

Original Research Article

Variations in the anatomical and branching pattern of the left coronary artery: a cadaveric study

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ABSTRACT

Background: Coronary arteries are the branch of ascending aorta and it is the main arterial supply of the myocardium of the heart. Left coronary artery (LCA) usually arises from left posterior aortic sinus. The site of manifestation of myocardial infarction depends on the occlusion of an artery or its branches involved in atherosclerosis. To know the site of lesion and occlusion of the particular artery, detailed anatomy of its course, branches and variations to be studied in detail.

Methods: Study was conducted on 55 heart specimens in Department of Anatomy at Sri Siddhartha Medical College (SSMC), Sri Siddhartha Academy of Higher Education (SSAHE). The left coronary artery was dissected carefully, and it was traced from its origin. Any variation in the course and branching pattern was recorded and photographed.

Results: No variation was found in the origin of LCA. In the present study, the most frequent division pattern of the left coronary artery was observed as the bifurcation in 30 specimens (54.54%) followed by trifurcation in 23 specimens (41.82%). Tetrafurcation and pentafurcation of LCA were observed in one specimen each (1.82%).

Conclusions: Our study tries to focus on branching pattern of LCA for the better knowledge of accurate diagnosis and therapeutic intervention in the management of coronary artery diseases.

Keywords: Anomalies, Coronary arteries, Heart vessels

INTRODUCTION

Heart act as a vital organ in terms of performance because it pumps the blood for the entire tissue in the human body through the aorta. However, the myocardium of the heart is supplied and gets its nutrition through coronary arteries (large vasa vasora). Coronary arteries are the branch of ascending aorta and it is the main arterial supply of the myocardium of the heart. Left coronary artery (LCA) usually arises from left posterior aortic sinus and divides into a left anterior ascending artery (LADA) and left circumflex artery (LCx).¹ An extensive review of the literature, we found that there is a high degree of variation in the branching pattern of LCA.

Trifurcation, tetrafurcation and pentafurcation of LCA were also documented in the earlier studies.²⁻¹⁵

Knowledge of branching pattern of the left coronary artery is not to be regarded as trivial in diagnostic imaging necessary for surgery of congenital heart disease.

With the expansion of modern technologies like coronary MR angiography, electron beam CT (EBCT) and coronary CT angiography, it is now possible to diagnose/predict many adverse coronary arterial diseases. The aim of the present study is to undertake and document the branching pattern, level of termination and variations of LCA in human cadaveric hearts.

METHODS

The total number of specimens used for this study is 55 adult human heart specimens. The specimens were obtained from routine dissection in the Department of Anatomy at Sri Siddhartha medical college (SSMC), Sri Siddhartha Academy of Higher Education (SSAHE), Tumakuru. The thoracic cavity was opened by reflecting the anterior thoracic wall. Heart along with great vessels is taken out from the pericardial cavity after incising the parietal pericardium.

All the specimens were numbered and stored in rectangular glass jars containing 10% formaldehyde. The left coronary artery was dissected carefully, and it was traced from its origin. Any variation in the course and branching pattern was recorded and photographed. A rough sketch was prepared regarding origin, course and branching pattern of the left coronary artery.

RESULTS

In all 55 specimens, LCA was originated normally, i.e. from left posterior aortic sinus. No abnormal origin was noted. In the present study (Table 1), the most frequent

division pattern of the left coronary artery was observed as bifurcation (divides into left anterior descending and left circumflex Artery) in 30 specimens (54.54%) followed by trifurcation in 23 specimens (41.82%).

The additional artery arising from the main trunk other than left anterior descending and left circumflex Artery in trifurcation is called as ramus intermedius (left Diagonal artery). Tetrafurcation and pentafurcation of the main trunk of left coronary artery were observed in one specimen each (1.82%).

Table 1: Division of the main trunk of LCA.

No. of Branches	Number	Percentage
A Bifurcation	30	54.54 %
B Trifurcation	23	41.82 %
C Tetrafurcation	1	1.82 %
D Pentafurcation	1	1.82%

In tetrafurcation, the additional artery is named as ramus intermedius 1 and ramus intermedius 2 (act as left diagonal and left marginal artery). The fifth artery in Pentafurcation was observed as left conus artery (Figure 1).

