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### Original Article

## Clinically relevant morphometric analysis of left coronary artery

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#### ABSTRACT

The anomalous origin and branching pattern of the left coronary artery (LCA) is more significant anatomical variation. Difficulties may occur in the diagnostic procedures, but recognition of the anomaly is essential for proper patient management, especially in patients undergoing evaluation for percutaneous coronary intervention, coronary artery surgery or prosthetic valve replacement. A high prevalence of coronary artery disease was found in proximal vessels and especially at or adjacent to proximal points of branching. In the left anterior descending artery (LAD), the lesions were most prevalent, even in the left circumflex artery (LCx); there was a predilection for narrowing. In the present study sixty four heart specimens were collected over a period of three years from August 2008 to July 2011 in the department of anatomy and preserved in 10% formalin. After careful dissection all the branches of LCA were exposed and the number, position, level of ostium, ostium diameter, length of the main trunk, LAD and LCx were noted. The branching pattern of LCA was studied and categorized as bifurcation, trifurcation and quadrifurcation. The objective of this study was to analyze in one single series all the characteristics of LCA that may be of use in the diagnosis and treatment of its pathologies.

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### 1. Introduction

The cardiovascular system is the first major system to function in the embryo. The primordial heart and vascular system appear in the middle of the third week of embryonic life; but the heart actually starts functioning at the beginning of the fourth week [1]. Since then it undergoes rhythmic and regular contractions and relaxations completing the 'cardiac cycle' which never stops until the cardiac death. The heart is supplied by two coronary arteries viz right and left coronary artery. Each coronary artery is a vasa vasorum of the ascending aorta, because heart is developed from the fusion of two primitive endothelial tubes which represent the ventral aorta [2]. Most of the area of the heart is supplied by the LCA. The area irrigated by each of coronary arteries using postmortem angiography shows that the LCA irrigates 68.8% of the

cardiac muscle mass (41.5% by LAD and 27.3% by the LCx) [3]. These values may vary depending upon the coronary arterial dominant pattern. The LCA presents wide variability in its morphology with regard to length, caliber and the number of branches of its trunk. The knowledge of such variations is important with respect to morphological variations of the LCA and its branches, in determining areas related to arterial occlusive disease, in hemodynamic procedures, in handling heart trauma for their implications for heart surgery and finally in terms of academic value.

### 2. Materials and method:

Sixty four heart specimens were collected from the Department of Anatomy, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar, Andhra Pradesh, India over a period of three years from August 2008 to July 2011 and preserved in 10% formalin. By cutting the ribs and sternum; the thoracic cavity was opened. The great vessels were ligated by thread at two places and then cut in between. The parietal pericardium was incised and heart along with great vessels was taken out of the pericardial cavity. The aorta and pulmonary trunk were excised about 2 cm

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above the supra-valvular ridge. With gradual separation and retraction of the myocardial fasciculi, the LCA was exposed. The length of the main trunk was measured. The number of terminal branches of main trunk was noted. The ascending aorta was cut longitudinally to see the position, number, level of left coronary ostium. The diameter of ostium, outer diameter of LCA, LAD, LCx were measured by Vernier caliper and noted. The length of the LAD and LCx were also measured. Coronary arteries of significant findings were painted by red fevicryl colour to give a good contrast for photography and photographs were taken.

3. Results:

It was observed from table 1 that, in all the sixty four heart specimens studied; the position of ostium was in the left posterior aortic sinus. The level of ostium was different in relation to the supra-valvular ridge (SVR). The level of ostium was below SVR in 51 (79.7%) cases, at SVR in 11 (17.2%) cases and above SVR in 2 (3.1%) cases.

Table 1: Level of Left Coronary Ostium

Level of left coronary ostium	Numbers	Percentage
Below supra-valvular ridge (SVR)	51	79.7
At supra-valvular ridge (SVR)	11	17.2
Above supra-valvular ridge (SVR)	02	3.1
Total	64	100

In the present study, only one case, there were two ostia below SVR i.e. LAD and LCx directly arose from the ascending aorta (Figure 1). The mean ostium diameter of the LCA was 3.3 mm ± 0.57 (range 2 to 5 mm). The mean outer diameter and length of LMCA was 4.64 mm ± 1.03 (3.0 to 6.8 mm) and 11.2 mm ± 3.6 (range 4 to 20 mm) respectively.

