

## Cadaveric study of the origin, course, branching pattern, and termination of the left coronary artery in Indian population: An observational study.

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### ABSTRACT

**Background:** The heart functions as a vital organ by pumping blood to all body tissues through the aorta. Its muscular wall (myocardium) receives oxygen and nutrients from the coronary arteries, which are divided into right and left coronary arteries.

**Methods:** A total of 50 adult human heart specimens were included in the study. The specimens were obtained from deceased individuals subjected to routine cadaveric dissection for undergraduate (MBBS) teaching purposes in the Department of Anatomy, Index Medical College Hospital & Research Centre (IMCH & RC), Indore. We proceeded to investigate the branching pattern of the LCA. Throughout their whole course, from the point of origin to the point of termination of LCA was tracked. The branching of LCA was observed till their termination. Any variation in the course and branching pattern was recorded and photographed.

**Results:** The left coronary artery most commonly originated from the left posterior aortic sinus (98%) which is the most common pattern, with only a rare origin from the anterior aortic sinus (2%). Regarding branching pattern, bifurcation was the predominant type (82%), followed by trifurcation (14%), while single and quadrifurcation patterns were uncommon (2% each).

**Conclusions:** the present study focuses on elucidating these variations to aid in accurate diagnosis and effective therapeutic management of coronary artery disease.

**Keywords:** Anomalies, Coronary arteries, Heart vessels, Left coronary artery, left descending artery, left circumflex artery.

### 1. INTRODUCTION

The heart functions as a vital organ by pumping blood to all body tissues through the aorta. Its muscular wall (myocardium) receives oxygen and nutrients from the coronary arteries, which are divided into right and left coronary arteries. The left coronary artery originates from the left posterior aortic sinus, passes between the pulmonary trunk and the left atrial auricle, and then divided into its two terminal branches the anterior interventricular/ anterior descending artery and circumflex branches, with an occasional diagonal branch. Being larger than the right coronary artery, it supplies the major portion of the left ventricle and left atrium [1, 2]

Anomalous coronary artery origins have important clinical implications during open-heart surgery, as multiple coronary ostia and variant branching patterns may contribute to conditions such as hypertrophic cardiomyopathy and increase the risk of thrombosis due to altered blood flow [3, 4]. These variations can also complicate diagnostic and therapeutic catheter-based procedures. Although numerous radiological studies describe the left coronary artery, cadaveric data are limited, outdated, or confined to case reports. Moreover, imaging studies often lack detailed anatomical descriptions of the course, branching, and anastomoses, underscoring the need for thorough knowledge of normal coronary anatomy to identify subtle variations accurately [4, 5, 6].

A thorough understanding of the branching pattern of the left coronary artery (LCA) is of considerable importance in diagnostic imaging and surgical planning, particularly in the management of congenital heart diseases. Advances in non-invasive imaging modalities, including coronary magnetic resonance angiography, electron beam computed tomography (EBCT), and coronary CT angiography, have greatly enhanced the ability to visualize coronary anatomy and identify clinically significant variations and pathological conditions. In this context

The present study aims to systematically examine and document the origin, branching pattern, level of termination, and anatomical variations of the LCA & its branches in human cadaveric hearts, thereby providing valuable anatomical data to support clinical, diagnostic, and interventional practices.

## 2. METHODS:

The present anatomical study was carried out in the Department of Anatomy, Index Medical College Hospital & Research Centre (IMCH & RC), Indore, Madhya Pradesh. A total of 50 adult human heart specimens were included in the study. The specimens were obtained from deceased individuals subjected to routine cadaveric dissection for undergraduate (MBBS) teaching purposes in the department. Following standard dissection procedures, the thoracic cavity was accessed by reflecting the anterior thoracic wall. The heart, along with the attached great vessels, was carefully removed from the pericardial cavity after incision of the parietal pericardium, ensuring minimal disturbance to surrounding anatomical structures. This method allowed accurate observation of cardiac morphology for detailed anatomical analysis.

After being cleaned, washed, and fixed in formalin at a concentration of 10% for a period of three days, the sample of the heart was then prepared for the study by being cleaned, washed, and attached. Once the fat has been removed from the epicardium and the sub-epicardial area, we proceeded to investigate the branching pattern of the LCA. Throughout their whole course, from the point of origin to the point of termination, they were tracked. The branching of LCA was observed till their terminations and the mode of termination was observed based on the area irrigated by them. Any variation in the course and branching pattern was recorded and photographed.

