

Morphometric Study of Left Coronary Artery and its Variations in Cadaveric Hearts and Coronary Angiography

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ABSTRACT

Introduction: the incidence of coronary artery variations (CAV's) differs in cadaveric and in angiographic images. There is no definite inheritance pattern and aetiology for its occurrence. They are different in different geographical area/region around the world. Knowledge of such variations is crucial for clinicians. Myocardial ischemia (MI) is one of the leading cause of mortality in India. The most common affected artery in myocardial ischemia is left coronary artery and its branches.

Objective: this study was carried out to investigate the morphometric parameters and variations of left coronary artery in human cadaveric hearts and coronary angiographic reports. **Methods:** The hearts of 50 human cadavers and 200 coronary angiography reports were included in the study. Origin, length of left Main trunk (LMT), branches and its course were studied in human cadaver specimens and in angiography reports.

Results: in 50 heart specimens and 200 angiography reports, origin of left coronary artery was from left posterior aortic sinus, average length of LMT was between 5-15mm in 72% of cadaveric and 60% in angiographic reports, but length >15mm was observed more in angiography reports 30% compared to 18% in cadaveric specimens. Branching pattern was bifurcation (62% in cadaver, 70% in CAG), trifurcation (30% in cadaver, 28% in CAG) and Quadfurcation (6% in cadavers only). Direct origin of Left anterior descending and left circumflex artery was 2% in cadaveric specimens and CAG reports.

Conclusion: knowledge about the morphometric parameters and anatomical variations of left coronary artery may help the clinicians in accurate identification of the artery involved in case of myocardial ischemia and for coronary artery interventional purposes.

Keywords: Coronary artery; Cadavers; Angiography.

Introduction

Heart is supplied by two main coronary arteries, right and left coronary artery arising from the sinuses of Valsalva and descend towards the cardiac apex. Left coronary artery (LCA) has a main trunk with an average length of 2-4 cm and normally bifurcates into the left anterior descending artery (LAD) and the left circumflex artery (LCX)^{1,2}. Then incidence of LAD affected in myocardial ischemia is more compared to other arteries. Coronary angiography (CAG) is one of the most common investigations preferred to assess the vessels affected in myocardial Ischemia^{3,4}. Though CAG is an invasive procedure, the percentage of accurate detection of occluded artery is high compared to other investigations. A study on coronary arteries using post-mortem angiography showed that the LCA irrigated 68.8% of the total cardiac muscle mass and 79% of the left ventricular cardiac muscle mass^{5,6}. Hence, obstructive disease of the LCA and its branches may reduce the coronary flow to a large proportion of the ventricular myocardium, and as a result, atherosclerotic diseases of the LCA have more serious implications than those of the RCA. Moreover, any anatomical variations of the coronary arteries

can increase the occurrence of myocardial ischemia with subsequent arrhythmia, angina pectoris, infarction, and sudden death. The incidence of such anatomical variations is reported in 0.3% in cadaveric series and 1.6% in patients undergoing coronary angiography⁷. Incidences of variations noted in cadaveric and angiographic study are not similar and also geographical variations of coronary arteries are reported in different parts of the world.

In India, one of the most common causes of MI is occlusion of LAD, followed by LCX and right marginal artery^{7,8}. Hence, the objective of this study was to analyse the anatomical characteristics of the LCA- its origin, length of left main trunk, branches and its course in cadaveric heart specimens and in coronary angiography reports. For routine clinical practice, cardiac surgeons and interventional radiologists must have a thorough knowledge on these important parameters for treatment and management of cases.

Materials and Method

The present study was conducted after obtaining Ethical Clearance from the Institute Ethics review board. The study was conducted in the Department

of Anatomy in a South Indian Medical college. A total of 50 cadaveric heart specimens used for undergraduate teaching and research purposes was included in the study. Heart specimens were fixed in 10% formalin. Dissection by subepicardial method was done. Origin of left coronary artery, length of Left main trunk, branching pattern and its course was studied. Photographic images were taken and labelled. Coronary Angiography (CAG) reports: Retrospective observation of 200 angiographic reports of patients who came with complaints of chest pain was included in the study. Findings of the angiographic reports were analysed by a team of two to three subject experts. Origin of left coronary artery, length of left main trunk, its branching pattern and course were studied. The obtained data was entered in Microsoft excel and percentage was calculated.

