

ANATOMICAL VARIATIONS OF CORONARY ARTERIES: AN OBSERVATION CROSS SECTIONAL STUDY USING CADAVERIC HEART SPECIMENS AND ANGIOGRAMS

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Abstract

Background: This study is to assess the morphological & radiological parameters of left & right coronary arteries. **Materials and Methods:** It was an Observational: Cross-sectional study conducted in Department of anatomy and Department of Cardiology Baba Raghav Das medical college, Gorakhpur, Uttar Pradesh in India, on 50 cadaveric heart & 50 angiograms. **Result:** Right coronary artery originated from the anterior sinus in 100% of cases across both morphological & angiographic evaluations which is consistent with the previous empirical evidences. Likewise, the LCA's origin from the left posterior sinus was consistently observed in all cases. The mean length of RCA was 10.758 cm, with variability observed (SD: ± 0.67 cm) in 72% of cases. The length ranged from 9.2 ± 0.77 cm to 11.4 ± 0.87 cm, with p value 0.00009 which is highly significant. **Conclusion:** The finding that of this study is valuable for treatment of ischemic heart diseases and in cases where percutaneous coronary interventions are required.

INTRODUCTION

Ischemic heart disease (IHD) remains the leading cause of both morbidity & mortality in developing nations around the globe. According to the most recent report from the World Health Organization (2022), approximately 197.2 million individuals are affected by IHD. The prevalence rate stands at 3,820 cases per 100,000 population worldwide.^[1,2] As per WHO, in the year 2020, 17.9 million people died from IHD which contributed 32% of all global death. Out of which 32%, 85% death was due to MI & stroke. The COVID-19 pandemic exacerbated this situation, particularly among individuals with pre-existing cardiovascular conditions. Studies have shown that patients with IHD are at a higher risk of severe outcomes if they contract COVID-19. In the year 2019, approximately 1.5 million people died in India due to IHD with the mortality rate of 109.23 per 1 lac population.^[3]

The heart is supplied by two set of coronary arteries, RCA & LCA, that arise from the aortic sinuses present at the root of ascending aorta.^[4] The RCA emerges from the anterior aortic sinus, travels downward & laterally to the right within the right anterior coronary sulcus.^[5]

The Left Anterior Descending Artery continues to descend along the sternocostal surface within the anterior interventricular sulcus, reaching the inferior border of the heart. It curves on diaphragmatic surface into posterior interventricular sulcus & finally anastomose with PIV branch of RCA. In anterior interventricular sulcus, it gives ventricular branch which supply adjacent portion of both ventricles & anterior one third part of IV septum as well as apex & one of the ventricular branches become larger known as left marginal branch. The left circumflex artery travels along the lateral surface of the heart & then curves around to the posterior aspect, moving through the left posterior coronary sulcus. It eventually anastomoses with the RCA at the crux of the heart. In certain instances, the circumflex branch of the LCA may also supply the AV node.^[6,7]

MATERIALS AND METHODS

It was an Observational: Cross-sectional study conducted in Anatomy and Cardiology Department Baba Raghav Das medical college, Gorakhpur, Uttar Pradesh in India.

1. Sample of 50 hearts were taken from donated & unclaimed human cadavers available in Anatomy Department, Baba Raghav Das Medical College.

2. 50 Coronary angiograms reading was taken from the individual visiting cardiology department of B.R.D. Medical College.

Inclusion Criteria

- Utilized 50 human hearts sourced from donated & unclaimed cadavers available in Anatomy Department at Baba Raghav Das Medical College after taking informed consent.
- Analyzed 50 angiograms from patients who visited the cardiology outpatient department at Baba Raghav Das Medical College

Exclusion Criteria

- The study's results may not be replicable without advanced anatomical knowledge & specialized tools due to the complexity of the dissection techniques employed.
- The dissection approach, involving multiple deep incisions to access the thoracic cavity & heart, could compromise the anatomical structures integrity, potentially introducing biases into the measurements & observations.
- The angiographic study does not account for anatomical variations, adhering strictly to predefined surgical pathways.

Dissection Method

Origin of RCA and LCA

Origin of RCA and LCA were observed arising from the sinus of Valsalva at the root of ascending aorta and noted.

Measuring the Length of RCA & LCA

The length of RCA & LCA were measured using a nylon thread & a vernier calliper. For the RCA, the length was measured from its origin to just before it gives off the marginal branch. The thread was placed along the RCA's course, & its length was measured with the vernier calliper. For the LCA, the length was measured from its origin to the point where it divides into LADA & LCX. The branching patterns of the LCA, including bifurcation, trifurcation, quadrifurcation, & pentafurcation, were also documented. The thread was placed along the LCA's course, & its length was measured similarly.

