Section: Anatomy

Original Research Article

AN ANATOMICAL STUDY ON VARIATIONS OF LEFT CORONARY ARTERY AND ITS BRANCHES

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ABSTRACT

Background: The coronary arteries are the vital for perfusion of the heart muscle. Anatomical variations in their branching patterns, as well as congenital abnormalities, can significantly affect myocardial blood supply, alter hemodynamics, and influence clinical symptoms. These variations may also increase the risk of atherosclerosis within these vessels. Since myocardial infarction is a leading cause of death, understanding these anatomical features is crucial. **Aim:** To describe the variation in the branching pattern and dimensions of left coronary artery. **Materials and Methods:** We dissected and grossly examined a total of 100 embalmed human hearts. **Results:** The mean length of the LCA, was 9.6±3.05mm, Whereas the mean outer diameter of left coronary artery (LCA) was 4.32±2.03mm.The main trunk of the LCA bifurcated in 65 specimens (65%), trifurcated in 30 specimens (30%) andquadrifurcated in 5 specimens (5%).**Conclusion:** Knowledge of normal and variant coronary artery anatomy is essential for accurate diagnosis, effective treatment, and safe procedural intervention.

INTRODUCTION

The heart is the vital organ that pumps blood to the entire body through the systemic circulation, originating from the aorta. However, the myocardium of the heart is supplied and gets its nutrition through two coronary arteries (Left and Right), which are located between the epicardium and myocardium. Left coronary artery (LCA) usually arises from left posterior aortic sinus and divides into a left anterior descending artery (LAD) and the left circumflex artery (LCx).[1]The LCA is responsible for the irrigation of most of the left ventricle and also a considerable proportion of the right ventricle.[2]A thorough knowledge of normal and variant coronary anatomy is vital in managing both congenital and acquired heart disease. As the use of diagnostic and therapeutic interventional procedures increases, a sound knowledge of coronary artery anatomy has become indispensable. This foundational knowledge enables cardiologists and radiologists to accurately predefine abnormalities using various imaging modalities.Numerous data on arterial variations have been reported, but their clinical significance requires further exploration. An extensive review of the literature revealed a high degree of variation in the branching pattern of the LCA. Earlier studies have also documented cases of its trifurcation, tetrafurcation, and pentafurcation.[3-5] This study aims to establish the branching patterns of the LCA. This knowledge is significant, as these variations have important anatomical, pathophysiological, diagnostic, and therapeutic implications.

MATERIALS AND METHODS

The present study was conducted at the Department of Anatomy, Government Medical College Krishnagiri, Tamilnadu. These specimens were taken from embalmed human cadavers used for undergraduate studies irrespective of sex and race, age ranging from 40 to 70 years.The specimens were dissected carefully.The study was approved by the Institutional Ethics Committee (No: (CDSCO): EC/NEW/INST/2023/15250-41012024).

Methodology: The thoracic cavity was opened by cutting the ribs and sternum. The great vessels were ligated in two places with thread and then cut between the ligatures. After incising the parietal pericardium, the heart, along with the great vessels, was removed from the pericardial cavity. The coronary arteries and their branches were then dissected on the surface of the heart within the atrioventricular and interventricular grooves by gradually separating and retracting the myocardial

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fascicule. Following microdissection to remove the epicardium, the coronary arteries were examined. After the left coronary artery and its branches were fully exposed, the branching pattern and the spatial relationships of the vessels were documented. Any vascular variations or anomalies were recorded. The length and external diameter of the LCA were measured using digital calipers. All data were manually recorded. The dissected vessels and their branches were also photographed.

RESULTS

In all 100 heart specimens, the dissected left coronary artery (LCA) was found to arise from the left posterior aortic sinus of the ascending aorta. As mentioned in Table 1, The mean length and outer diameter of the LCA, was 9.6±3.05mm and 4.32±2.03mm respectively.

The main trunk of LCAruns a short course after its originand then mainly divides into LAD and circumflex artery (CA). The most frequent type of division was a bifurcation into two terminal branches as LAD and CA [Figure 1A]. Third branch coming from the main trunk of LCA other than LAD and CA is called ramus intermedius (diagonal) which is seen in trifurcation of LCA [Figure 1B]. In quadrifurcation total four branches arise from main trunk, they are LAD, CA and two diagonal arteries (Figure 1C). The main trunk of LCA bifurcated in 65 specimens (65%), trifurcated in 30 specimens (30%) and quadrifurcated in 5 specimens (5%).