Results and Observations

In normal anatomy, left Main Trunk (LMT) arises from the left aortic sinus of ascending aorta. The average length of left main coronary artery (LMT) is 1-2cm. After its origin, the artery passes between the left atrial appendage and the pulmonary trunk and divides into left circumflex and left anterior descending (LAD) branches. In addition, one or two median arteries are also seen arising from LMT.

Cadaveric Study:

Origin and Length of LMT: In 48 (96%) specimens LMT arose from left aortic sinus and in 2 (4%) specimen's absence of LMT with direct origin of LAD and LCX artery from left aortic sinus was seen. Length of LMT- LMT measured of varying length in all the specimens. It was < 5mm in 5(10%) hearts,

between 5-15mm in 36 (72%) specimens and more than > 15mm in 9 hearts (18%). Branching of LMT- LMT bifurcated in 30 (60%), trifurcated in 15 (30%) (Fig 2A) and quadfurcation was seen in 3 (6%) and in 2 (4%) absence of LMT with direct origin of LAD, LCX and median artery from left aortic sinus was noted (Fig 1 A,B,C). Termination of LAD and LCX- Normally the LAD after its origin traverses along the anterior interventricular groove and terminates at various levels. Level of termination of LAD is important to estimate the area of myocardium involved in case of MI. LAD terminated in the posterior one third of interventricular groove in 30 (60%) hearts, at apex in 12 (24 %) and in remaining 8 (16%) of specimens it terminated before apex (Table 1).

Angiographic study:

Origin and Length of LMT: In 200 CAG reports studied, LMT originated from left aortic sinus in all the cases. Ectopic origin of LMT was not observed. Length of LMT- The average length of LMT was between 5-15mm. Following the standard protocol of classification of LMT based on length, < 5mm was noted in 20 (10%) reports, between 5-15mm in 120 (60%) reports and more than > 15mm in 60 cases (30%) (Fig 2A,B). Branching pattern of LMT- LMT bifurcated into LAD and LCX in 140 patients (70%), trifurcated in 56 patients (28%) (Figure 2C) with additional median artery and absent quadfurcation. In 4 cases (2%) direct origin of left anterior descending (LAD) and left circumflex artery (LCX) from left aortic sinus was noted (Figure 2D). Termination of LAD- In CAG reports, 80 cases (40%) showed termination before apex, 110 (55%) reports showed termination in the posterior one third of interventricular groove and in 10 reports (5%) it terminated at apex (Table 1).