Measuring the Diameter of RCA & LCA

The diameter of coronaries was measured 0.5 cm from their origins using a vernier calliper, with the arteries cleared of surrounding fat. The coronary artery diameter was recorded as the external diameter.

Dominance of coronary artery and the branching pattern was observed and noted.

Angiographic Method

During the procedure, HR (heart rate) & rhythm of the patient were monitored via ECG, blood was measured using a non-invasive brachial cuff, & oxygen saturation was monitored by pulse oximeter. Coronary angiography is typically performed by introducing a catheter through the femoral artery, which is commonly accessed by adducting & slightly externally rotating the leg, palpating the femoral

pulse approximately 3 cm below inguinal ligament, & puncturing femoral artery at 45° angle.

LCA origin best visualized in LAO view, angled 45° to 60° to the left & anterior whereas RCA was best visualized in RAO view, angled 30° to 45° to right and anterior.

Commonly used views Include

- Right anterior oblique (RAO)
- Left anterior oblique (LAO)
- Cranial & caudal view of LAO & RAO
- Right & left lateral views

Using these views appropriately allows for clear assessment of the coronary artery origins & their branches, facilitating accurate diagnosis & intervention planning.

RESULTS

The Right Coronary Artery (RCA) originates solely from the anterior aortic sinus and the Left Coronary Artery (LCA) originates from the Posterior aortic sinus, with all 50 instances recorded in both morphological and angiographic assessments showing 100% frequency.

[Table 1] showed that the length of RCA was 10.1-11 cm, comprising 72% of the data having highest representation, with a mean length of 10.79 cm and a standard deviation of 0.67 cm. A p-value of 0.00009 indicated a statistically significant variation in the RCA length distribution among the different categories.

[Table 2] showed that the length of LCA ranged 10.2-10.3 mm represented the largest proportion at 36%, with a mean length of 10.22 mm and a very low standard deviation of 0.01 mm. Additionally, the p-value of 0.003 indicated a statistically significant difference in the distribution of LCA trunk lengths across the various categories.

[Table 3] showed that the branching pattern of LCA most commonly observed was bifurcation, which accounted for 76% of the cases, while trifurcation represented 20%. The p-value of 0.000695 suggested a statistically significant difference in the occurrence of these branching patterns.

[Table 4] showed that the right coronary artery was identified as the dominant artery in 90% of the morphological cases and 84% of the angiographic cases, with a p-value of 0.002 indicating a statistically significant difference between the two assessments.

[Table 5] showed the diameters of the Right Coronary Artery (RCA) with most prevalent diameter range of 3.1-3.4 mm, which accounted for 68% of the cases, and the p-value of 0.0001 indicated a statistically significant difference in the observed diameters.

[Table 6] showed the diameters of the Left Coronary Artery (LCA) with majority of measurements within 4.1-5 mm, representing 64% of the total, while the p-value of 0.0009 indicated a statistically significant difference among the various diameter categories.

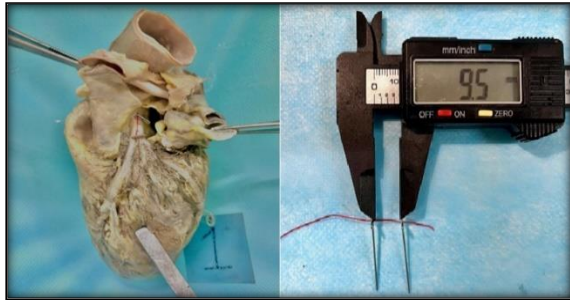
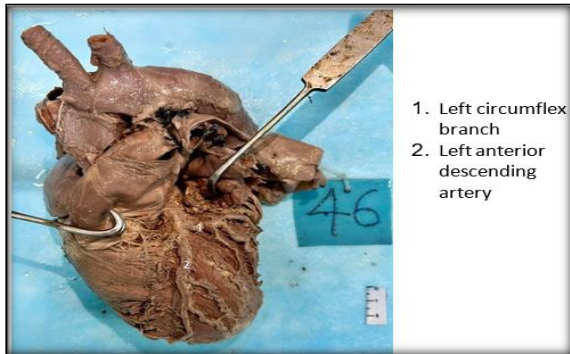


