

# A Cadaveric Study of the Variations in Coronary Arterial System

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## Abstract

**Background:** The human heart is a muscular, hollow organ that circulates blood throughout the body. Normally, the Left Coronary Artery (LCA) and Right Coronary Artery (RCA), along with their branches, supply the heart. The RCA and the LCA show variations in terms of their origin, course, termination, branching pattern, and distribution. The posterior interventricular artery (PIVA), which is the branch of the RCA, or the LCA, or both, determines the dominance pattern of the heart.

**Aim:** This study aims to identify the variations in the origin and branching pattern of coronary arteries and to determine the dominance of the heart.

**Materials and Methods:** 60 formalin-fixed human cadaveric hearts were collected from Dept. of Anatomy, KAHER's J.N. Medical College, Belagavi. The coronary arteries and their branches were dissected. The variations were photographed and documented.

**Result:** The data obtained after the examination of the 60 hearts shows that:

- The RCA originates from the anterior aortic sinus and the LCA originates from the left posterior aortic sinus.
- The LCA terminates into bifurcation (45%), followed by trifurcation (41.6%), and quadrifurcation (13.3%).
- Right dominant hearts were found in 76.6% of cases. The left dominant hearts were found in 21.6% of cases and a balanced condition was found in 1.6% of cases.

**Conclusion:** Interpreting coronary angiography requires a thorough understanding of the coronary artery's branching pattern. Cardiologists and radiologists may benefit from this study by having a better grasp of and ability to manage cardiac disorders.

**Keywords:** Left coronary artery, right coronary artery, Dominance.

## Introduction:

The Right Coronary Artery (RCA) and the left Coronary Artery (LCA), along with their branches supply blood to the human heart, which is a muscular, hollow organ. The right conus artery, right marginal artery, and atrial and ventricular rami are the branches of the RCA. While the left circumflex artery (LCx) and left anterior descending artery (LAD) are the branches of the left coronary artery (LCA)<sup>[1]</sup>. The Posterior Interventricular Artery (PIVA) is the branch from either the RCA or the LCA or both.

It determines the dominance pattern of the heart. If the Posterior Interventricular Artery (PIVA) originates from the RCA then it is the right dominance of the heart and if it originates from the LCA then it is the left dominance of the heart and if it originates from both

the RCA and the LCA then it is known as a balanced pattern/codominance of the heart. The SA nodal artery and the AV nodal artery can originate from either the RCA or the LCA.

The present study gives an overview and detailed understanding of the possible variations and branching patterns of the coronary arteries which will provide an anatomical view to the clinicians especially the cardiothoracic surgeons, cardiologists, radiologists, and anatomists to know the site of lesion and occlusion of the particular artery.

This study demonstrates its value by mentioning uncommon differences such as the origin of the SA nodal artery, the different path of the circumflex artery, and the origin of the right conus artery as the third coronary artery.

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**Materials and Methods:**

Sixty formalin-fixed human cadaveric hearts of both sexes were collected from the Department of Anatomy, KAHER's J.N. Medical College, Belagavi (see Figure 1). Removal of subepicardial fat and visceral pericardium was done. Both the RCA and the LCA were dissected and their lengths were measured and their branches were dissected and traced as much as possible up till their termination. The variations were noted and photographed.

Ethical clearance has been taken to conduct the study.



Figure 1. A Sample size of 60 Human Cadaveric Hearts

**Results:**

**RIGHT CORONARY ARTERY (RCA)**

a. Length of the RCA

**Table 1: Length of RCA**

Length in cm	No. of hearts	Percentage (%)
5-10 cm	3	5
10-15 cm	26	43.3
15-20 cm	31	51.6

Out of 60 human cadaveric hearts examined, it was found that only 3 hearts (5%) showed that the length RCA was between 5-10 cm, 26 hearts (43.3%) showed that the length was between 10-15 cm and 31 hearts (51.6%) showed that the length was between 15-20 cm. (See Table No. 1)

b. Termination of the RCA

**Table 2: Termination of RCA**

Termination of RCA	No. of hearts	Percentage (%)
RCA ending before the crux	4	6.6%
RCA ending at the crux	31	51.6%
RCA ending beyond the crux	25	41.6%

The RCA terminated before the crux in 4 hearts (6.6%), at the crux in 31 hearts (51.6%), and beyond the crux in 25 hearts (41.6%). (See Table No. 2 and Figure 2)

