

# Prevalence and Distribution of Coronary Dominance and Ramus Intermedius in North Indian Population on CT Coronary Angiography- A Cross-sectional Study

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## ABSTRACT

**Introduction:** The Computed Tomography (CT) coronary angiography is a non invasive method to evaluate coronary artery stenosis in patients presenting with cardiac symptoms. It can also be used to decide coronary artery dominance which has various clinical implications like relatively higher death rates in left dominant coronary circulation. The most common variation of left coronary artery is ramus intermedius seen in approximately 30% of cases.

**Aim:** To find the type of coronary artery dominance in male and female patients and to look for the prevalence of ramus intermedius in patients undergoing CT angiography for coronary artery disease following cardiac symptoms and to look for predominance based on gender if any.

**Materials and Methods:** This cross-sectional study was done on 161 patients who visited the Department of Radiodiagnosis, Dr Ram Manohar Lohia Institute of Medical Sciences, Lucknow,

Uttar Pradesh, India from January 2020 to October 2020 for CT coronary angiography on 64 slice CT scan machine and were evaluated for the type of coronary dominance and the presence or absence of ramus intermedius.

**Results:** Of 161 patients (108 males and 53 females), right, left and co-dominance was present in 77%, 14.9%, and 8%, respectively with no significant difference between the sexes. Ramus intermedius was present in 20.4% cases, it was found to be more in males (16.77%) compared to females (3.73%), significantly more in males (Chi-square=4.0820, p=0.0430), and co-dominance (Chi-square=6.2930, p=0.0430).

**Conclusion:** Right dominance was found to be in a greater number of subjects as compared to left dominance and co-dominance with no significant difference between both the sexes. Ramus intermedius came out as a common variation and is significantly more in co-dominance.

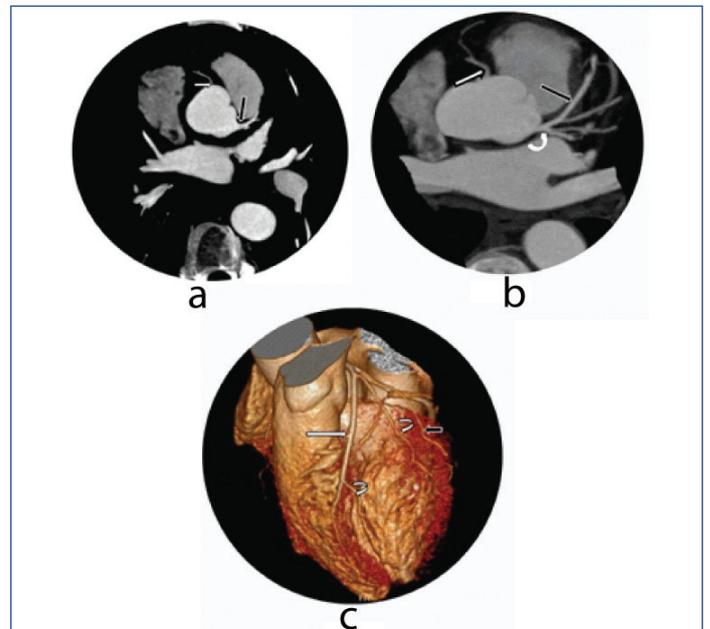
**Keywords:** Co-dominance, Computed tomography, Coronary artery disease

## INTRODUCTION

Computed Tomography (CT) coronary angiography is increasingly used as a non invasive method to evaluate coronary artery stenosis in patients presenting with cardiac symptoms and to look for coronary anatomy and various pathological conditions for predicting as well as treating coronary artery diseases. Various techniques including Multi Planar Reformation (MPR), three dimensional (3D) Maximum Intensity Projection (MIP), and 3D volume rendering are being used to evaluate coronary artery variation and coronary artery diseases accurately. Though coronary artery variation has been described conventionally by angiography technique, its spacial relationship with the heart is evaluated with a high level of resolution by the cross-sectional nature of CT angiography and 3D reconstruction [1].

**Coronary artery anatomy:** The left and right coronary artery arises from the right and left sinuses of valsalva situated at the root of aorta [Table/Fig-1]. The posterior sinus generally does not give any coronary artery and is sometimes called 'non coronary sinus' [1].