Figure 1: Measuring the length of right coronary artery

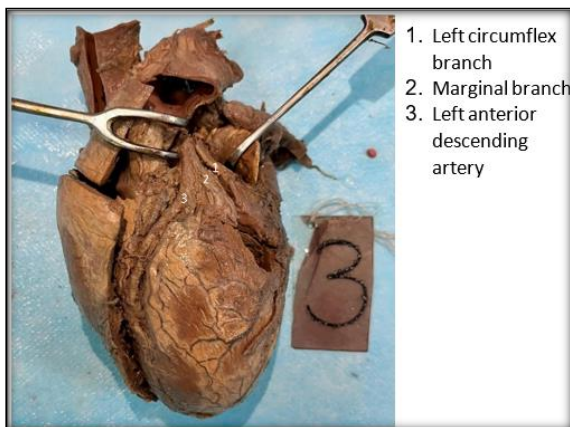


Figure 2: Measuring the diameter of left coronary artery



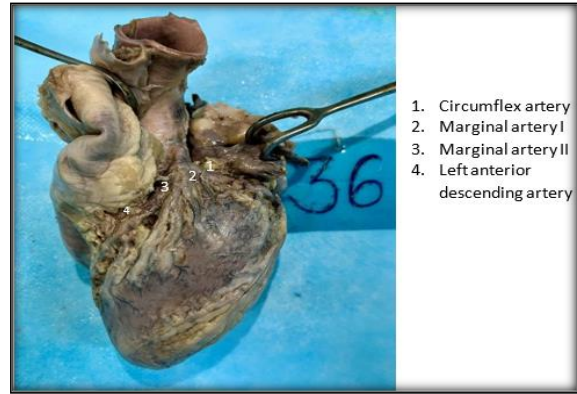
1. Left circumflex branch
2. Left anterior descending artery

Figure 3: Bifurcation of left coronary artery near its origin



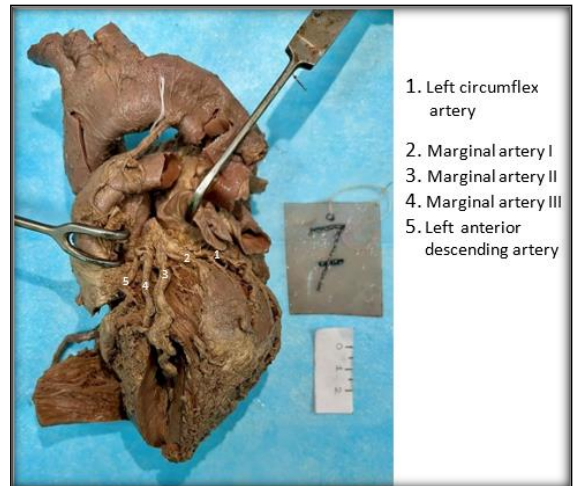
1. Left circumflex branch
2. Marginal branch
3. Left anterior descending artery

Figure 4: Trifurcation of left coronary artery near its origin



1. Circumflex artery
2. Marginal artery I
3. Marginal artery II
4. Left anterior descending artery

Figure 5: Left coronary artery showing quadrifurcation near its origin



1. Left circumflex artery
2. Marginal artery I
3. Marginal artery II
4. Marginal artery III
5. Left anterior descending artery