Figure 1: Shows two ostia on the left side-one for LAD and another for LCx



As mentioned in table 2, the mean diameter of LAD was 3.19 ± 0.55 mm and its length was 85 ± 25.2 mm. The mean diameter of LCx was 2.94 ± 0.7 and its length was 45.6 ± 19.9 mm.

Table 2: Mean diameter and mean length of LAD and LCx artery

Name of the artery	Diameter (in mm)	Length (in mm)
left anterior descending (LAD) artery	3.19 ± 0.55	85 ± 25.2
left circumflex (LCx) artery	2.94 ± 0.70	45.6 ± 19.9

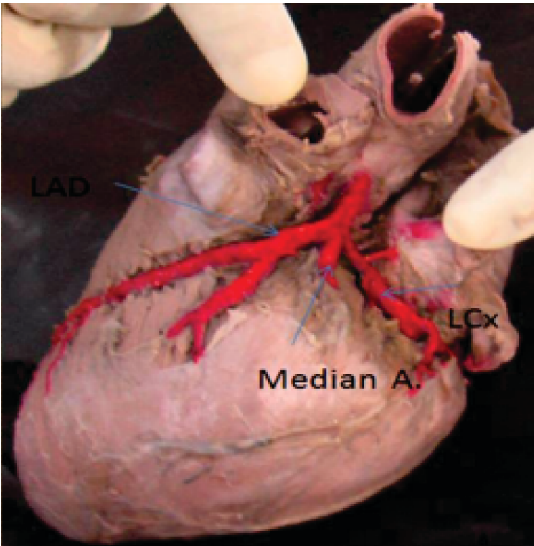
In relation to the branching pattern of LMCA, we found bifurcation in 35 (54.7%) cases followed by trifurcation in 23 (35.9%) cases (Figure 2), and quadrifurcation in 5 (7.8%) cases (Figure 3), while in one (1.6%) case LAD and LCx directly arose from the aorta.

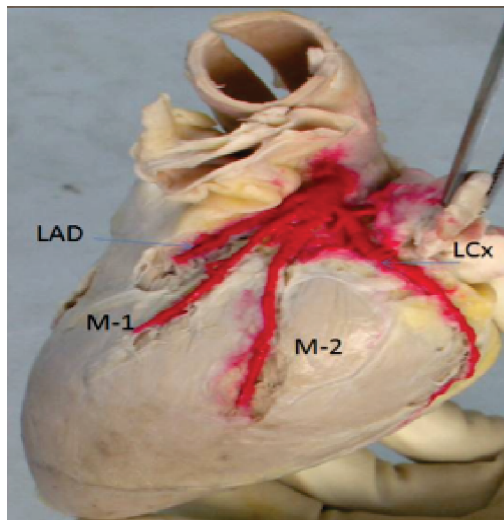
Table 3: Comparison of the branching pattern of LCA with the past studies

Author(s) and Year	Specimens	Branching pattern
Baptista et al, 1991 [17]	100	B:60%; T:38.18% Direct LAD & LCx from ostium:1.8%
Cavalcanti et al, 1995 [18]	100	O:1%; B:47%; T:40%; Q:11%; P:1%
Reig et al, 2004 [10]	100	B:62%; T or Q:38%
Ballesteros L.E. et al, 2008 [15]	154	B:52%; T:42.2%; Q:5.8%
Das Hirak, 2005 [16]	100	B:60%; T:35%; Q:5%
Present study	64	B:54.7%; T:35.9%; Q:7.8% Direct LAD & LCx from ostium:1.6%

O- One branch; B- Bifurcation; T- Trifurcation; Q- Quadrifurcation; P- Penta-furcation

Figure 2. Trifurcation of LCA



**Figure 3. Quadrifurcation of LCA M-1 & M-2: Median artery**

#### 4. Discussion:

The anatomy of LCA has recently been reemphasized in association with the use of coronary arteriography. The importance of ostium anomalies relates to the surgical difficulties encountered in cannulating these vessels during open aortic surgery or in performing coronary arteriography. The number, location, level and size of the ostium are very important in successful performance of coronary angiogram. Normally there is only one ostium in the left posterior aortic sinus for the LCA. But multiple ostia were reported in the left posterior aortic sinus [4, 5, 6]. In the present study in one case (1.6%) two ostia were present in the left posterior aortic sinus i.e. LAD and LCx directly arose from the aorta.