The left coronary artery divides into Left Anterior Descending artery (LAD) which runs in the anterior interventricular sulcus and Left Circumflex (LCX) branch. Sometimes the Left Main Coronary Artery (LMCA) trifurcated into three -LAD, LCX, and Ramus Intermedius [1]. The most common variation in the LMCA anatomy is the intermediate artery that arises from the LMCA as the third vessel between the LAD and LCX and is seen in approximately 30% of the cases [2]. LAD three dimensional (3D) gives septal perforators that supply the adjacent interventricular septum and diagonal branches that supply the anterior wall of the left ventricle. The diagonal and septal branches are numbered as D1, D2.....and S1, S2.... according to their origin [1].

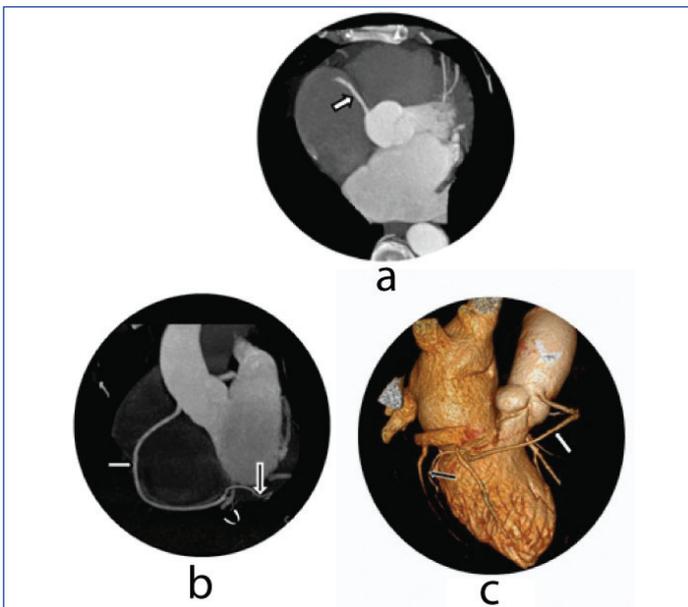


**[Table/Fig-1]:** Axial Computed Tomography (CT) Angiography showing normal Coronary anatomy; a) Image showing the origin of the right coronary artery (white arrow) and left coronary artery (black arrow); b) Image showing the right coronary artery (white arrow), left anterior descending (LAD) artery (black arrow) branch of the left main coronary artery (curved white arrow); c) Corresponding 3D image showing the LAD artery (white arrow) with its diagonal branches (curved arrows). Also, note the obtuse marginal branches (black arrow) of the left circumflex artery.

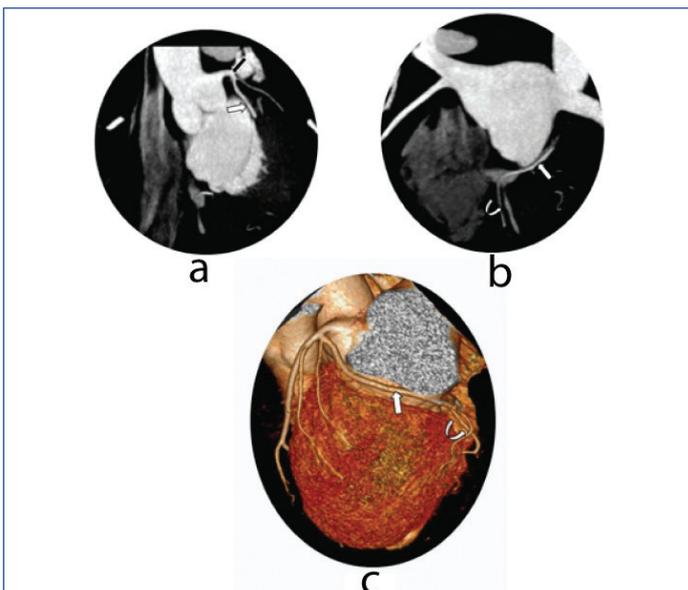
LCX runs in the posterior Atrioventricular (AV) groove and supplies the left lateral wall of the left ventricle by its Obtuse Marginal (OM) branches numbered according to their origin i.e., OM1, OM2.... etc., [1].

