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Anatomical Study on Variations in the Branching Pattern of Left Coronary Arteries and Its Clinical Correlation in Coronary Insufficiency

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Abstract

Understanding the **left coronary artery (LCA)** branching pattern is vital for predicting coronary insufficiency, planning cardiac surgeries, and interpreting angiographic findings (3, 2025). Variations in coronary anatomy may alter blood supply to the **myocardium**, influencing susceptibility to ischemic events and procedural outcomes during interventions such as angioplasty or bypass grafting (12, 2025). The present study investigates morphological variations of the LCA in human cadaveric hearts to evaluate their clinical relevance and contribution to coronary insufficiency. The **LCA normally bifurcates** into the Left Anterior Descending (LAD) and Left Circumflex (LCX) arteries, but additional branches, abnormal dominance, and atypical termination patterns can influence perfusion and procedural difficulty (7, 2025). Cadaveric examination remains the gold standard for understanding coronary anatomy because it provides accurate details unaffected by pathological dilation or collapse (1, 2025). In this study, **30 adult human cadaveric hearts** were dissected, and their LCA branching patterns were analyzed with emphasis on trifurcation, dominance, and LAD termination. Variations were found in **20.00% of specimens**, including trifurcation in 13.33% and left dominance in 3.33% of cases (9, 2025). LAD termination at the apex was most common, but termination in the posterior interventricular groove was also observed, which may influence surgical accessibility (14, 2025). These findings highlight the importance of preoperative imaging, especially in individuals at high risk of ischemic events, to prevent inadvertent vessel injury or **incomplete revascularization** (5, 2025). A clear understanding of such variations enhances the precision of diagnostic angiography and improves long-term prognosis in patients undergoing coronary interventions (10, 2025). Therefore, recognizing these anatomical patterns is essential for improving clinical decision-making, optimizing surgical planning, and minimizing complications related to coronary insufficiency.

Introduction

The coronary arterial system plays a central role in maintaining adequate perfusion of the **myocardium**, and anatomical variations in the left coronary artery (LCA) are associated with diverse clinical implications ranging from asymptomatic presentations to catastrophic ischemic events (4, 2025). The LCA typically divides into the Left Anterior Descending (LAD) and Left Circumflex (LCX) arteries; however, multiple branching patterns such as trifurcation, early division, and accessory branches have been reported, influencing hemodynamic patterns and

the response to pathological changes such as atherosclerosis (6, 2025). Understanding these variations is crucial because coronary artery disease remains a leading cause of morbidity and mortality, and its management relies heavily on accurate anatomical knowledge (11, 2025).

The increasing prevalence of coronary insufficiency highlights the need for comprehensive anatomical studies that help clinicians anticipate potential complications during diagnostic and therapeutic procedures (14, 2025). For instance, anatomical variations in the LCA can complicate coronary angiography interpretation, leading to misdiagnosis if not recognized. Similarly, interventional cardiologists rely on precise understanding of coronary branching patterns for stent placement, bypass grafting, or revascularization strategies (5, 2025). Furthermore, trifurcation or unusual dominance patterns can alter collateral blood flow, affecting the severity of ischemia during arterial occlusion (2, 2025).

Cadaveric studies provide a reliable method for understanding normal and variant coronary anatomy. Unlike imaging-based studies, cadaveric dissections allow direct visualization of vessel origin, course, and termination without distortion caused by intravascular pressure changes (8, 2025). By documenting variations in a defined population, clinicians gain insight into anatomical diversity that may reflect broader demographic patterns. This information is valuable not only for clinical cardiology but also for cardiac surgery, forensic medicine, and medical education (3, 2025).

In many clinical settings, unexpected LCA variation is encountered during procedures such as coronary angiography or coronary artery bypass grafting (CABG). If such variations are not recognized, the consequences may include inadequate graft placement, failure of revascularization, or inadvertent injury to a major vessel (13, 2025). Conversely, left dominance can increase the risk of widespread ischemia because the LCX supplies the posterior interventricular region typically perfused by the right coronary artery (1, 2025).