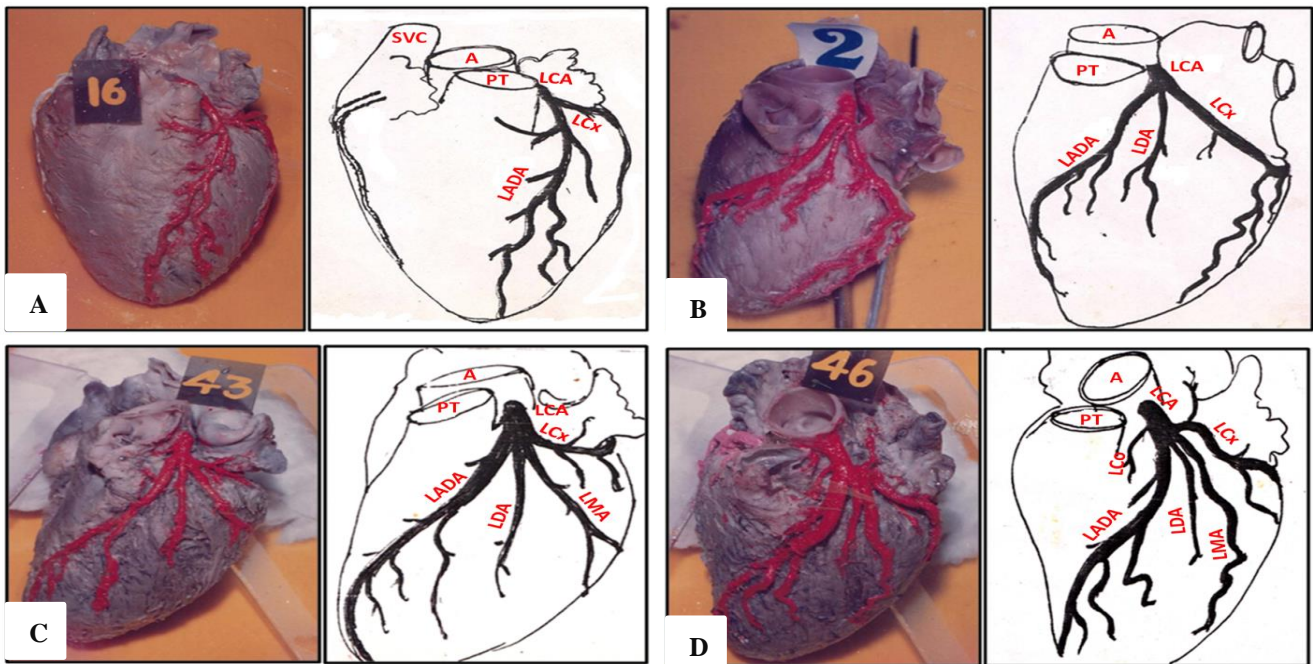


Figure 1: The branching pattern of LCA. A) Bifurcation, B) Trifurcation, C) Tetrafurcation and D) Pentafurcation. LCA-left coronary artery, LADA-left anterior descending artery, LCx-left circumflex artery, LDA-left diagonal artery, LMA-left marginal artery, LCo-left conus artery, A-ascending aorta, PT- pulmonary trunk, SVC-superior vena cana.

Table 2 shows the termination of LADA, LCx as well as origin and termination of LDA. In the present study, 80%

of specimens LAD were terminated after wrapping around the apex and supplying inferoapical segment.

In 60% of specimens, LCX was terminated between the obtuse border and crux. In 74.5% of specimens, LDA was terminated before the apex.

DISCUSSION

Coronary artery disease (CAD) or coronary artery anomalies are congenital alterations in origin, course and structure of the coronary arteries which entail a risk of sudden death. CAD represents one of the major causes of morbidity and mortality in India especially in the urban population.^{16,17} The coronary arteries are the first vessel arises from the ascending aorta and left coronary artery (LCA) arises from left posterior aortic sinus. Its length may vary, not generally more than a few millimeters. The main trunk of left coronary artery usually doesn't give any branches but terminates into a left anterior descending artery (LADA) and Left Circumflex artery (LCx). While analyzing and comparing the branching pattern of LCA in the literature, there is a great variability in the branching pattern in the normal population and the most common branching pattern of LCA reported was bifurcation into LADA and LCx arteries. Similarly, in the present study, we observed that the most common branching pattern of LCA was bifurcation followed by trifurcation. The incidence of bifurcation of LCA into LADA and LCx in the literature varies from 45% to 80%.²⁻¹⁵ In the present study, the incidence of bifurcation of LCA was 54.54% which coincides with the result reported by Ogeng'o.¹¹ But the study conducted by Bosco observed that in 2% of the specimens, there was no division of the main LCA trunk.¹⁸

Table 2: The termination of LADA, LCX as well as origin and termination of LDA.