The RCA runs in the anterior AV groove like LCX on the opposite side. It supplies the anterior wall of the right ventricle by its acute marginal branches. In half of the cases, a conus branch is the first branch of the RCA which supplies the pulmonary outflow tract. In another half of the cases, the conus branch arises directly from the aorta. It may also sometimes arise from the LCA or together with the RCA. In about 55% of cases, the SA Nodal artery is the second branch of the RCA which supplies the Sinoatrial (SA) node. In the rest 45%, the Sinoatrial Nodal Artery (SANA) arises from the LCX [1].

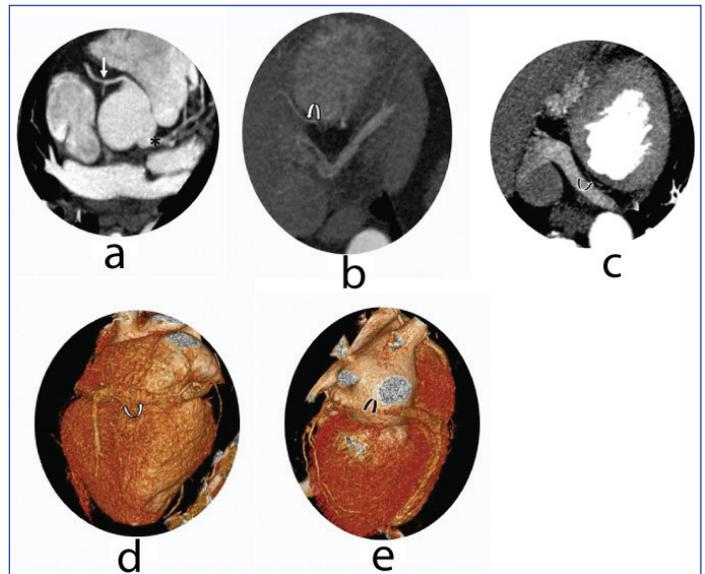
**Dominance:** The artery which gives the Posterior Descending Artery (PDA) and Posterolateral Branches (PLB) to supply the inferior part of the septum and inferior part of the LV respectively, decides the dominance. If the PDA and PLB arise from the RCA, then it is called the right dominance and if it arises from the LCX, then it is called the left dominance [Table/Fig-2,3] [3]. However, if the PDA arises from RCA and PLB from LCX, it is referred to as balanced or codominant [Table/Fig-4] [3].



**[Table/Fig-2]:** Axial CT angiography image showing right coronary dominance: a) axial CT image shows the right main coronary artery (white arrow) arising from the aortic cusp; b) Oblique CT image showing RCA (white arrow) supplying PDA (curved arrow) PLB (black arrow); c) 3D volume-rendered image showing RCA (white arrow) and PLB (black arrow). PDA: Posterior descending artery; PLB: Posterolateral branches; CT: Computed tomography; RCA: Right coronary artery



**[Table/Fig-3]:** Oblique CT angiography image showing left dominance: a and b) oblique CT angiography images showing the left coronary artery (black arrow) and its branch circumflex artery (white arrow) supplying the posterior inter-ventricular artery (curved arrow); c) corresponding 3D image showing left circumflex artery (white arrow) supplying the posterior inter-ventricular artery (curved arrow) in a left dominant circulation.



**[Table/Fig-4]:** Computed Tomography (CT) angiography images showing co-dominance: a) CT image showing the Right Coronary Artery (RCA) (arrow) and left coronary artery (LCA) (\*); b) Image showing posterior descending branch (curved white arrow) arising from RCA; c) Image showing posterolateral branch (curved black arrow) arising from LCA; (d) and (e) Images showing Posterior Descending Artery (PDA) (curved white arrow) and Posterolateral Branches (PLB) (curved black arrow) arising from RCA and LCA respectively forming a codominant circulation.