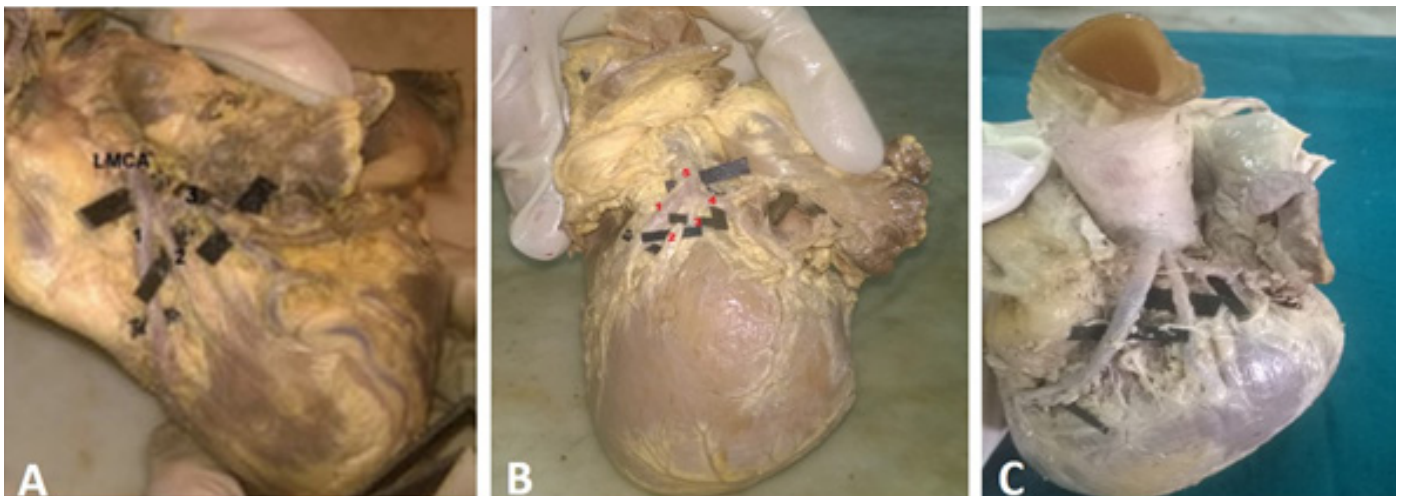


Figure 1. Cadaver Heart specimens showing Long MT(A) with trifurcation, Short MT(B) with Quadrifurcation and Absent MT (C) with direct origin of Left anterior descending, Median artery and left Circumflex artery.