## 3. RESULTS:

In the present study of 50 specimens, the left coronary artery most commonly originated from the left posterior aortic sinus (98%), with only a rare origin from the anterior aortic sinus (2%) as seen in table 1, fig 3 A & fig 4 A.

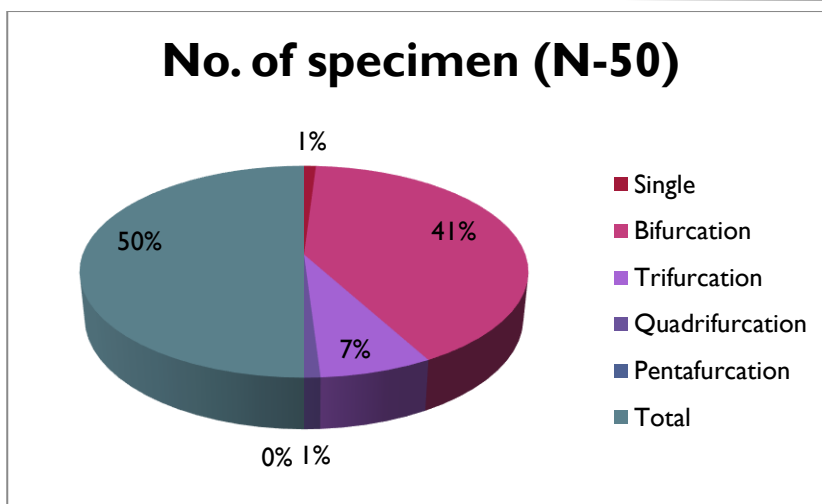
Regarding branching pattern, bifurcation was the predominant type (82%), followed by trifurcation (14%), while single and quadrifurcation patterns were uncommon (2% each) exhibits in table no 2, fig 1, fig 3 B, fig 4.

S.N	Origin	No. of specimen (N-50)	Percentage
1	Left posterior aortic sinus	49	98%
2	Right posterior aortic sinus	0	0%
3	Anterior aortic sinus	1	2%
	Total	50	100%

**Table 1: Origins of LCA from various anatomical places; LCA- left coronary artery**

S.N	No. of Branches	No. of specimen (N-50)	Percentage
1	Single	1	2%
2	Bifurcation	41	82%
3	Trifurcation	7	14%
4	Quadrifurcation	1	2%
5	Pentafurcation	0	0%
	Total	50	100%

**Table 2: Exhibits the number and percentage of branches of LCA; LCA- left coronary artery**



**Fig. 1: Chart Exhibits the number and percentage of branches of LCA.**

The left anterior descending artery (LAD) most frequently wrapped around the cardiac apex and supplied the inferoapical segment (86%). In a smaller proportion, the LAD reached the apex without supplying the inferoapical segment (12%), and termination before the apex was rare (2%) as exhibited in table no 3, fig 5A. The left circumflex artery most commonly terminated between the obtuse border and the crux (46%), followed by termination at the obtuse border (32%). Less frequent patterns included termination at the crux (12%, including continuation as posterior interventricular artery in 8%), between the crux and acute border (8%), and before the obtuse border (2%) exhibits in table no 4, fig 2, fig 5B.

S.N	Termination of LAD	No. of specimen (N-50)	Percentage
1	Before cardiac apex	1	2%
2	Reaching apex but not supplying inferoapical segment	6	12%
3	LAD wrapping around apex and supplying inferoapical segment	43	86%
	Total	50	100%

**Table 3: Showing the termination of LAD; LAD- left anterior descending artery**

S.N	Termination of left circumflex artery		No. of specimen (N-50)	Percentage
1	Before obtuse border		1	2%
2	At obtuse border		16	32%
3	Between obtuse border and crux		23	46%
4	At the crux	Terminating at crux	2	4%
		Turning at right angle to continue in piva	4	8%
5	Between crux and acute border		4	8%
	Total		50	100%