The dominance pattern in a coronary circulation is thought to have significant clinical implications. It has been stated that there are relatively higher death rates in left dominant coronary circulation which may be explained by the fact that there is a greater myocardial area at risk in anterolateral myocardial infarcts with left coronary dominance [4]. We could not find any study of cardiac CT in literature correlating coronary artery dominance type and ramus intermedius incidence. Thus, the aim of the present study was to look for prevalence of coronary dominance and prevalence of ramus intermedius in North Indian population.

## MATERIALS AND METHODS

This cross-sectional study was done in the Department of Radio-Diagnosis, Dr Ram Manohar Lohia Institute of Medical Sciences on 161 patients lying in age group of 55-70 years (108 males and 53 females) who after giving informed consent underwent coronary artery CT angiography for chest pain or any other cardiac symptoms referred by the Cardiology Department from January to October 2020. The study was approved by the Institutional Ethical Committee (letter ref. no 187 dated 05.01.2020).

**Inclusion criteria:** Patients coming to the Department for coronary artery evaluation and giving consent for the same were included.

**Exclusion criteria:** Patients not willing to undergo CT Angiography or those allergic to contrast medium used were excluded.

### Methodology

All CT examinations were performed on a 64- Multidetector Computed Tomography (MDCT) scanner (Philips Medical System Version 6.4, Extended Brilliance Workspace). Technical features of MDCT were as following: 64×0.625 mm collimation, minimum slice thickness of 0.9 mm, gantry rotation time of 0.4 s, kV of 120, and mAs of 790. The patients were nil per oral for 4–6 hr.

### Parameters Studied

All the patients underwent heart rate evaluation before the CT angiography. Patients with heart rate >70 bpm underwent cardiology reference. Patients were premedicated with 50 mg metoprolol one hour before the scan and another dose of metoprolol was given if the heart rate remained high. In patients with a heart rate <65 bpm after one hour of medication, a non contrast CT scan was done to detect coronary artery calcification and to further plan the coronary angiography before contrast was administered. The bolus of contrast

medium-iodhexol (omnipaque) 350 mg and saline solution were injected with a medrad power injector at 5 millilitres (mL)/sec through an 18-gauge plastic intravenous catheter placed in an antecubital vein in most of the cases. Contrast medium volumes varied between 100 and 120 mL at 1.5 mL/Kg followed by 50 mL saline flush [5].

Bolus tracking was measured; the region of interest kept from around 1 cm above coronary artery origin to the base of the heart with a trigger threshold at 100 Hounsfield Unit (HU) in descending aorta with retrospective Electrocardiography (ECG) gating. The patient was exposed to CT Dose Index (CTDI) of 80-90 million Gallons per year (mGy) with Digital Light Processing (DLP) of 800-900mGy\*cm.

## STATISTICAL ANALYSIS

Chi-square test was done to analyse the association between dominance and gender, association between ramus intermedius and gender and association between ramus intermedius and dominance. A p-values  $\leq 0.05$  was considered as statistically significant.

## RESULTS

Out of 161 patients 77% (124) showed right cardiac dominance, 14.9% (24) showed left cardiac dominance and 8.07% (13) showed co-dominance [Table/Fig-5]. Distribution of all the three types of dominance did not show any difference among both the genders.

Dominance	Cases	Male	Female
Right	124 (77.01%)	83 (51.55%)	41 (25.46%)
Left	24 (14.9%)	16 (9.94%)	8 (4.97%)
Codominant	13 (8.07%)	9 (5.59%)	4 (2.48%)
Total	161 (100%)	108 (67.08%)	53 (32.92%)

[Table/Fig-5]: Prevalence of types of dominance.  
Chi-square=0.0300; p-value=0.9850

Out of the 161 patients, 20.4% (33) patients had ramus intermedius. Comparing the two genders for the presence or absence of ramus intermedius, it was found to be slightly more in males (16.77%) compared to females (3.73%) [Table/Fig-6,7]. No association between dominance and gender (Chi-square=0.0300 p-value=0.9850). A significant association between ramus intermedius and gender was seen (Chi-square=4.0820, p-value=0.0430). It means that, the ramus intermedius is significantly more in males as compared to females. The study also showed the presence of ramus intermedius in 46.1% of cases with co-dominance which is significantly higher as compared to cases with the right (19.3%) and left dominance (12.5%). [Table/Fig-8]. A significant association between ramus intermedius and Dominance (Chi-square=6.2930, p-value=0.0430) was found.