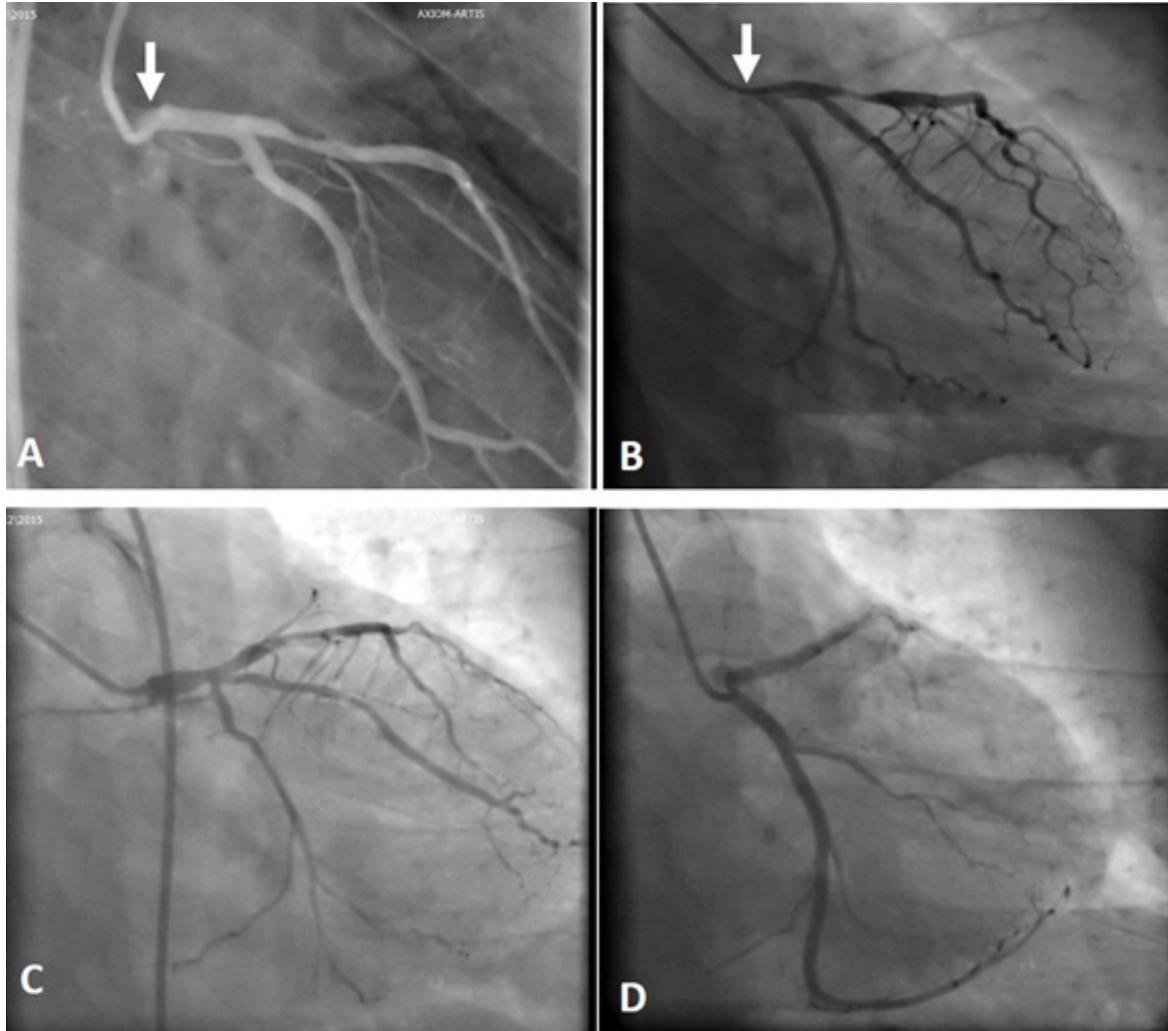


Figure 2. Coronary angiogram report of Right anterior oblique view of (RAO) showing Long MT(A), Short MT(B), Trifurcation of LMT(C), Separate origin of Left anterior descending and Left circumflex artery.

Table1. Left Coronary Artery (LCA) and its variations in Cadavers and in Angiography Reports.

Parameters Studied	Cadavers (n=50)	Angiography reports (n=200)
Origin from Left aortic sinus	100%	100%
Length of LMT		
<5mm	5(10%)	20(10%)
5-15mm	36(72%)	120(60%)
>15mm	9(18%)	60(30%)
Branches		
Bifurcation	31(62%)	140(70%)
Trifurcation	15(30%)	56(28%)
Quadfurcation	3(6%)	0
Direct origin	1(2%)	4(2%)
Termination of LAD		
At apex	12(24%)	10(5%)
Before apex	08(16%)	80(40%)
After apex	30(60%)	110(55%)

Discussion

Coronary artery variations (CAV) vary from region to region based on the characteristics of the study population. Any abnormality such as variations and anomalies can be identified by cadaveric studies and CAG reports. The incidence of CAAs ranges from 0.2% to 1.3% in CAG series and 0.3% in autopsy series^{7,8,9}. CAV's could be variations in origin, branching pattern and its course. According to Angelini and Khatami's modified classification of CAV. Group A CAV includes variations in origin and distribution and group B includes coronary artery fistulas (CAF). Several studies with large number of cases have reported varying incidences of CAV in CAG and CT angiography^{10,11}. The incidences of group A variations are reported to be more compared to group B. In the current series, group A variations were only studied. In the present study, left main trunk originated from left aortic sinus in both cadaveric and angiographic reports. Ectopic origin was not observed in both the series. On literature search, the most frequent anomaly was the absence of left main trunk and separate origin of the LAD and LCX from left aortic sinus with an incidence ranging

between 0.41%-0.67% in angiography reports⁸. The incidence of absence of LMT was reported in 0.43% in Indian population⁸, 0.23%, 0.58% and 0.9 % in Turkish population^{9,10,11}. In the current study, absent LMT was observed in 2% coronary angiographic reports. Earlier cadaveric studies in Indian population have not reported absent LMT. To our knowledge, ours is the first study to report absent LMT in 2% of cadaveric specimens. Absent LMT is one of the most important findings for clinicians. During coronary interventions, care should be taken to note the origin of LMT and its branches. Absence of LMT may misguide the clinicians in identifying the branches arising from the aortic sinus^{7,8}. Hence, knowledge about the incidence of absent LMT should be taken into consideration while doing any procedures.