**Table 4: Showing the termination of LCX; LCX- left circumflex artery**

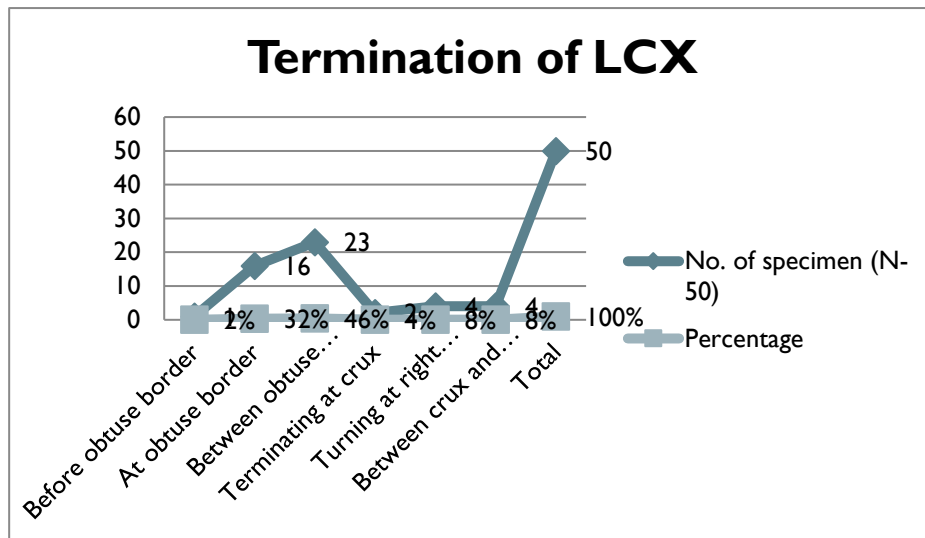


Fig. 2: Chart Exhibits the termination of LCX.

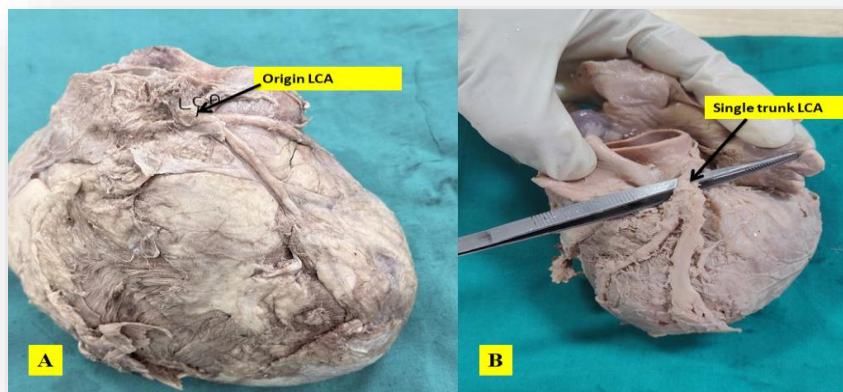


Fig. 3. Showing the A. Anomalous origin of LCA from AAS, B. Single trunk of LCA; LCA- left coronary artery, AAS- anterior aortic sinus.

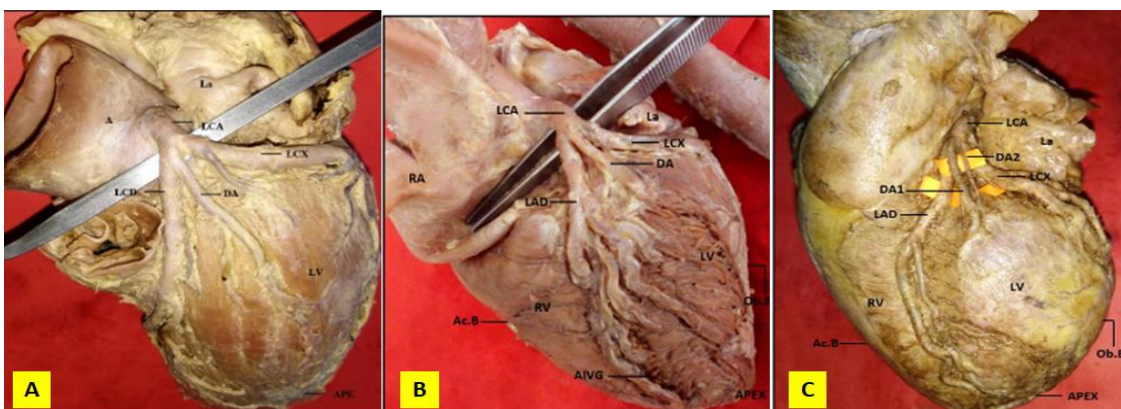
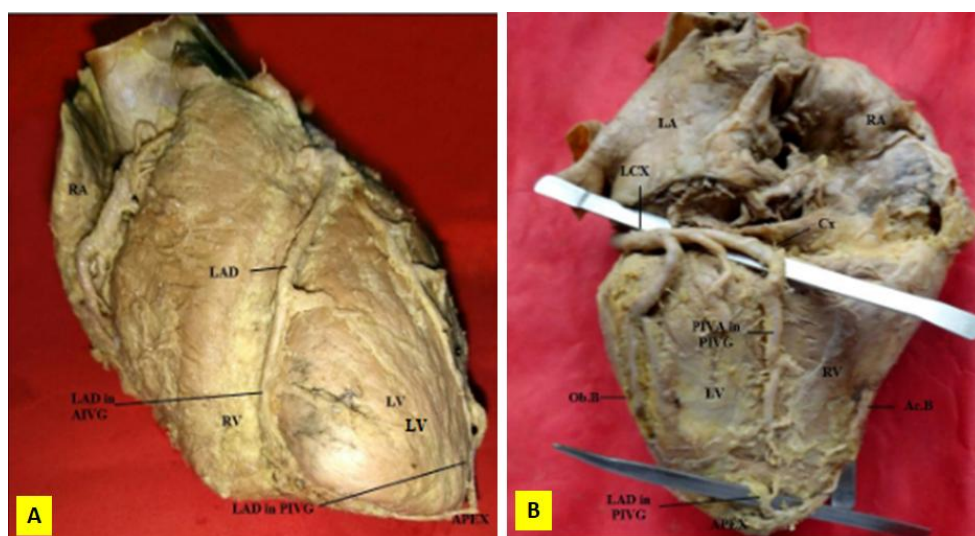