		Number	%
Level of termination of LADA			
A	Before cardiac apex	4	7.3
B	Reaching apex but not supplying inferoapical Segment	7	12.7
C	LADA wrapping around apex and supplying inferoapical segment	44	80
Level of termination of LCx			
A	Proximal to Obtuse border	0	0
B	At obtuse border	2	4
C	Between obtuse border and crux	33	60
D	At the crux	0	0
E	Turn at right angle to continue in PIVS	16	29
F	Between crux and acute border	4	7
Origin of LDA			
A	Main Trunk of LCA	25	45.45
B	LADA	30	54.55
C	LCX	0	0
Level of termination of LDA			
A	Before apex	41	74.5
B	At apex	14	25.5
C	Beyond apex	0	0

Comparison of variations related to the branching pattern of LCA with different studies was tabulated and compared with present study in Table 3.

Table 3: Variation in the branching pattern of LCA among the different population.

Authors	No. of Specimens	Branching pattern of LCA (%)			
		Bifurcation	Trifurcation	Tetrafurcation	Pentafurcation
Baptista et al ²	150	54.7	38.7	6.7	-
Kalpana et al ³	100	47	40	11	1
Surucu et al ⁴	40	47.5	47.5	2.5	2.5
Reig & Petit et al ⁵	100	62	38	-	-
Ballesteros et al ⁶	154	52	42.2	5.8	-
Bhimalli et al ⁷		56.7	33.3	8.3	-
Udhayakumar et al ⁸	40	75	22.5	2.5	-
Agnihotri G et al ⁹	100	66	30	4	-
Dharmendra et al ¹⁰	93	58.06	35.48	6.45	-
Ogeng'so JA et al ¹¹	208	54.8	32.2	9.6	3.4
Mirza R U Beg et al ¹²	40	45	42.5	10	-
Patel J P et al ¹³	50	74	18	6	2
Mallashetty NS et al ¹⁴	30	66.67	23.33	10	
Vandana Ravi et al ¹⁵	30	80%	13.3	3.3	3.3
Present study	55	54.54	41.82	1.82	1.82

The second prominent finding in the present study was trifurcation with the incidence of 41.82%. The incidence

of Trifurcation of LCA in the literature varies from 18-47.5%.²⁻¹⁵ Our finding was similar to Ballesteros et al,

Mirza RU Beg et al, who had reported the incidence of trifurcation of LCA in 42.2% and 42.5% respectively.^{6,12}

The distinguished observation of the present study is the comparatively lower incidence of tetrafurcation (1.82%). The incidence of tetrafurcation in the literature ranges between 2.5-11%. The occurrence of pentafurcation of LCA was not well documented. From the literature reviewed, there are very few authors were documented the frequency of pentafurcation which ranges between 1-3.4%.^{3,4,11,13,15} Out of 55 specimens studied, pentafurcation was found in one specimen (1.82%). The highest incidence was observed by Ogeng'o who had reported in 7 Specimens (3.4%).¹¹

LADA arises as one of the branches of bifurcation of LCA, emerges on the anterior surface of the heart between the pulmonary trunk and auricle of the left atrium. It descends obliquely forward to the left in the anterior interventricular sulcus and reaches the apex of

the heart. LADA almost wrapping around the apex and runs into the posterior interventricular sulcus. There is no abnormal origin of LADA was found. In the present study, the LADA reaches and terminates at the apex in 12.7% of specimens. Our finding was concordance when compared to the study done by Kalpana et al but contradicts with Ballesteros et al and Mallashetty et al, who have reported the incidence of 50% each, which was higher than our study.^{3,6}

In 80% of specimens, the LADA wrapped around the apex and supplied the inferoapical segment. Other researchers like Kalpana et al and Siri AM et al have reported similar findings 80% and 87% respectively regarding the termination of LADA.^{3,19} Table 4 shows the report of various authors regarding the termination of LADA.

Table 4: Level of termination of LADA.

Level of termination	Authors				
	Kalpana R ³	Siri AM ¹⁹	Ballesteros ⁸	Mallashetty ¹⁴	Present study
A Before cardiac apex	8	0	3.33	3.33	7.3
B Reaching apex but not supplying inferoapical segment	12	13	50	50	12.7
C LAD wrapping around apex and supplying inferoapical segment	80	87	46.6	46.6	80

Table 5: Level of termination of LCx.