Banchi A. [7] reported that the LCA arose at the level of free margin of aortic cusps in 48%, above in 34%, and below in 18%. A study by Kalpana R. [8] revealed that the ostium was below the level of STJ (sino-tubular junction) in 80% and at STJ level in 20%. In the present study the level of left coronary ostium was below SVR in 79.7% cases, at SVR in 17.2% cases and above the SVR in 3.1% cases. The results of the present study coincide with the observations of Kalpana R. Difficulty in manipulating the catheter tips will be considerably higher in patients with the ostium above the level of STJ.

The diameter of coronary arteries; both main stem and larger branches have often been recorded. The maximum ranges recorded in major studies are 1.5 to 5.5 mm for coronary arteries at their origin. Baroldi and Scmazzone (1967) gave the mean diameter of LCA and right coronary artery as 4.0 and 3.2 mm respectively [1]. The left exceeds right in about 60% of the hearts, right being larger in 17%, the vessels approximately equal in 23%. Vogelberg et al. [9] considered that coronary artery diameter increases up to thirtieth year. Reg J et al. [10] studied all the characteristics of the main trunk of LCA in 100 autopsy heart specimens. The diameter of the main trunk measured at its mid-point was found to be in between 3 to 7 mm with average value  $4.86 \pm 0.8$  mm.

In the present study the mean ostium diameter of the LCA was  $3.3 \text{ mm} \pm 0.56$  (range 2 to 5 mm) and the outer diameter of the LMCA was  $4.64 \text{ mm} \pm 1.02$  (range 3.0 to 6.8 mm). Jeffery J. [11] mentioned that balloon angioplasty of aorto-ostial lesions and ostial lesions of LAD and LCx coronary arteries has been associated with reduced success and high recurrence rates owing to smooth muscle and eccentric intimal proliferation noted pathologically in ostial lesions.

In the present study the mean length of the LMCA was  $11.2 \text{ mm} \pm 0.36$  (range 4 to 20 mm). Similarly by Green G.E. et al [12] studied the length of the LMCA in 50 consecutive autopsy specimens in which 48% of cases, the LMCA were 10 mm or less in length; in remaining 52% cases the length was up to 25 mm. A study by Reg J et al. [10] revealed that the average length of the main trunk of LCA was  $10.8 \pm 5.52 \text{ mm}$  (range 2 to 23 mm). The short LMCA explains some failures of adequate coronary perfusion. During aortic valve surgery myocardial perfusion depends on the placement of one or more cannulas in the coronary arteries. In this regard the length of the LCA prior to its bifurcation is particularly important. A short main trunk makes carrying out coronary angiography difficult because when catheter is inserted into one of the terminal branches, the opacification of the other branch does not occur and an incomplete image of the coronary tree is seen.

Banchi A. [7] described the termination of LCA varying between two or three branches with the most common pattern the bifurcation (64%). He also mentioned the possibility of the main trunk dividing into three or four branches (35% and 5%) respectively; these complimentary branches were termed as median arteries. The division of the main trunk of LCA is a controversial topic since Banchi's study; because contradictory data have been published regarding the frequency of bifurcation or trifurcation. Identification of the median artery is important clinically. Its area of distribution to the heart is small. In the absence of this artery the area is irrigated by the branches of LAD and LCx; so in the occlusion of LAD & LCx more area is affected. When this median artery (ramus intermedius) is present, its origin is frequently the site of narrowing.

Rex N et al. [13] measured the human coronary artery size by cine-arteriography in 99 patients. The mean diameter of LAD was  $3.5 \text{ mm} \pm 0.5$  (range 2.9 to 4.7 mm) and the mean diameter of the LCx artery was  $3.1 \text{ mm} \pm 0.7$  (range 1.7 to 4.1 mm). In the present study the mean outer diameter of LAD was  $3.19 \text{ mm} \pm 0.5$  (range 2.0 to 5.02 mm) and the total length of LAD was  $84.6 \pm 25 \text{ mm}$ . The mean outer diameter of the LCx artery was  $2.94 \text{ mm} \pm 0.7$  (range 2 to 5 mm) and the mean length of the LCx was  $45.6 \pm 19.9 \text{ mm}$ . A study by Charles Welch [14] revealed that the LAD artery is most frequently involved and affected in 60% of single vessel disease.

#### 5. Conclusion:

The advances made in coronary arterial bypass surgeries and modern methods of myocardial revascularization makes it imperative that thorough sound and complete knowledge of the normal and variant anatomy of the left coronary artery and its circulation is required which led to the present study.

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