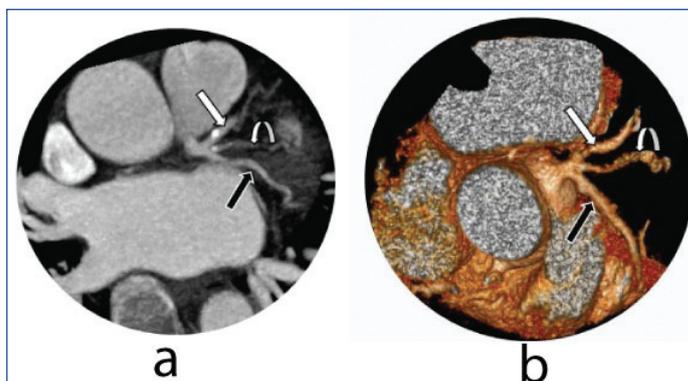
Ramus intermedius	Cases	Male	Female
Present	33 (20.4%)	27 (16.77%)	6 (3.73%)
Absent	128 (79.5%)	81 (50.31%)	47 (29.19%)
Total	161 (100%)	108 (67.08%)	53 (36.64%)

[Table/Fig-6]: The prevalence of ramus intermedius.  
Chi-square=4.0820; p=0.0430

## DISCUSSION

The CT angiography is increasingly being used for the evaluation of coronary artery stenosis as well as its variations. CT angiography has now also become the non invasive procedure of choice to evaluate anomalies of the coronary artery [6]. In 1940, the criteria for arterial dominance were first described by Schlesinger, who stated that the dominant artery is that which gives rise to the PDA or supplies the posterior interventricular septum and the crux cordis (the crux of the heart). The crux of the heart is located at the point of transaction of the AV groove and the posterior interventricular septum [7].

In a study by Das H et al., the researchers found the right dominance in 70% of the cases, left dominance in 18.5%, and co-dominance



[Table/Fig-7]: CT angiography images showing ramus intermedius: a) Oblique CT angiography image shows the left anterior descending artery (white arrow) left circumflex artery (black arrow) ramus intermedius (curved arrow); b) A 3D reformatted image of the same patient shows left anterior descending artery (white arrow) left circumflex artery (black arrow) ramus intermedius (curved arrow).

Ramus intermedius	Right dominant	Left dominant	Codominant
Present	24 (19.3%)	3 (12.5%)	6 (46.1%)
Absent	100 (80.6%)	21 (87.5%)	7 (53.8%)
Total	124 (100%)	24 (100%)	13 (100%)

[Table/Fig-8]: Prevalence of ramus intermedius in various types of dominance.  
Chi-square=6.2930; p=0.0430

in 11.43% [3]. In another study of 1453 cases, Knaapen M et al., found the right dominance in 81.2%, left dominance in 9.1% and co-dominance in 9.7% [4]. It is evident from the literature that there is variation in the prevalence of various coronary dominance patterns. The incidence of the right, left and co-dominancy reported in literatures is 70-89%, 7-13%, and 2.5-25%, respectively [2].

In a study by Cademartiri F et al., right dominance was found in 86.6% (n=470), left in 9.2% (n=50), balanced in 4.2% (n=23) [6]. These findings are nearly same as the present study. In majority of studies conducted earlier higher percentages of right dominance was reported which is comparable to the findings of the present study. Similarly, although there is variation in percentages of left and co-dominance as compared to other studies, it still lies within the ranges reported in the literature [2].

In a study done by Kosar P, 76% showed the right dominance, 9.1% showed left dominance and 14.8% showed co-dominance which is nearly same as the findings of this study. The study showed a significantly higher incidence of ramus incidence (31%) as compared to present study in which ramus intermedius was found in 20.4% cases [8]. Another study by Gohain N and Saikia R, stated right dominance in 64.44%, left dominance in 24.44%, and co-dominance in 11.11%. The study also found a slight predominance of left and co-dominance in males and right dominance in females [9].