Fig. 4: Anterior surface of heart showing A. Bifurcation of LCA into LAD & LCX DA arise from LAD, B. Trifurcation of LCA into LAD, LCX and DA, C. Quadrifurcation of LCA into LAD, LCX, DA1 & DA2;

LCA- left coronary artery, LAD- left anterior descending artery, LCX- left circumflex artery, DA- Diagonal artery



**Fig. 5: A. LAD wrapping around around the apex supplying the inferoapical segment and terminating the posterior inter-ventricular groove, B. Diaphragmatic surface of heart showing LCX terminating at right angle to continue in PIVA such a pattern is known as LCD;**

LAD- left anterior descending artery, LCX- left circumflex artery, LCD- left coronary dominance

#### 4. DISCUSSION:

**Origin of the Left coronary artery:** LCA usually arises from the left posterior aortic sinus and divides shortly after its origin into two major branches—the left anterior descending (LAD) artery and the left circumflex (LCx) artery. Rare anomalies include high takeoff, double ostia, or origin from the right sinus (0.1-0.3%), increasing ischemia risk during aortic procedures as reported in 2% cases in our study also where it originated from AAS along with the right coronary artery. These findings align with prior studies, where 98-99% show standard left sinus origin.

**The branching pattern of the Left Coronary Artery (LCA):** In some individuals, LCA presents as a **single trunk**, in which a common arterial stem arises from the posterior aortic sinus and courses for a variable distance before giving rise to its terminal branch LAD. LCx was absent in this case and the area of heart supplied by LCx is supplied by the extended branches from RCA [1,2]. The presence of a single trunk of the LCA is of significant **clinical importance**. A longer common trunk may be advantageous by providing a robust blood supply, but it can also pose risks during interventional and surgical procedures. Occlusion or injury to a single trunk can compromise blood flow to a large portion of the left ventricle, potentially resulting in extensive myocardial ischemia or infarction. Moreover, variations in the length and branching of the single trunk may lead to technical challenges during coronary angiography, angioplasty, and coronary artery bypass grafting (CABG) [3, 4].

As reported by various authors across different populations and sample sizes. Overall, **bifurcation** is the most common branching pattern, followed by **trifurcation**, while **tetrafurcation and pentafurcation** are relatively rare. This anatomical pattern is considered a normal variant but shows considerable individual variability in length, caliber, and branching pattern

Most studies report bifurcation as the predominant pattern, ranging from 45% (Beg et al.) to as high as 80% (Vandana Ravi et al.). Classical studies such as those by **Baptista et al. (54.7%)**, **Ballesteros et al. (52%)**, and **Ogeng'so et al. (54.8%)** demonstrate a consistent predominance of bifurcation. However, some studies show a notably higher frequency, including **Udhayakumar et al. (75%)**, **Patel J. P. et al. (74%)**, and **the present study (82%)**, indicating population-based variations.

**Trifurcation** emerges as the second most common pattern, with frequencies varying widely from 13.3% (Vandana Ravi et al.) to 47.5% (Surucu et al.). Studies by **Kalpana et al. (40%)**, **Baptista et al. (38.7%)**, and **U. Beg et al. (42.5%)** highlight that trifurcation is a significant anatomical variant and, in some populations, approaches the incidence of bifurcation.