Figure 6: Left coronary artery showing pentafurcation near its origin

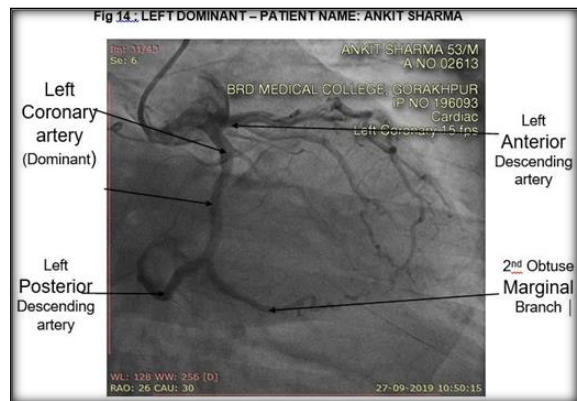


Figure 7: Left dominant – patient name- Ankit Sharma

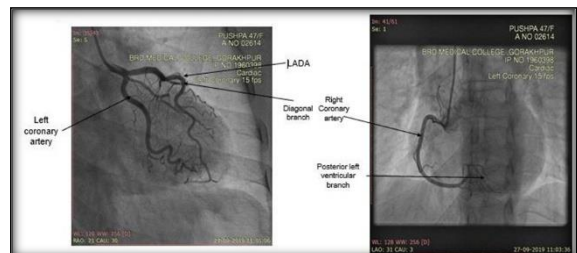


Figure 8: Right dominant – patient name- Pushpa

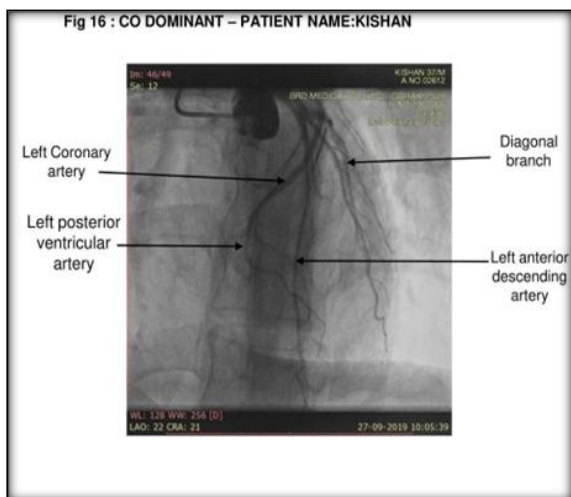


Figure 9: Co-Dominant. Patient Name- Kishan

Table 1: Length of RCA with probability distribution (Morpho.)

Length of RCA in cm	Freq.	Percentage	Mean ± S.D.	P-value
9-10 cm	4	8%	9.2 ± 0.77 cm	0.00009 (Chi-square)
10.1-11 cm	36	72%	10.79 ± 0.67 cm	
11.1-12 cm	4	8%	11.4 ± 0.87 cm	
12.1-13 cm	6	12%	12.3 ± 0.71 cm	

Table 2: Length of Main Trunk of LCA in mm (Morpho.)

Length of Main Trunk of LCA in mm	Freq.	Percentage	Mean ± S.D.	P-value
<9.5 mm	8	16%	6.32 ± 2.13 mm	0.003 (Chi-square)
9.6-9.9 mm	7	14%	9.19 ± 0.75 mm	
10-10.1 mm	8	16%	10.03 ± 0.13 mm	
10.2-10.3 mm	18	36%	10.22 ± 0.01 mm	
10.4-10.6 mm	8	16%	10.52 ± 0.12 mm	
25 mm	1	2%	25±NAN	

Table 3: Branching Pattern of LCA (Morpho.)

Branching Pattern of LCA	Freq.	Percentage	P-value
Bifurcation	38	76%	0.000695
Trifurcation	10	20%	
Quadrifurcation	1	2%	
Pentafurcation	1	2%	

Table 4: Dominant Artery (Morpho. & Angio.)

Dominant Artery	Frequency (Mor)	Percentage (Mor)	Frequency (Rd)	Percentage (Rd)	P-value
Right	45	90%	42	84%	0.002 (Chi-square)
Left	5	10%	6	12%	
Co-dominance	0	0%	2	4%	

Table 5: Diameter of RCA (Morpho.)

Diameter of RCA (mm)	Freq.	Percentage	Mean ± S.D.	P-value
2.5-3 mm	10	20%	2.71 ± 0.27	0.0001
3.1-3.4 mm	34	68%	3.20 ± 0.3	
3.5-3.9 mm	6	12%	3.7 ± 0.47	

Table 6: Diameter of LCA (Morpho.)

Diameter of LCA (mm)	Freq.	Percentage	Mean ± S.D.	P-value
2.6-3 mm	4	8%	2.39 ± 0.15	0.0009
3.1-4 mm	8	16%	3.31 ± 0.45	
4.1-5 mm	32	64%	4.39 ± 0.55	
5.1-6 mm	4	8%	5.79 ± 0.15	
6.1-6.2 mm	2	4%	6.19 ± 0.11	

DISCUSSION

The coronary arteries are essential for supplying oxygenated blood to the heart muscle, playing a vital

role in cardiovascular health. This study investigates the anatomical variations and morphological characteristics of these arteries, emphasizing their impact on clinical outcomes and treatment strategies. By leveraging advanced imaging technologies, the

research aims to enhance understanding of the diverse structures of coronary arteries, exploring how these variations affect coronary artery disease, surgical planning, and patient management.