In a study by Bordoloi R et al., right dominance was found in 76%, left dominance was found in 20% and co-dominance was found in 4% of the cases. The study showed a higher prevalence of right dominance in females (80.4%) as compared to males (70.9%) whereas in the present study no significant difference could be found between females and males (77.3% in females and 76.8% in males). However, left dominance was found to be more in males (22.5%) as compared to females (15.7%), unlike this study which did not show any significant difference of left dominance in females and in males [10].

In a study by Erol C and Seker M, prevalence of ramus intermedius was found in 31.3% of cases which is significantly higher as compared to this study (20.4%). Moreover, similar to the findings of the present study which showed a higher prevalence of ramus in males (25%) as compared to females (11.3%) Erol C and Seker M, stated a higher prevalence of ramus in men (34.2%) than women (24.6%) (p-value <0.001) [2].

In a retrospective study conducted by Rao A et al., about 77% (n=391) of the patients had a right dominant system while left

dominant and co-dominant systems were seen in 12% (n=61) and 11% (n=56), respectively. Coronary CT angiography was successful in visualising smaller branches, such as the conus artery (96.25%, n=489), the sinus node artery (83.07%, n=422), and the septal branches (95.27%, n=484) [Table/Fig-9] [2-4,6,8-11].

S. No.	Author	Year	Results
1.	Cademartiri F et al., [6]	2008	Right dominance (86.6%, n=470), left (9.2%, n=50), balanced in 4.2% (n=23)
2.	Kosar P et al., [8]	2009	76% showed the right dominance, 9.1% showed left dominance and 14.8% showed co-dominance
3.	Das H et al., [3]	2010	Right dominance (70%), left dominance (18.5%), codominant (11.43%)
4.	Erol C and Seker M, [2]	2012	Ramus intermedius in 31.3%
5.	Knaapen M et al., [4]	2013	Right dominance (81.2%), left dominance (9.1%), co-dominance in 9.7%
6.	Gohain N and Saikia R, [9]	2015	Right dominance 64.44%, left dominance in 24.44%, co-dominance in 11.11%.
7.	Bordoloi R [10]	2016	Right dominance in 76%, left dominance in 20%, and co-dominance in 4%.
8.	Rao A et al., [11]	2017	77% (n=391) of the patients had a right dominant system, left dominant and co-dominant systems were seen in 12% (n=61) and 11% (n=56) respectively.
9.	Present study	2021	Right, left and co-dominance was present in 77%, 14.9%, and 8% respectively with no significant difference between the sexes. Ramus intermedius was present in 20.4% with a male predominance (Chi-square=4.0820, p=0.0430). A significant association between ramus intermedius and Dominance (Chi-square=6.2930, p=0.0430).

[Table/Fig-9]: Previous studies and results [2-4,6,8-11].

### Limitation(s)

Firstly sample size was less due to COVID-19 in the country during study. Secondly, age group included in the study is mainly from 55-75 years of age. Coronary angiography is mainly done in elderly so the prevalence of coronary dominance and ramus intermedius could not be generalised for all age groups or whole population. Thirdly, as the prevalence of co-dominant circulation is very low, so a larger group of population should be studied in future to confirm the higher prevalence of ramus in co-dominant coronary circulation.

## CONCLUSION(S)

The CT angiography with 3D reconstruction and MIP is an excellent tool for depicting coronary artery anatomy and its variations. In the present study, we found that most of the sample population had right coronary dominance, followed by left dominance and then co-dominance with no significant difference in males and females. The study also showed the presence of ramus intermedius in 20.4% cases with higher number of cases of ramus in males as compared to females and in co-dominant coronary artery circulation. The findings of the study correlate well with the angiography findings in the literature.

### Acknowledgement

The authors would like to thank the Department of Radiodiagnosis, Dr. Ram Manohar Lohia Institute of Medical Sciences Lucknow for the help rendered in completion of the study.

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### AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

### PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Nov 17, 2020
- Manual Googling: Apr 15, 2021
- iThenticate Software: May 08, 2021 (21%)

### ETYMOLOGY: Author Origin

Date of Submission: **Nov 16, 2020**

Date of Peer Review: **Mar 02, 2021**

Date of Acceptance: **Apr 17, 2021**

Date of Publishing: **Oct 01, 2021**