Section: Anatomy

Original Research Article

A STUDY OF CORONARY DOMINANCE AND MYOCARDIAL BRIDGES IN HUMAN CADAVERIC HEARTS

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ABSTRACT

Background: Coronary artery dominance and myocardial bridges are important anatomical variations of the coronary circulation with significant clinical and surgical implications. Variations in coronary artery anatomy may influence myocardial perfusion, affect the interpretation of coronary angiography, and alter outcomes during coronary artery bypass grafting and percutaneous coronary interventions. Myocardial bridges, although often considered benign, have been associated with myocardial ischemia, arrhythmias, and sudden cardiac death.
Materials and Methods: A prospective, observational cadaveric study was conducted on 60 formalin-fixed adult human hearts. The coronary arteries were meticulously dissected to evaluate their origin, branching pattern, coronary dominance, and the presence and distribution of myocardial bridges. Coronary dominance was classified as right, left, or co-dominant based on the origin of the posterior interventricular artery. The anatomical location and distribution of myocardial bridges were recorded, and the findings were analyzed using descriptive statistics.
Results: Right coronary dominance was observed in 44 (73.3%) specimens, while 11 (18.3%) showed left dominance and 5 (8.3%) demonstrated co-dominance. The left coronary artery exhibited bifurcation in 35 (58.3%), trifurcation in 19 (31.7%), and tetrafurcation in 6 (10.0%) specimens. Myocardial bridges were identified in 22 (36.7%) hearts, predominantly involving the left coronary arterial territory (77.3%). The left anterior descending artery was the most frequently affected vessel, accounting for 50% of all myocardial bridges, with the middle segment being the commonest site of occurrence.
Conclusions: Right coronary dominance was the predominant coronary circulation pattern, and myocardial bridges were most commonly located in the middle segment of the left anterior descending artery. Recognition of these anatomical variations is essential for accurate interpretation of coronary imaging, appropriate surgical planning, and safe performance of coronary interventions.
Keywords: Coronary dominance; Myocardial bridge; Coronary artery anatomy; Left anterior descending artery; Cadaveric study.

INTRODUCTION

Coronary artery disease (CAD) remains one of the leading causes of mortality worldwide and is an increasing public health concern in developing countries, including India. Cardiovascular diseases account for a substantial proportion of premature deaths, particularly among individuals in their productive years, unlike developed nations where mortality occurs predominantly in older populations.[1,2] Congenital, inflammatory, metabolic, and degenerative disorders affecting the coronary circulation contribute significantly to morbidity and mortality. Despite significant advances in cardiovascular diagnostics, interventional cardiology, and cardiac surgery, anatomical variations of the coronary arteries continue to pose diagnostic and therapeutic challenges because they can alter coronary blood flow and complicate surgical and angiographic procedures.[3]

Coronary dominance and myocardial bridges (MBs) are among the most important anatomical variations of the coronary circulation with considerable clinical significance. Coronary dominance is determined by the artery giving rise to the posterior descending artery and influences myocardial perfusion, collateral circulation, and the extent of ischemic injury. A myocardial bridge is an anatomical variant in which a segment of an epicardial coronary artery follows an intramyocardial course beneath overlying myocardial fibers instead of remaining on the epicardial surface.[4] This phenomenon was first observed by Reyman in 1737 and later described by Geiringer in 1951 as a "myocardial bridge."[5,6] The left anterior descending (LAD) artery, particularly its middle segment, is the vessel most commonly involved, although bridges may occur in other coronary arteries and their branches.[7,8] The bridged artery is divided into the pre-bridged, tunneled, and post-bridged segments according to its anatomical course.[9]

Although myocardial bridges are often considered benign and are frequently detected incidentally during autopsy or coronary angiography, they may produce important hemodynamic consequences. Compression of the tunneled arterial segment during systole produces the characteristic "milking effect," resulting in transient luminal narrowing and altered coronary blood flow.[10] Noble et al. suggested that this phenomenon may contribute to myocardial ischemia.[11] Furthermore, myocardial bridges have been associated with proximal atherosclerosis, arrhythmias, acute coronary syndromes, and, rarely, sudden cardiac death, particularly in individuals with left coronary dominance or multiple bridges.[12,13] Therefore, detailed knowledge of coronary dominance and myocardial bridges is essential for accurate interpretation of coronary angiography, surgical planning, and management of ischemic heart disease.[14,15] Hence, the present cadaveric study was undertaken to evaluate coronary dominance and myocardial bridges in human hearts.

MATERIALS AND METHODS

This was a prospective, observational cadaveric study conducted in the Department of Anatomy, Saraswathi Institute of Medical Sciences, Hapur UP, after obtaining approval from the Institutional Ethics Committee.