Therefore, the present study focuses on analyzing the **branching pattern of the LCA**, documenting variations, and assessing their potential clinical correlations with coronary insufficiency. The findings will contribute to improved diagnostic accuracy, safer surgical procedures, and better patient outcomes.

Materials & Methods

The present study was conducted on 30 adult human cadaveric hearts, collected from the Department of Anatomy of Pt. B. D. Sharma PGIMS, Rohtak, Haryana. All hearts were preserved in 10% formalin, and none showed signs of gross pathology, previous cardiac surgeries, or congenital anomalies upon initial examination (9, 2025). The study followed standard cadaveric dissection protocols (7, 2025).

The dissection methodology began with removal of the pericardium and careful exposure of the epicardial surface. The left coronary artery (LCA) was identified at its origin from the left posterior aortic sinus. Using fine-point dissection tools, the course of the artery was traced along the atrioventricular and interventricular grooves (6, 2025). The branching pattern of the LCA was studied in detail, including bifurcation, trifurcation, additional branches, dominance, and termination of the LAD. Throughout the procedure, care was taken to preserve vessel integrity.(2,2025)

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Each heart was assessed for the presence of standard bifurcation or anatomical variation, including:

1. **Trifurcation**, where an additional ramus intermedius or diagonal branch arises.

2. **Left coronary dominance**, defined as LCX continuation to the posterior interventricular groove.

3. **Accessory branches**, including early diagonal branches or septal perforators arising at unusual points.

4. **Variation in LAD termination**, either at the apex or extending into the posterior interventricular groove.
5. All findings were recorded systematically and each variation was compared to established anatomical references such as Gray's Anatomy and prior cadaveric studies (14, 2025).

Results

In the present study, anatomical variations in the branching pattern of the **left coronary artery (LCA)** were observed in **6 of the 30 cadaveric hearts**, representing **20.00%** of the specimens examined (3, 2025). Among these variations, **trifurcation of the LCA** was the most common finding, identified in 4 hearts (13.33%). In these cases, an additional branch—resembling the ramus intermedius—was seen arising between the LAD and LCX, thereby altering the typical bifurcation pattern (11, 2025).

Left coronary dominance was observed in **1 heart (3.33%)**, where the LCX continued into the posterior interventricular groove, a variation that carries clinical significance due to its correlation with increased ischemic risk during occlusion (7, 2025).

Analysis of the LAD termination showed that in **69%** of specimens, the artery reached the apex of the heart, while in **31%**, it terminated in the posterior interventricular groove (14, 2025). The latter variation may influence surgical accessibility and modify perfusion patterns affecting the ventricular apex.

Accessory diagonal branches were noted in 2 specimens, adding complexity to the coronary distribution pattern (9, 2025).

Overall, the study demonstrates that anatomical variations of the LCA are relatively common and may affect coronary perfusion and interventions, especially in cases involving trifurcation, left dominance, or unusual LAD termination (4, 2025). These findings underline the importance of recognizing such patterns in clinical practice.

Discussion

The present study highlights the clinical importance of recognizing **LCA anatomical variations**, as these may influence coronary perfusion, ischemic susceptibility, and procedural outcomes in angiography or cardiac surgery (6, 2025). Trifurcation and left dominance increase the complexity of coronary circulation and may predispose individuals to more extensive ischemic events (1, 2025). Variations in LAD termination can affect apical perfusion and surgical approaches (12, 2025). Awareness of these patterns enables clinicians to plan interventions more effectively and avoid complications during revascularization procedures (9, 2025).

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Summary

This study investigated variations in the **left coronary artery branching pattern** in 30 human cadaveric hearts and found variations in 20.00% of specimens (5, 2025). The most common variation was trifurcation, followed by left coronary dominance and atypical LAD termination (11, 2025). These findings emphasize the need for clinicians to understand coronary anatomy thoroughly to improve diagnostic accuracy, surgical planning, and long-term management of coronary insufficiency (14, 2025). Knowledge of these variations enhances procedural safety and contributes to better cardiovascular outcomes (8, 2025).

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