The researches done by Jyoti P. Kulkarni, El Sayed S. Atta-Alla, and Ashwini Vijay Bhele reported that the RCA originates exclusively from the anterior aortic sinus in 100% of cases, a conclusion supported by the present study.^[7]

The studies of Kalpana R, Jyoti P. Kulkarni, Anil Kumar, and the present study consistently found that the LCA originates from the left posterior aortic sinus. The only deviation came from Ashwini Vijay Bhele et al., who reported that in 2% of cases, the LCA originated from the right posterior aortic sinus, but overall, the findings affirm a consistent anatomical pattern for LCA origin.^[7-9]

The length of RCA as reported by El Sayed S. Atta-Alla et al. showed segment lengths of 5.7 to 8 cm and 3.4 to 6 cm, while Venkateshwer Reddy M et al. found a broader range of 10 to 13 cm, and Ashwini Vijay Bhele et al. observed lengths from 6 to 17 cm. In contrast, our study identified RCA lengths between 9.2 and 12.7 cm, aligning more closely with the lower range reported by Ashwini Vijay Bhele et al. These discrepancies may be a result of differences in measurement methods, sample sizes, or population characteristics, highlighting the importance of understanding RCA length variability for surgical planning and diagnostic evaluations in cardiology.

The length of LCA as studied by O. Pereira da Costa Sobrinho et al. reported an average length of 8.53 mm, while Jyoti P. Kulkarni et al. found a shorter length of 7 mm. In our study, the LCA length was reported at 10.2 mm, aligning with Anil Kumar et al.'s findings at the higher end of the observed range, indicating anatomical differences among populations.

The comparison in the diameter of LCA by Nagaraj Mallashetty et al. reported a mean diameter of 4.28 ± 0.90 mm, while Anil Kumar et al. found a slightly broader range at 4.34 ± 2.0 mm. Our study identified a mean diameter of 4.39 ± 0.55 mm, closely aligning with the findings of Nagaraj Mallashetty et al.^[7,9]

The comparison of coronary dominance reported by Kalpana R, Jyoti P. Kulkarni, and our study, report a high prevalence of right dominance, ranging from 89% to 92%, supported by Anbumani et al.'s finding of 84%. In contrast, Hirak Das et al. and Bheemesh Pusala et al. noted a lower prevalence of right dominance at 70%, with Bheemesh Pusala reporting a notable 15% of codominance. Overall, these findings emphasize the predominance of right coronary dominance and the relatively low occurrence of left dominance and codominance in the studied populations.^[7,10-12]

The branching pattern of LCA majority of studies, including Anil Kumar et al. and Jyoti P. Kulkarni et al., reported high bifurcation rates of 80.76% and 84%, with our study also observing 76%. In contrast, trifurcation rates varied widely, with O. Pereira da Costa Sobrinho et al. reporting 52.38%, while

Anbumani et al. and Lakshmi Praba et al. found lower rates of 26% and 41.82%. Quadrifurcation was noted in 11% of cases by Kalpana et al., but only 2% in our study, indicating inconsistency, while pentafurcation was observed in 1.28% of cases by Anil Kumar et al. and 2% in our study. These variations underscore the diversity in LCA branching patterns, emphasizing their relevance in clinical assessments and interventions.^[9]

The comparison of coronary dominance from angiographic studies shows a prevailing trend of right dominance as 84% in our study, aligning closely with N. O. Ajayi et al. at 81.5% and Ali Vasheghani Farahani et al. at 82.2%. However, Kaimkhani ZA et al. and Edwin Omerbasic et al. reported lower rates of 60% and 69%, respectively. The prevalence of codominance in our study (10.9%) is supported by Ali Vasheghani Farahani et al., while higher rates were noted by Kaimkhani ZA et al. (25%) and N. O. Ajayi et al., indicating a diverse range of findings in coronary dominance.^[6,8]

CONCLUSION

RCA originated from the anterior sinus in 100% of cases across both morphological & angiographic evaluations which are consistent with the previous empirical evidences. Likewise, the LCA's origin from the left posterior sinus was consistently observed in all cases. The mean length of RCA was 10.758 cm, with variability observed (SD: ± 0.67 cm) in 72% of cases. The length ranged from 9.2 ± 0.77 cm to 11.4 ± 0.87 cm, with a significance level of $p = 0.00009$. The study revealed a higher frequency of right dominance in coronary artery distribution, observed in 90% of morphological evaluations & 84% of angiographic evaluations. The consistent observation of the LCA originating from the left posterior sinus & the RCA from the anterior aortic sinus across all radiological examinations underscores the reliability of radiological imaging for determining coronary artery origins. Additionally, the finding that the RCA was the dominant artery in 84% of cases is valuable for cardiovascular treatment strategies which include diagnostic- angiography as well as therapeutic- angioplasty (ballon inflation and stenting).

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