Level of termination	Authors				
	Kalpana R ³	Hirak Das ²¹	Anbumani ²²	Mallashetty ¹⁴	Present study
A Proximal to Obtuse border	0	0	0	6.6	0
B At obtuse border	13	17.14	4	0	4
C Between obtuse border and crux	67	52.86	80	60	60
D At the crux	6	18.57	0	26.6	0
E Turn at right angle to continue in PIVS	0	0	16	0	29
F Between crux and acute border	11	11.4	0	6.6	7

Documentation of duplication or dual LADA is quite not uncommon in the literature. Dual LADA termed when it consists of early bifurcation into one early terminating branch which remains in the anterior interventricular sulcus and a second branch which has variable course outside either to the right or left side of the sulcus but returns to it distally.²⁰ The frequent of this variant in the present study was seen in 2 specimens (3.6%) (Figure 2).

LCx is the second main division of LCA generally runs towards the left border of heart. After wrapping around the left border, it runs into the posterior part of the left

coronary sulcus and almost terminates just before the crux of the heart but sometimes it continues as a posterior interventricular artery. The variation in the termination of LCx is very frequent and illustrated in Table 5.

In general, the LDA arises from LADA but variability in origin from the neighboring arteries like LCA and LCx are also documented. In the present study, the incidence of LDA arises from the main trunk of LCA in 25 specimens (45.45%), from LADA in 30 specimens (54.55%). In none of the specimens, LDA arises from

LCx. The LDA was terminated before the apex in 74.5% of specimens and at the apex in 25.5% of specimens.

Our observation is almost similar to Mallashetty et al, where he observed the termination of LDA before the

apex in 76.67% and at the apex in 23.33% of specimens.¹⁴ In the present study, none of the LDA was terminated beyond the apex.

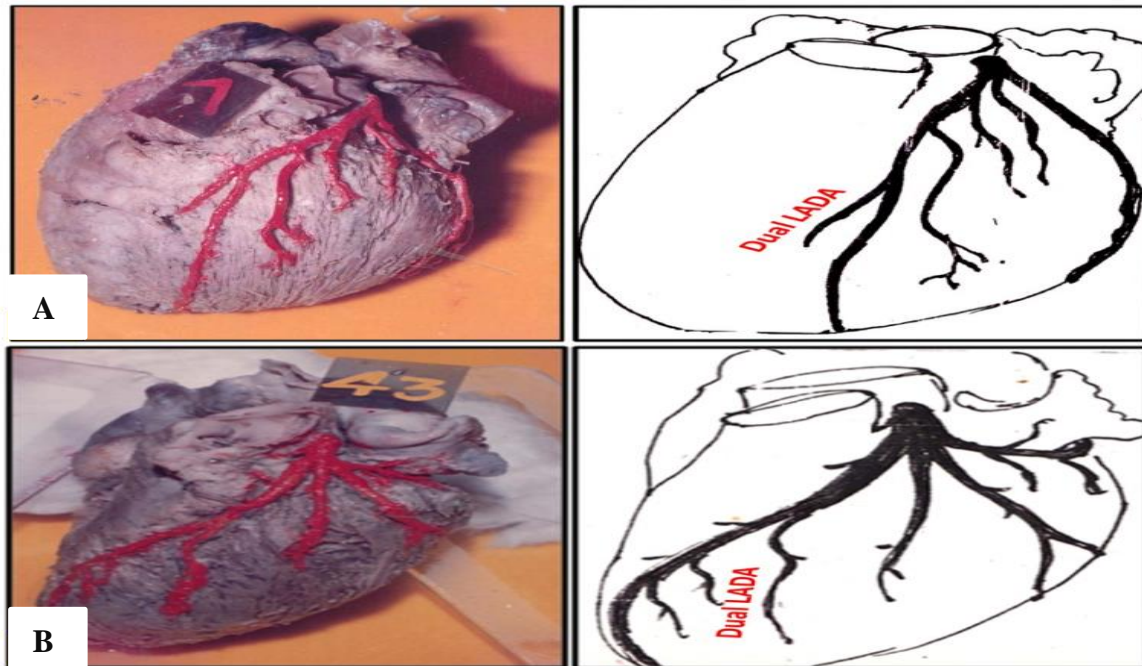


Figure 2: Dual LADA. LADA-left anterior descending artery.

The coronary arteries pass through several complex steps during their development in utero which includes angiogenesis, vasculogenesis, arteriogenesis and remodeling. Any disturbances above said steps leads to variant branching pattern of coronary arteries.²³

CONCLUSION

Early diagnosis of patients with coronary artery abnormalities or anomalies can reduce the morbidity and mortality for cardiovascular death and are important in considering the severity of coronary stenosis, particularly during therapeutic maneuvers such as angioplasty and bypass surgery. Variability in the branching pattern of LCA can cause technical difficulties in catheterization and may be a source for complication or misdiagnosis. Hence it is mandatory for the operating surgeon to know about the normal anatomy and the variations of branching pattern of LCA.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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