Study Sample

The study included 60 formalin-fixed adult human cadaveric hearts obtained from routine cadaveric dissections in the Department of Anatomy. The age, sex, cause of death, and clinical history of the cadavers were not available.

Inclusion Criteria

- Formalin-fixed adult human cadaveric hearts.
- Hearts with intact coronary arterial anatomy suitable for detailed anatomical dissection.
- Adequately preserved specimens without gross decomposition.

Exclusion Criteria

- Hearts with congenital cardiac anomalies.
- Hearts showing previous cardiac surgery or traumatic damage affecting coronary anatomy.
- Hearts with advanced pathological changes obscuring the coronary arteries.
- Specimens with incomplete or damaged coronary arterial circulation.

Dissection Procedure

The thoracic cavity was opened using the standard anatomical dissection technique. After removal of the sternum and costal cartilages, the fibrous and serous pericardium were incised longitudinally from the roots of the great vessels to the diaphragm, followed by transverse incisions at both ends. The ascending aorta was transected at the level of the arch, the pulmonary trunk at its bifurcation, and the superior and inferior venae cavae along with the pulmonary veins were divided to facilitate removal of the heart.

Each heart specimen was assigned a unique identification number. Excess epicardial fat and connective tissue were carefully removed while preserving the coronary arteries and their branches. The right and left coronary arteries were meticulously dissected from their origin to their terminal branches using standard anatomical instruments.

Assessment of Coronary Arteries

The origin, course, branching pattern, and termination of the right and left coronary arteries were examined in all specimens. The branching pattern of the left coronary artery was recorded as bifurcation, trifurcation, or tetrafurcation. The origin of the sinoatrial (SA) nodal artery, atrioventricular (AV) nodal artery, marginal artery, anterior interventricular artery, and posterior interventricular artery was documented.

Assessment of Coronary Dominance

Coronary dominance was determined according to the origin of the posterior interventricular (posterior descending) artery. Hearts were classified as:

- **Right dominant:** Posterior interventricular artery arising from the right coronary artery.
- **Left dominant:** Posterior interventricular artery arising from the left circumflex artery.
- **Co-dominant (balanced):** Contribution from both right and left coronary arteries to the posterior interventricular region.

Assessment of Myocardial Bridges

The coronary arteries were examined throughout their entire course for the presence of myocardial bridges. A myocardial bridge was identified when a segment of an epicardial coronary artery coursed beneath myocardial fibers, forming a tunneled arterial segment.

For every myocardial bridge identified, the following parameters were recorded:

- Coronary artery involved.
- Coronary arterial territory (right or left).
- Number of myocardial bridges (single or multiple).
- Segment involved (proximal, middle, or distal), particularly for bridges over the left anterior descending artery.
- Association between myocardial bridges and coronary dominance.

Data Collection

All observations were recorded using a predesigned structured proforma and entered into a master chart for analysis. Photographic documentation was performed wherever required to support anatomical findings.

Statistical Analysis

The collected data were compiled and analyzed using IBM Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages. Continuous variables, where applicable, were expressed as mean ± standard deviation. The findings were presented using appropriate tables and figures. Since the study was primarily descriptive, emphasis was placed on the distribution of coronary dominance patterns, branching characteristics of the coronary arteries, and the prevalence and anatomical distribution of myocardial bridges. Associations between coronary dominance and myocardial bridges were analyzed descriptively, and a p-value <0.05 was considered statistically significant wherever inferential statistical analysis was performed.

RESULTS

A total of 60 formalin-fixed adult human cadaveric hearts were examined to evaluate coronary dominance and the presence of myocardial bridges.

The right coronary artery (RCA) showed a normal origin in all specimens except 1 (1.7%) heart, in which it was bifurcated into a small right conus artery and a larger right coronary artery. The left coronary artery (LCA) demonstrated bifurcation in 35 (58.3%) specimens, trifurcation in 19 (31.7%), and tetrafurcation in 6 (10.0%) specimens.

The sinoatrial (SA) nodal artery originated from the right coronary artery in 43 (71.7%) specimens and from the circumflex branch of the left coronary artery in 17 (28.3%) specimens. The atrioventricular (AV) nodal artery arose from the right coronary artery in 48 (80.0%) specimens and from the left coronary artery in 12 (20.0%) specimens. The marginal artery originated from the right coronary artery in all specimens, whereas the anterior interventricular artery originated from the left coronary artery in every heart examined.