**Quadrifurcation** is comparatively uncommon and generally reported in less than 10% of cases. Notable observations include **Kalpana et al. (11%)**, **Ogeng'so et al. (9.6%)**, and **Mallashetty N. S. et al. (10%)**, while several studies did not report this pattern at all.

**Pentafurcation** is the rarest branching pattern, observed only sporadically. It was documented by **Kalpana et al. (1%)**, **Surucu et al. (2.5%)**, **Ogeng'so et al. (3.4%)**, **Patel J. P. et al. (2%)**, and **Vandana Ravi et al. (3.3%)**, whereas most other

studies, including the present one, reported no cases. In the **present study**, bifurcation was observed in **82%** of specimens, followed by trifurcation in **14%**, tetrafurcation in **2%**, and no pentafurcation, reinforcing the dominance of bifurcation and highlighting comparatively lower incidences of complex branching patterns.

#### **Termination of left anterior descending (LAD):**

**Termination before the cardiac apex:** This pattern, where the LAD ends before reaching the apex, was relatively uncommon across studies. Kalpana R reported this in 8% of cases, while Siri AM did not observe this pattern at all (0%). Ballesteros and Mallashetty each reported a low incidence of 3.33%. In the present study, termination before the apex was seen in only 2% of cases, confirming that this is the least frequent termination pattern.

**Reaching the apex but not supplying the inferoapical segment:** In this category, the LAD reaches the apex but does not extend to supply the inferoapical region. Kalpana R observed this pattern in 12% of cases, while Siri AM reported a similar incidence of 13%. Ballesteros and Mallashetty documented a much higher prevalence, with 50% of cases in each study falling into this group. In contrast, the present study found this pattern in 12% of cases, aligning more closely with Kalpana R and Siri AM.

**LAD wrapping around the apex and supplying the inferoapical segment:** This was the most common termination pattern in most studies. Kalpana R reported a high prevalence of 80%, and Siri AM observed it in 87% of cases. Ballesteros and Mallashetty reported comparatively lower values (46.6% each). In the present study, this pattern was observed in 86% of cases, indicating a strong predominance of an LAD that wraps around the apex and supplies the inferoapical segment.

#### **Termination of left circumflex artery (LCX):**

**Between obtuse border and crux:** is the **most common level of termination** across almost all studies. It accounts for **67%** in Kalpana R, **52.86%** in Hirak Das, a markedly high **80%** in Anbumani, **60%** in Mallashetty, and remains predominant in the **present study (46%)**. This indicates a consistent anatomical preference for termination in this region.

**At obtuse border:** shows considerable variability. It is reported in **13%** of cases by Kalpana R and **17.14%** by Hirak Das, is minimal in Anbumani (**4%**), absent in Mallashetty, but shows a **notably higher frequency in the present study (32%)**, making it the **second most common pattern** in the current observations.

**At the crux:** demonstrates moderate occurrence in some studies—**6%** in Kalpana R and **18.57%** in Hirak Das—while it is absent in Anbumani. Mallashetty reports a relatively higher incidence (**26.6%**), whereas the **present study shows a low frequency (4%)**.

**Between crux and acute border:** is observed in **11%** of Kalpana R and **11.4%** of Hirak Das, absent in Anbumani, present in **6.6%** of Mallashetty, and shows a **moderate incidence (8%)** in the present study.

**Proximal to obtuse border:** is rare overall, being absent in Kalpana R, Hirak Das, and Anbumani, minimally reported by Mallashetty (**6.6%**), and very infrequent in the **present study (2%)**.

**Turn at right angle to continue in PIVS:** is a distinctive pattern reported only by **Anbumani (16%)** and the **present study (8%)**, while it is completely absent in the other studies, suggesting population or methodological differences. Statistical analysis (chi-square,  $p > 0.05$ ) shows no sex predilection, consistent with population data

## **5. CONCLUSION:**

Early identification of coronary artery abnormalities is crucial for reducing cardiovascular morbidity and mortality and for accurately assessing the severity of coronary stenosis, especially during interventions such as angioplasty and bypass surgery. Variations in the branching pattern of the left coronary artery (LCA) may lead to technical challenges during catheterization and can result in complications or misdiagnosis, making detailed knowledge of both normal and variant LCA anatomy essential for operating surgeons. With advances in coronary bypass surgery and modern myocardial revascularization techniques, a thorough understanding of LCA branching patterns has become imperative; therefore, the present study focuses on elucidating these variations to aid in accurate diagnosis and effective therapeutic management of coronary artery disease.

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**Conflict of interest:** None declared

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

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