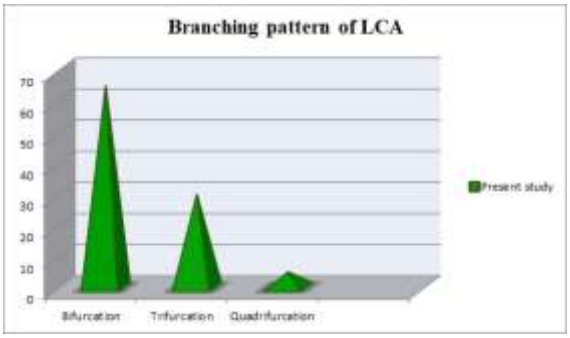

Figure 1: Comparison of branching pattern of the left coronary artery (LCA).

Table 1: Length of theLeft coronary artery (LCA).

Length of LCA (mm)	Frequency	Percentage
≤ 5mm	12	12 %
6-10 mm	67	67%
11-15mm	19	19 %
16-20mm	02	2%
Total	100	100 %

DISCUSSION

Cardiovascular diseases are the leading cause of mortality worldwide, being responsible for about one-third of all deaths. With the increasing burden of coronary heart diseases, the detailed anatomy of coronary arteries has been extensively studied by medical professionals.[5]

Nowadays, with the extensive use of advanced imaging diagnostic techniques and the development of non-invasive treatments, a in depth knowledge of the anatomy of the normal coronary arteries, their variations and anomalies is important. Branches of coronary arteries may vary in origin, distribution, number and size. The origins of coronary arteries show great variability, about 90% of anomalies were anomalies of origin.[6] It was observed that in all the 100 heart specimens. The LCA is the main source of blood supply to the heart.[1,2] In a postmortem angiographic study, it was demonstrated that the left coronary artery (LCA) supplies 68.8% of the total cardiac muscle mass and 79% of the left ventricular myocardium. Consequently, LCA obstruction can reduce perfusion to a large proportion of the ventricle, explaining why atherosclerotic disease in the LCA has more serious complications than in the right coronary artery (RCA).

Bhele et al,[8]reported that when the common trunk of LCA is less than 5 mm then it is considered to be short and when it is more than 15mm, it is considered as long common trunk. In the present study the LCA trunk was short (<5 mm) in 12 cases (12%). A long trunk (>10 mm) was found in 21 specimens (21%). The average length ranged from 2.5 mm to 15 mm.

These results were consistent with the Reig & Petit study,[2]which reported an average of 10.8mm. Kalpana R[9] observed length of the main trunk of LCA ranges between 6mm to 15mm. Study conducted by Kulkarni et al[10] reported the length of LCA to be 5mm in 76.7% of specimens, while it was observed to be 10mm in 5% of specimens. Waller &Schlant,[11]revealed the length of LCA to be 6 mm in 76% of all specimens and 10mm in 3% of specimens. Reddy &Pusala,[12] observed, that the LCA ranges in length from 1 to 25mm before bifurcating into the LAD and CA. However in the current study, the mean length of LCA was 9.6±3.05mm. Dattatray D et al,[13]reported the mean length of LCA was 8.5±25.2mm. The length of the left main coronary artery (LMCA) is clinically significant, as a short LMCA may contribute to failures of adequate coronary perfusionduring aortic valve surgery, myocardial perfusion depends on the placement of one or more cannulas in the coronary arteries. In this regard, the length of main LCA prior to its bifurcation is particularly important.[14]

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A short trunk of LCA could be at risk during aortic valve replacement surgeries. The catheter may be inserted into one of the terminal branches, thereby producing an ischemic area, which can lead to arrhythmia, myocardial ischemia or both. A short trunk has also been considered as a risk factor in developing coronary atherosclerosis.[15]

The diameter of LCA was recorded. The mean diameter of LCA was 4.32±2.03mm. Similar findings were reported by Dattatray D et al,[13]the mean diameter of LCA was 4.64±1.02mm. Fazliogullari Z et al.[16]reported that the average diameter of LCA was 4.44±1.79mm. Reg & Petit,[2] studied all characteristics of the main trunk of LCA in 100 autopsy heart specimens and found the diameter of the main trunk measured at its midpoint was between 3 and 7mm with average value 4.86±0.8mm.

