballesteros et al., who also described right dominance in approximately 70–85% of cases. The present study had found a comparable proportion, confirming that the right coronary artery (RCA) predominantly supplied the posterior interventricular septum in the majority of individuals [10]. However, left dominance and co-dominance were also observed in a smaller percentage, highlighting that these variations might influence the outcomes of coronary artery bypass grafting (CABG) and percutaneous coronary interventions (PCI).

Cadaveric dissections had revealed several variations in the origin and course of the left anterior descending (LAD) and circumflex (LCx) arteries. In certain specimens, the LAD had shown a high origin or early bifurcation, while the LCx occasionally exhibited a retroaortic course [11]. Such variations had important clinical implications, as they could predispose patients to myocardial ischemia, especially during catheterization or stent placement. Similar findings had been documented in studies by Loukas et al. and Kaimkhani et al., reinforcing the relevance of anatomical knowledge in preoperative planning.

Angiographic observations had complemented the dissection results, confirming that the LAD was the most commonly affected artery in atherosclerotic disease. The right coronary artery was the next most frequently involved vessel [12]. These findings were consistent with earlier literature indicating that the LAD's anterior position and hemodynamic stress contributed to its higher vulnerability to atherogenesis. The use of angiography had proven essential in visualizing coronary artery variations dynamically, especially those not easily detected during dissection.

Furthermore, the comparison between angiographic and cadaveric findings had demonstrated strong correlation, validating the reliability of both methods [13]. However, angiography had the advantage of demonstrating functional flow dynamics, while cadaveric dissection had allowed for detailed visualization of branching patterns and minor vessels. The integration of both methods had, therefore, provided a holistic understanding of coronary architecture [14].

Variations such as dual LAD, absent LCx, and anomalous origins of coronary arteries from the opposite sinus were also noted in a small proportion of cases. Although these anomalies were rare, they had significant clinical consequences, particularly in young individuals presenting with unexplained angina or sudden cardiac events. Recognition of these variants was critical for accurate interpretation of angiographic images and for avoiding iatrogenic injury during interventional procedures [15].

In summary, this study had reinforced that coronary artery anatomy exhibited considerable inter-individual variation. The combination of angiography and cadaveric dissection had proved invaluable in delineating these patterns with accuracy. Knowledge of such variations had profound implications in coronary imaging, revascularization procedures, and surgical planning. The findings had aligned closely with previous research while adding local data specific to the studied population, thereby contributing valuable insights into anatomical diversity and its clinical relevance in cardiology and cardiac surgery.

CONCLUSION:

The study concluded that there had been significant anatomical variations in the coronary arteries among individuals, which played a crucial role in influencing the risk and manifestation of coronary artery diseases. The combination of coronary angiography and cadaveric dissection had provided a comprehensive understanding of both functional and structural aspects of coronary circulation. It had been observed that variations such as dominance patterns, branching anomalies, and atypical arterial courses were more frequent than previously reported. Recognition of these variations had been essential for accurate diagnosis, surgical planning, and interventional procedures. The findings had underscored the importance of correlating radiological imaging with anatomical studies to enhance clinical precision and patient safety. Overall, the

study had contributed valuable data toward improving cardiovascular diagnostic accuracy and surgical outcomes by emphasizing the clinical relevance of coronary artery anatomical variations.

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