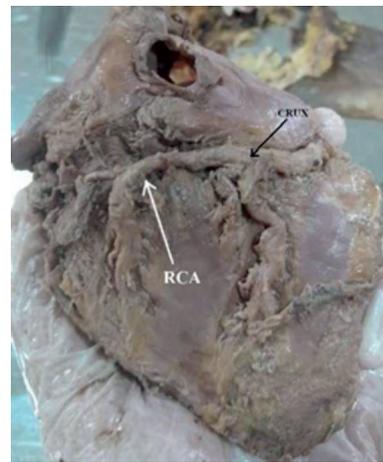


Figure 2. RCA terminating beyond the crux

c. Branches of the RCA

- Origin of the Right Conus Artery

**Table 3: Origin of the Right Conus Artery**

Origin of the Right Conus Artery	No. of Hearts	Percentage (%)
From the Anterior Aortic Sinus (then the Right Conus Artery is known as the Third Coronary Artery)	19	31.6%
From the RCA	41	68.4%

The Right Conus Artery originates from the Anterior Aortic Sinus in 19 hearts (31.6%) and from the RCA in 41 hearts (68.4%). (See Table No.3 and Figure 3, 4)

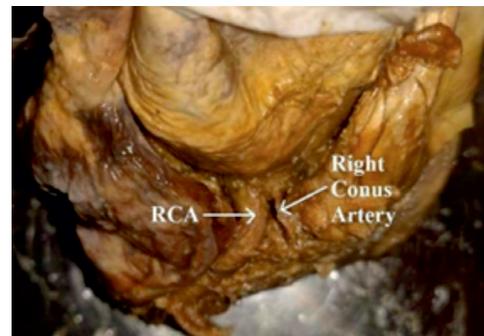


Figure 3. Right Conus Artery originating

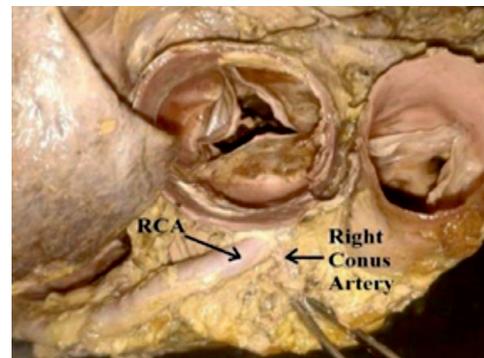


Figure 4. Right Conus Artery originating from the Anterior Aortic Sinus from the RCA

• Origin of the SA Nodal Artery (SANA)

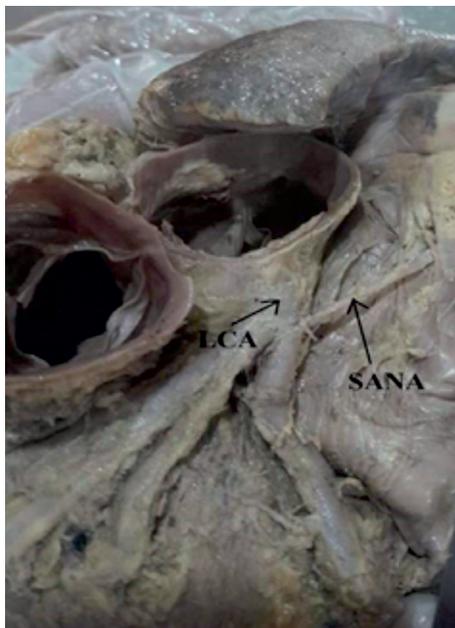
**Table 4: Origin of the SA Nodal Artery (SANA)**

Origin of the SA Nodal Artery	No. of Hearts	Percentage (%)
From RCA	45	75%
From LCA	15	25%

The SA Nodal Artery (SANA) originated in 45 (75%) of the 60 hearts from RCA and in 15 (25%) from LCA. (See Table No. 4 and Figure 5, 6)



**Figure 5. SA Nodal Artery originating from the LCA**



**Figure 6. SA Nodal Artery originating from the RCA**

**LEFT CORONARY ARTERY (LCA)**

a. Length of the LCA

**Table 5: Length of the Left Coronary Artery (LCA)**

Length in mm	No. of Hearts	Percentage (%)
<5mm	1	1.6%
5-15mm	39	65%
>15mm	20	33.3%

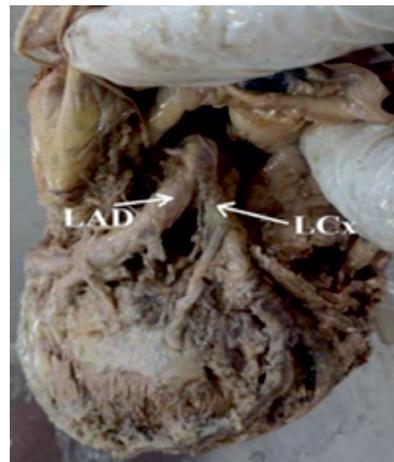
Out of 60 human cadaveric hearts, the length of LCA was less than 5mm in only 1 heart (1.6%), around 39 hearts (65%) had lengths between 5-15mm, and around 20 hearts (33.3%) had lengths more than 15mm. (See Table No. 5)

b. Branching pattern of the LCA

**Table 6: Branching pattern of the LCA**

Branching pattern of the LCA	No. of Hearts	Percentage (%)
Bifurcation	32	53.3%
Trifurcation	24	40.0%
Quadrifurcation	4	6.7%