Loukas et al[17] noted that to evaluate the value of screening, it is first necessary to determine the incidence of coronary variations that can potentially cause sudden cardiac death. Furthermore, such variations in coronary origin and branching can complicate imaging with conventional catheters, leading to challenges in both diagnosis and intervention.[10]

Table 2: Comparison of dimension of the left coronary artery with previous studies

Authors	No. of Specimens(n)	Mean length of LCA (mm)	Mean diameter of LCA (mm)
Reig& Petit et al2	100	10.8	4.86±0.8
Dattatray et al13	64	8.5±2.5	4.64±1.02
Present study	100	9.6±3.05	4.32±2.03

In the present study, bifurcation of LCA was found in 65 specimens (65%), trifurcation in 30 specimens (30%), quadrifurcation in 5 specimens (5%).

Similar results have been reported by Agnihotri Get al.[22] Reig & Petit[2]and Cvalcantiet al.[23] Bosco.19 reported that in 2% of the specimens, there was no division of the main LCA trunk, while 42% of the specimens had bifurcation and 55% had trifurcation. Hadziselimovic[20] observed that out of the 52% of cases with bifurcation in the series, 44% had trifurcation and only 4% had more than three branches. Benther et al[21] reported that 2% of specimens with no division of the trunk, 89% with bifurcation and 9% with trifurcation. A comparison of the various studies is shown in [Table 3].

The diagonal branch is considered to be the artery located in the angle formed by the LAD and the circumflex artery (CA). A broader definition describes it as originating at the vertex of the angle formed by the terminal branches of the left coronary artery (LCA).[22]

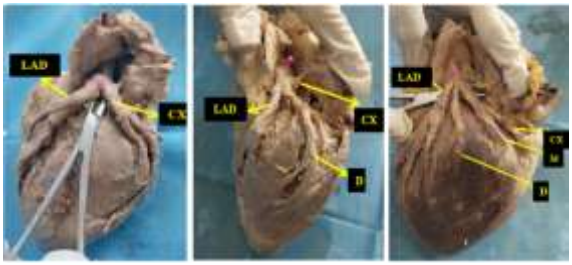

Figure 2a.Bifurcation of LCA. Figure2b: Trifurcation of LCA. Figure 2c:Quadrifurcation of LCA

Abbreviation:**LAD** – Left Anterior Descending Artery; **CX** – Circumflex Artery:D – Diagonal Artery:**M** – Median Artery

Table 3: Comparison of branching pattern of the left coronary artery with previous studies

Authors	No. of Specimens (n)	Bifurcation (%)	Trifurcation (%)	Quadrifurcation (%)	Pentafurcation (%)
Reig& Petit et al[2]	100	62	38	-	-
Baptistaet al[3]	150	54.7	38.7	6.7	-
Kalbfleisch et al[7]	141	51.1	44.4	4.3	-
Kalpana et al[9]	100	47	11	1	-
Dattatray et al[13]	64	54.7	35.9	7.8	-
Cavalcanti[23]	110	60	38.18	-	-
Ballesteros et al[15]	154	52	42.2	5.8	-
Fazliogullari et al[16]	50	46	44	10	-
Surucu et al[18]	40	47.5	47.5	2.5	2.5
Agnihotri et al[12]	100	66	30	4	--
Hadziselimovic[20]	-	52	44	4	-
Bosco[19]	-	42	55	-	-
Present study	100	65	30	5	-

Embryology

Coronary artery development proceeds through sequential vasculogenesis, angiogenesis, and arteriogenesis, with integration into the systemic circulation occurring as a secondary event.[24,25] Lineage-tracing studies, notably using quail-chicken chimeras, have established the proepicardial epithelium (PEO) as the principal source of coronary precursors. PEO-derived cells migrate to the heart, forming the epicardium, and a subset undergoes epithelial-to-mesenchymal transition to become epicardium derived cells (EPDCs). These EPDCs generate a primitive peritruncal vascular plexus,[26] which subsequently remodels and invades the aortic root to form initial coronary orifices,[27] predominantly within the left and right aortic

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sinuses. However, the existence of multiple aortic orifices for the coronary arteries has been described; most of these regress with further development, so that only the definitive coronary arteries persist.[28-31]

CONCLUSION

Early diagnosis of coronary artery anomalies is crucial for reducing cardiovascular morbidity and mortality. The high degree of variability in the left coronary artery (LCA) and its branching patterns has significant anatomical, pathophysiological, diagnostic, and therapeutic implications. These variations can cause technical difficulties during catheterization and may lead to complications or misdiagnosis. Hence, adequate knowledge of LCA variations is essential for accurately interpreting coronary angiography and for performing stenting procedures and surgical myocardial revascularization.

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