Table 1: Origin of various branches of the coronary arteries (n = 60)

Branch	Right Coronary Artery n (%)	Left Coronary Artery n (%)	Both n (%)
SA nodal artery	43 (71.7)	17 (28.3)	0
AV nodal artery	48 (80.0)	12 (20.0)	0
Marginal artery	60 (100)	0	0
Anterior interventricular artery	0	60 (100)	0
Posterior interventricular artery	44 (73.3)	11 (18.3)	5 (8.3)

Based on the origin of the posterior interventricular artery, right coronary dominance was the predominant pattern and was observed in 44 (73.3%) hearts, followed by left coronary dominance in 11 (18.3%) hearts and co-dominance in 5 (8.3%) hearts.

Table 2: Coronary dominance pattern (n = 60)

Coronary dominance	Number of specimens	Percentage (%)
Right dominance	44	73.3
Left dominance	11	18.3
Co-dominance	5	8.3
Total	**60**	**100**

Myocardial bridges were identified in 22 (36.7%) of the 60 hearts examined, while 38 (63.3%) hearts showed no myocardial bridging. Among the bridged hearts, 17 (77.3%) involved the left coronary arterial territory and 5 (22.7%) involved the right coronary arterial territory.

Table 3: Distribution of myocardial bridges according to coronary arterial territory (n = 60)

Coronary arterial territory	Number of hearts	Percentage (%)
Right coronary artery	5	8.3
Left coronary artery	17	28.3
No myocardial bridge	38	63.3
Total	**60**	**100**

The left anterior descending (anterior interventricular) artery was the most common site of myocardial bridging, accounting for 11 (50.0%) of the 22 bridged hearts. The remaining bridges were observed over the marginal artery in 5 (22.7%), left diagonal artery in 3 (13.6%), left circumflex artery in 2 (9.1%), and posterior interventricular artery in 1 (4.5%) specimen.

Table 4: Distribution of myocardial bridges according to involved coronary artery (n = 22)

Coronary artery	Number	Percentage (%)
Left anterior descending (Anterior interventricular)	11	50.0
Marginal artery	5	22.7
Left diagonal artery	3	13.6
Left circumflex artery	2	9.1
Posterior interventricular artery	1	4.5
Total	**22**	**100**

Among the myocardial bridges involving the left anterior descending artery, the middle segment was the most frequently affected (7; 63.6%), followed by the proximal segment (3; 27.3%) and distal segment (1; 9.1%).

Table 5: Segment-wise distribution of myocardial bridges in the left anterior descending artery (n = 11)

Segment	Number	Percentage (%)
Proximal	3	27.3
Middle	7	63.6
Distal	1	9.1
Total	**11**	**100**

Most specimens demonstrated a single myocardial bridge, whereas two specimens showed double myocardial bridges, resulting in a total of 24 myocardial bridges in 22 hearts.

Table 6: Distribution of single and double myocardial bridges

Number of myocardial bridges	Number of hearts	Percentage (%)
Single myocardial bridge	20	90.9
Double myocardial bridges	2	9.1
Total hearts with myocardial bridges	**22**	**100**

Myocardial bridges were most frequently associated with right coronary dominance, being observed in 16 (72.7%) of the bridged hearts, followed by left coronary dominance in 4 (18.2%) hearts and co-dominance in 2 (9.1%) hearts.

Table 7: Association of myocardial bridges with coronary dominance (n = 22)

Coronary dominance	Hearts with myocardial bridges n (%)
Right dominance	16 (72.7)
Left dominance	4 (18.2)
Co-dominance	2 (9.1)
Total	**22 (100)**

Overall, right coronary dominance was the predominant coronary circulation pattern in the present study, while myocardial bridges were observed in 36.7% of hearts, occurring predominantly in the left coronary arterial territory. The left anterior descending artery, particularly its middle segment, was the most common location for myocardial bridging.

Figure 1: Right coronary artery dominance with myocardial bridge over posterior interventricular artery

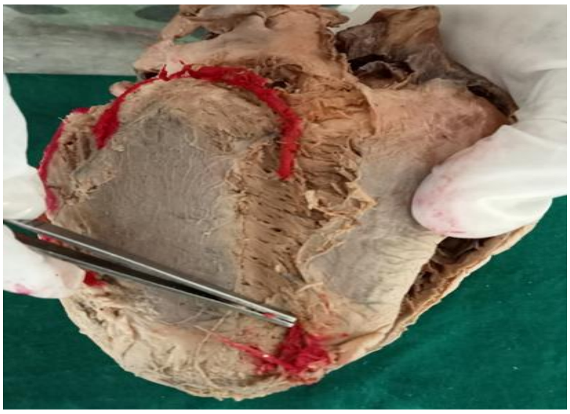

Figure 2: Left coronary artery dominance with myocardial bridge over posterior interventricular artery