The LCA bifurcated into LAD and LCx in around 32 hearts (53.3%), trifurcation was noticed in 24 hearts (40%) and quadrifurcation was seen in only 4 hearts (6.7%). (See Table No. 6 and Figure 7,8,9)



**Figure 7. Bifurcation**



**Figure 8. Trifurcation**

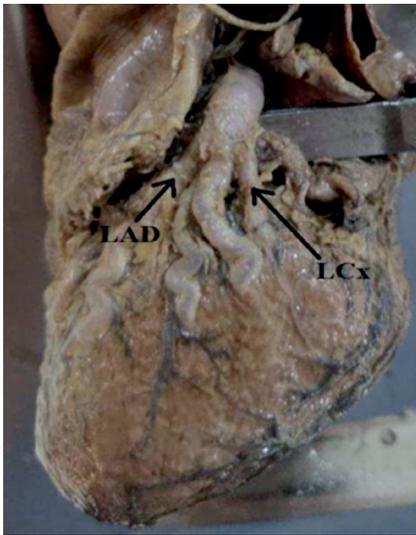


Figure 9. Quadrifurcation

**Dominance Pattern of the Heart**

**Table 7: Dominance Pattern of the Heart**

Dominance pattern	No. of Hearts	Percentage (%)
Right Dominance	51	85%
Left Dominance	8	13.3%
Balanced Dominance	1	1.7%

Out of 60 human cadaveric hearts, 51 hearts (85%) were found to have right dominance, 8 hearts (13.3%) to have left dominance and only 1 heart (1.7%) to have balanced dominance (See Table No. 7 and Figure 10,11,12)



Figure 10. Right Dominance



Figure 11. Left Dominance

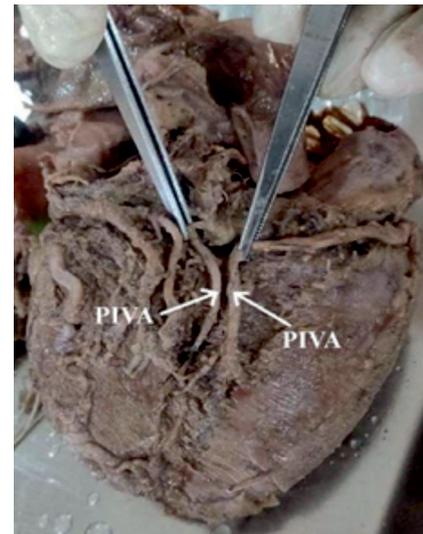


Figure 12. Balanced Dominance

\*\*\*In one of the hearts, an altered course of the left circumflex artery (LCx) was found, where the artery instead of traveling through the Atrioventricular sulcus made an arched course inferior to the sulcus and terminated at the crux of the heart. (See Figure 13)

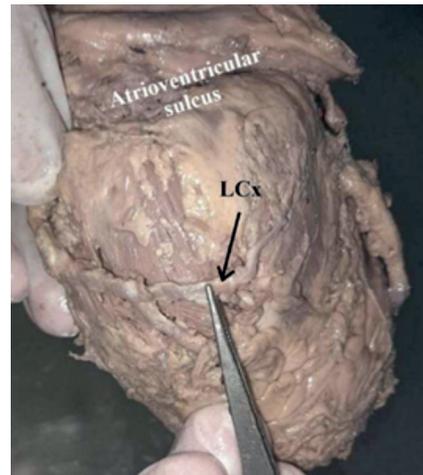


Figure 13. The altered course of the left circumflex artery

**Discussion:**

Normally, the heart is supplied by the Right Coronary Artery (RCA) and the Left Coronary Artery (LCA) along with their branches. The SA nodal artery generally arises from the RCA but sometimes may arise directly from the LCA.

**Table 8: Studies on Origin of the SA Nodal Artery**

Previous study	Sample size	Origin of the SA Nodal Artery from RCA	Origin of the SA Nodal Artery from LCA
Dr. Priti Sinha et al. <sup>[2]</sup> (2017)	20	90%	10%
Present study	60	75%	25%

In the present study done on 60 human cadaveric hearts, 75% of the hearts showed the origin of the SA Nodal Artery from the RCA and 25% of the hearts showed its origin from the LCA. In another study, the author noticed that the majority of the hearts showed the origin of the SA Nodal Artery from the RCA and few hearts showed its origin from the LCA<sup>[2]</sup>.

The right conus artery often emerges as the first branch of the RCA, but it can sometimes occasionally emerge independently from the anterior aortic sinus; in this case, it is referred to as the Third Coronary Artery.