In normal anatomy, left main trunk divides into two branches namely LAD and LCXA. Based on the length, left Main trunk is categorised as short MT and long MT variants. Length of LMT < 5 mm is considered as short MT and > 15mm as Long MT^{12,13}. Measuring the length of left main trunk plays an important role in the pathogenesis of ischemic heart diseases. In the current series, cadaveric study showed short MT in 5 cases (10%) which is similar to the findings of Mamatha *et al*¹⁴. Angiography reports also showed 10%. In earlier studies, a long MT > 15 mm was observed in 18% of cadaveric specimens and in 30% of CAG reports. But in both the studies the average length was predominantly between 5-15mm. Based on the length of LMT, stenotic lesions are grouped. Short MT have stenosis near the aortic ostium and long MT has stenosis near the bifurcation. Hence, short MT has been shown as a predisposing factor in the development of coronary artery disease and is considered as a risk factor in coronary artery perfusion during surgical operations^{15,16}. In the present series, long MT > 15 mm was observed relatively more in CAG reports, which could be due to catheter insertion and lengthening of LMT at the point of insertion. Earlier studies on CAG reports have shown that long LMT has no predisposing risk to CAD and it is benign⁹.

Branching pattern of left main trunk was studied by several authors in cadavers and in coronary angiography reports. Previous studies in cadavers have found wide variations in branching pattern with a greater incidence of bifurcated expression^{12,14}. Results of the present study showed bifurcation in 64%, similar to the findings of previous cadaveric studies. whereas it was 72% in CAG reports. The two arteries are left anterior descending and left circumflex artery. Trifurcation of LMCA with additional median artery was seen in 30% of cadaveric hearts and 26% in CAG reports. Presence of Diagonal/Median artery is important to understand the area of myocardial perfusion in case of MI. Presence of one or two median artery increases the area of left ventricular perfusion. Quadrifurcation of LMCA was seen in 6% cadaveric study and none in CAG reports. In case of quadrifurcation, two median arteries were

running parallel to each other along the left border was seen in cadaveric specimens. A cadaveric study by Reig and Petit reported presence of two median arteries in 38% cases^{12,13}. More incidence of trifurcation observed by Earlier studies on CAG reports have only mentioned bifurcation and trifurcation with absent quadfurcation¹⁰. While doing angiography in a patient with MI identification of the median artery plays a role in estimating the area of myocardium affected. Presence of median artery will reduce the area of left ventricular tissue affected in LAD occlusion and enhance the myocardial perfusion.

Hence, identifying and studying the course of median arteries is clinically important for treatment^{16,17}.

Based on the termination of LAD, termination can be at apex, before apex and after apex.

In the present study 60% of cadaver heart specimens and 55% of CAG reports showed termination of LAD in the posterior interventricular groove. Termination at apex was observed in 24% of cadaver hearts and in 5% of CAG reports. Whereas termination before apex was noted in 16% of heart specimens and in 40% of CAG reports. The higher percentage of termination before apex as observed in CAG reports could be due to the presence of Myocardial bridge (MB). In a similar study on CAG reports, incidence of MB was reported to be 0.1% in a Turkish population¹⁷. Clinically MB can cause complications such as vasospasm, angina pectoris and arrhythmias¹⁸. Earlier cadaveric studies have reported myocardial bridges in more than 50% of LAD compared to other coronary arteries¹⁹. Knowledge on the termination pattern is very important, to know the area of myocardium affected in LAD occlusion. When LAD terminates before apex, the most frequent area of myocardium affected is middle superior portion of left ventricle^{13,14}. Termination of LAD at apex and beyond apex has no clinical significance since there is anastomosis of other arteries at apex and posterior wall of left ventricle.

Conclusion

Though the incidence of variations observed in our study was similar to earlier reports from different parts of the world. In the present study the percentage of variations observed in both cadaveric and angiographic reports are different for each parameter studied. Overall, the absence of left main trunk and direct origin of LAD, LCX and median artery from left aortic sinus was 2% in both the studies. The observed findings of the present study in cadavers and in CAG reports could add knowledge to the clinicians for diagnosis and coronary interventions.

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Mini Curriculum and Author's Contribution

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