Figure 3: Myocardial bridge over left anterior descending artery

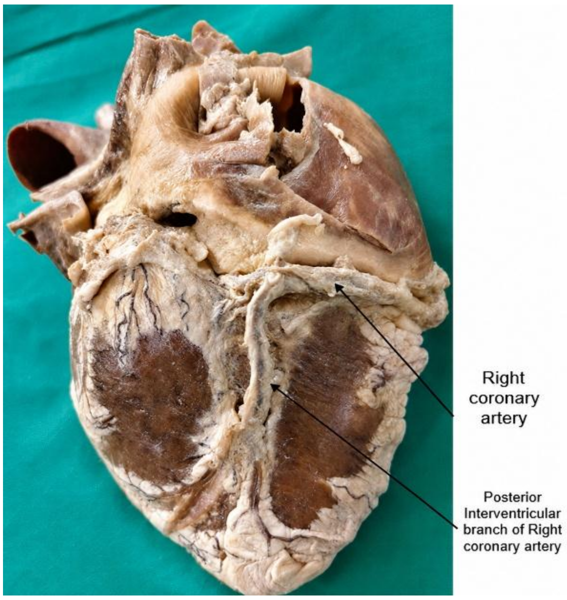

Figure 4: Posterior Interventricular branch of Right coronary artery showing Right Dominance

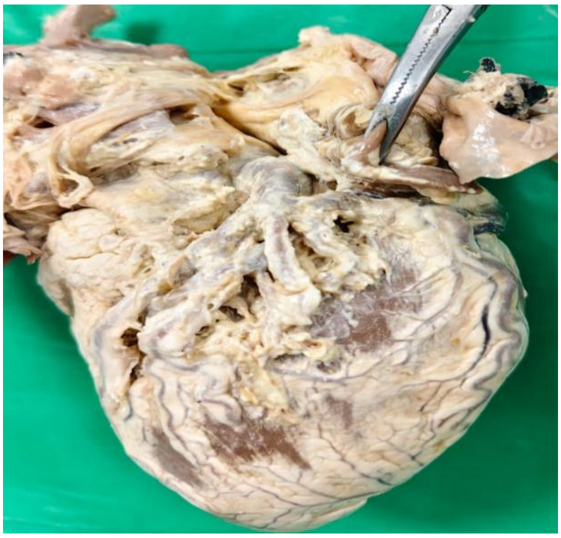

Figure 5: Left coronary artery showing Quadrifurcation near its origin

Figure 6: Myocardial bridge over left diagonal artery

DISCUSSION

The present cadaveric study was undertaken to evaluate coronary dominance and myocardial bridges in 60 formalin-fixed adult human hearts. Knowledge of these anatomical variations is important because they influence coronary perfusion, interpretation of coronary angiography, and planning of cardiac surgical and interventional procedures.

In the present study, the right coronary artery (RCA) showed bifurcation in one (1.7%) specimen. Similar findings were reported by Bhingardeve CV et al., who observed bifurcation of the RCA in 2% of specimens.[3] Wilkins et al. reported an incidence of 0.02%, while Koser P et al. identified duplication of the RCA in 0.1% of patients undergoing CT coronary angiography, indicating that this variation is uncommon but clinically important.[16,17]

The branching pattern of the left coronary artery (LCA) demonstrated bifurcation in 58.3%, trifurcation in 31.7%, and tetrafurcation in 10.0% of specimens. These findings are almost identical to those reported by Bhingardeve CV et al., who observed bifurcation, trifurcation, and tetrafurcation in 58%, 32%, and 10% of specimens.[3] Comparable observations have also been reported by Koser P et al,[17] Reig J et al,[18] Lujinovic A et al,[19] Kalbfleisch et al,[20] and Kalpana R.,[2] indicating that these branching patterns represent common anatomical variations. Trifurcation of the LCA may provide an anatomical advantage by supplying an additional myocardial territory, thereby potentially reducing the extent of ischemia following proximal LAD occlusion.

The SA nodal artery originated from the RCA in 71.7% of specimens and from the circumflex branch of the LCA in 28.3%, while the AV nodal artery arose from the RCA in 80.0% and from the LCA in 20.0% of specimens. These findings closely correspond with those of Bhingardeve CV et al,[3] Since the SA and AV nodal arteries usually arise from the dominant coronary artery, occlusion of the dominant vessel may result in conduction abnormalities, emphasizing the importance of understanding coronary arterial anatomy before cardiac interventions.