**Table 9: Studies on conus Artery**

Previous studies	Sample size	Right Conus Artery origin from RCA	Right conus Artery origin from the Anterior Aortic Sinus (Third Coronary Artery)
Dr. Arjun Singh Parmar et al. <sup>[3]</sup> (2018)	50	68%	32%
Lakshmi et al. <sup>[4]</sup> (2017)	50	70%	30%
Nafees et al. <sup>[5]</sup> (2019)	50	58%	42%
Present study	60	68.4%	31.6%

In the current study, it is found that the Right Conus Artery originated from the RCA in 68.4% of cases, while it originated from the Anterior Aortic Sinus in about 31.6% of cases. As per the study done by another author, it was found that most of the hearts, about 68% of the total, indicated that the Right Conus Artery originated directly from the RCA, while 32% of the hearts indicated that the Right Conus Artery originated from the Anterior Aortic Sinus as the Third Coronary Artery<sup>[3]</sup>. The left circumflex artery (LCx) and left anterior descending artery (LAD) are the anatomical divisions of the Left Coronary Artery (LCA), which normally runs between the pulmonary trunk and the left auricle. Variations in the LCA branching pattern, such as bifurcation, trifurcation, and quadrifurcation, can be observed occasionally.

**Table 10: Studies on branching pattern of LCA**

Previous studies	Sample size	Bifurcation	Trifurcation	Quadrifurcation	Pentafurcation
J.P. Patel et al. <sup>[6]</sup> (2016)	50	74%	18%	6%	2%
Lakshmiprabha et al. <sup>[7]</sup> (2018)	55	54.5%	41.28%	1.82%	1.82%
Shihas et al. <sup>[8]</sup> (2022)	50	74%	24%	2%	0%
Kumar et al. <sup>[9]</sup> (2018)	78	80.7%	10.2%	7.69%	1.28%
Bhimalli et al. <sup>[10]</sup> (2011)	60	56.6%	33.3%	8.3%	1.8%
Present study	60	53.3%	40%	6.7%	0%

In the present study, 53.3% of the hearts showed bifurcation, 40% of the hearts showed trifurcation and 6.7% of the hearts showed quadrifurcation. No hearts were seen with pentafurcation. In another study, the author noticed almost similar results of quadrifurcation i.e. 6% of hearts showed quadrifurcation<sup>[6]</sup>. Whereas a study done on 55 hearts showed that 54.5% of the hearts had bifurcation, 41.28% of the hearts had trifurcation, but only 1.82% of the hearts had quadrifurcation<sup>[7]</sup>. The results related to pentafurcation in the present study were similar to

the results obtained by Shihas et. al<sup>[8]</sup>.

The posterior interventricular artery (PIVA) controls the dominant pattern of the heart. It was known as "right dominance" when the PIVA originated from the RCA, "left dominance" when it originated from the circumflex artery, and "balanced pattern/codominance" when it originated from both the RCA and the circumflex artery.

**Table 11: Studies on Coronary Dominance**

Previous studies	Sample size	Right Dominance	Left Dominance	Balanced Dominance
Jaishree et al. <sup>[11]</sup> (2015)	76	83%	14.5%	2.5%
Saminathan et al. <sup>[12]</sup> (2021)	50	52%	20%	28%
Vinitha et al. <sup>[13]</sup> (2015)	50	62%	22%	16%
Present study	60	85%	13.3%	1.7%

According to the present study, 85% of the hearts showed right dominance, 13.3% of the hearts showed left dominance and around 1.7% of the hearts showed balanced dominance. In another study, the author observed similar results with 83% of the hearts showing right dominance, 14.5% of the hearts showing left dominance, and 2.5% of the hearts showing balanced dominance<sup>[11]</sup>. However, another author observed that 52% of the hearts showed right dominance, 20% of the hearts showed left dominance and 28% of the hearts showed balanced dominance<sup>[12]</sup>.

### Conclusion:

In this study, it can be concluded that the length of RCA was longer than LCA. The RCA terminated mostly at the crux. In most of the hearts, the Right Conus Artery and the SA Nodal Artery originated from the RCA. The LCA was generally branching into LAD and LCx thereby showing bifurcation but only a few hearts showed quadrifurcation by giving two additional branches between LAD and the left circumflex artery. The study revealed that balanced dominance was the least prevalent dominance type while right dominance was the most common.

The purpose of this study was to further our understanding of the variability in coronary artery structure. It is compared to previous studies to emphasize the importance of precise anatomy for positive clinical results, and it may aid radiologists and cardiologists in their understanding and treatment of heart conditions.

### Recommendations:

This study will help to create a scope for further research into the variations in the coronary arterial system and to establish correlations with coronary angiography and other cardiovascular imaging modalities.

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