The present study demonstrated right coronary dominance in 73.3%, left dominance in 18.3%, and co-dominance in 8.3% of hearts. These observations are nearly identical to those reported by Bhingardeve CV et al,[3] who observed 74%, 18%, and 8%, respectively. Similarly, Gohain N et al,[1] reported 70% right dominance, 22% left dominance, and 8% co-dominance, confirming that right coronary dominance is the predominant pattern in the majority of cadaveric studies. Coronary dominance has important prognostic implications because patients with left-dominant circulation have a larger myocardial territory supplied by a single coronary artery, increasing the severity of myocardial ischemia following proximal coronary occlusion.

The present study identified myocardial bridges in 22 (36.7%) hearts. This prevalence is almost identical to that reported by Bhingardeve CV et al. (36%),[3] although lower than the 52% incidence reported by Gohain N et al.[1] The overall incidence reported by Gohain N et al,[1] was comparable to the studies conducted by Lujinovic A et al,[19] (53.33%), M.P. Wakchaure,[20] (54%), and Gunjan Rai et al,[21] (53.06%). However, lower incidences of 5% and 0.61% have also been documented,[16,17] whereas P. Moula et al,[22] reported a remarkably higher incidence of 92.5%. These variations are likely attributable to differences in study populations, methods of dissection, and criteria used for identification of myocardial bridges.

Most myocardial bridges in the present study involved the left coronary arterial territory (77.3%), while 22.7% involved the right coronary circulation. Similar observations were reported by Bhingardeve CV et al. [3], who found myocardial bridges involving the left coronary artery in 28% and the right coronary artery in 8% of specimens. Likewise, Gohain N et al, [1] observed that myocardial bridges were significantly more common in the left coronary arterial territory than in the right coronary arterial territory.

The left anterior descending (LAD) artery was the most frequently affected vessel in the present study, accounting for 50% of all myocardial bridges. Furthermore, the middle segment of the LAD represented the most common site of myocardial bridging (63.6%). These findings are in agreement with those reported by Bhingardeve CV et al,[3] Gohain N et al,[1] Lujinovic A et al,[19] and Narayanan VK et al,[23] all of whom identified the middle segment of the LAD as the commonest location for myocardial bridging. Since the LAD supplies a major portion of the left ventricular myocardium, bridging in this artery may significantly influence coronary haemodynamics during systole.

The present study demonstrated that 90.9% of bridged hearts had single myocardial bridges, while 9.1% exhibited double myocardial bridges. Similar findings were reported by Gohain N et al,[1] who observed that single myocardial bridges predominated, with the LAD showing the highest frequency of both single and double bridges. No triple or quadruple myocardial bridges were identified in either study, unlike the observations of Ballesteros et al.[24]

The relationship between myocardial bridges and coronary dominance was also evaluated. In the present study, 72.7% of bridged hearts exhibited right coronary dominance, 18.2% showed left dominance, and 9.1% demonstrated co-dominance. These findings are comparable with those of Gohain N et al,[1] who reported that myocardial bridges were most frequently associated with right coronary dominance. Bharambe et al,[25] and Firdaus Shaikh et al,[26] also reported a higher incidence of myocardial bridges involving the left coronary arterial territory in right-dominant hearts. Conversely, Loukas M,[27] observed a relatively higher incidence of myocardial bridges in the left coronary circulation among hearts with left coronary dominance. These observations suggest that the clinical significance of myocardial bridging may be influenced by the pattern of coronary dominance.

Overall, the findings of the present study are in close agreement with previous cadaveric investigations by Bhingardeve CV et al,[3] and Gohain N et al,[1] The predominance of right coronary dominance, frequent branching variations of the left coronary artery, and preferential involvement of the middle segment of the LAD by myocardial bridges reaffirm the importance of detailed anatomical knowledge. Such information is valuable for cardiologists, cardiovascular surgeons, anatomists, and radiologists during coronary angiography, coronary artery bypass grafting, percutaneous coronary interventions, and other cardiac procedures, thereby facilitating accurate diagnosis, appropriate surgical planning, and improved patient outcomes.

CONCLUSION

Right coronary dominance was the predominant pattern of coronary circulation, whereas left dominance and co-dominance were observed less frequently. Myocardial bridges were identified in 36.7% of the cadaveric hearts, with the left anterior descending artery, particularly its middle segment, being the most commonly affected site. Most myocardial bridges involved the left coronary arterial territory and were associated with right coronary dominance. These anatomical variations have important implications for coronary angiography, percutaneous coronary interventions, and cardiac surgery. Awareness of coronary dominance patterns and myocardial bridging can facilitate accurate diagnosis, optimize surgical planning, reduce procedural complications, and improve the management of patients with coronary artery disease.

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