

# HUMAN CORONARY ARTERIES- A STUDY BASED ON GROSS ANATOMY AND CORONARY CAST

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## ABSTRACT

### BACKGROUND

Present study is an attempt to throw light upon the coronary arterial pattern, variations in arterial distribution and extent of intercoronary anastomosis and arterial preponderance in different age groups.

### MATERIALS AND METHODS

Total of 115 hearts were made use for this study. Ninety hearts were dissected for the gross anatomical study of coronary arteries and 25 hearts including three fetal hearts were used for the coronary cast study. The right and left coronary arteries were traced from aortic sinus along the atrioventricular groove to the area of its termination. The atrial ventricular and septal branches were traced and looked for anastomosis. Coronary casts were prepared by injecting coloured liquid latex through the coronary ostia and the branching pattern and anastomosis were studied. The coronary arterial pattern, extent of distribution of its branches, arterial preponderance and variations were observed.

### RESULTS

It was found that 73 % cases of SA nodal branch arise from right coronary artery and 27 % from circumflex branch of left coronary artery. SA node has dual blood supply from both coronary arteries in 4% cases. Right coronary preponderance was observed in 83% of cases and left coronary preponderance in 11 % cases, and balanced supply in 6% cases. Coronary cast was helpful to understand the branching pattern of vessels, and the anastomosis of small capillaries. It was also seen that all 11 % of left preponderance were seen in male hearts and all of the 31 female hearts dissected were right preponderant.

### CONCLUSION

Coronary arteries are called end arteries functionally. Right coronary artery originates from anterior aortic sinus in all cases except one which takes origin from posterior left aortic sinus along with left coronary artery. Right coronary preponderance is observed in 83% cases. Left coronary artery branching pattern shows variability. Left coronary preponderance was observed in 11% and all cases are male. Coronary cast demonstrates intercoronary anastomosis clearly at capillary levels.

### KEYWORDS

Right Coronary Artery, Left Coronary Artery, Coronary Cast, Intercoronary Anastomosis, Coronary Preponderance.

**HOW TO CITE THIS ARTICLE:** Vijayamma KN, Ushavathy P. Human coronary arteries: a study based on gross anatomy and coronary cast. J. Evid. Based Med. Healthc. 2018; 5(6), 498-503. DOI: 10.18410/jebmh/2018/101

### BACKGROUND

Study on coronary arteries in relation to area of distribution and existence of an intercoronary anastomosis is obviously a matter of prime medical importance. Coronary angiography and more recently Doppler Echocardiography provide good information on arterial supply of heart. This study is an attempt to throw light upon the coronary arterial pattern, variation in arterial distribution and extent of intercoronary anastomosis in various age groups. In an average normal heart, the right coronary artery supplies all of the right ventricle except a region right of anterior

Interventricular groove, variable part of diaphragmatic surface of left ventricle, right atrium and part of left atrium, posterior one third or more of interventricular septum including most of the conducting system of the heart, as far as proximal part of right and left crura. The left coronary artery supplies the whole of the of left ventricle except variable part of the diaphragmatic surface supplied by right coronary, a narrow strip of anterior surface of right ventricle, anterior two-third of interventricular septum, most of the left atrium and distal parts of conducting system of the heart.<sup>1</sup> In 35 percent of cases, left coronary artery supplies sinuatrial node. The S A nodal artery plays an important role in supplying blood to atrial musculature and inter atrial septum. Interruption of blood flow through this artery can result in risk of ischemia and infarction of these structures in 59% of individuals.<sup>2</sup> The coronary arteries and their branches form a subepicardial network like an inverted oblique crown and hence the name corona means crown. The coronary arteries show microscopic anastomosis of arterial vessels of calibre as much as 100- 200 microns.<sup>3</sup> But for effective collateral circulation, they need 1 mm or more

*Financial or Other, Competing Interest: None.*  
*Submission 10-01-2018, Peer Review 19-01-2018,*  
*Acceptance 30-01-2018, Published 31-01-2018.*  
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 DOI: 10.18410/jebmh/2018/101



in diameter. The anastomotic vessels are straight in normal heart, but coiled in hearts subjected to episodes of coronary occlusion.<sup>4</sup> The aim of this study is to illustrate the coronary arterial tree, extent of the distribution of its branches and inter coronary anastomoses in a random population by gross dissection and coronary cast preparation using latex.

## MATERIALS AND METHODS

Human heart specimens for this study was collected from post mortem cases brought to Forensic Medicine Department of Govt. Medical College, Kottayam and foetal hearts from Labour room of Obstetrics & Gynaecology department after getting ethical clearance. For gross anatomical studies, the specimens were grouped according to age (Table 1). Ninety hearts were made use for dissection after fixing in 10 % formalin for two days, and twenty-five hearts were made use for coronary cast studies. The right and left coronary arteries were traced from aortic sinus, along the atrioventricular groove to the area of its termination. All branches were traced towards its areas of supply and branching pattern, sites of anastomosis were studied and photographed.

Twenty-five human hearts including three foetal hearts were made use for coronary arterial cast study. Fresh specimens of heart, within 6 hours after death were collected (Table 2). The coronary arteries washed and perfused with 2% normal saline through a cannula introduced through the coronary ostia. After one hour, latex (coloured with eosin) was injected first to right coronary artery and half an hour later into the left coronary. The heart was allowed to remain suspended for one day. In the next day, the heart was transferred in to concentrated hydrochloric acid for two days so that myocardium gets dissolved out and the coronary arterial cast left behind. The cast was washed in water, dried and mounted. The branching pattern and anastomosis were studied and photographed.

## OBSERVATION AND RESULTS

Observations were made on the basis of gross anatomical and coronary arterial cast studies. The coronary arterial branching pattern, extent of distribution, arterial preponderance and variations were observed.

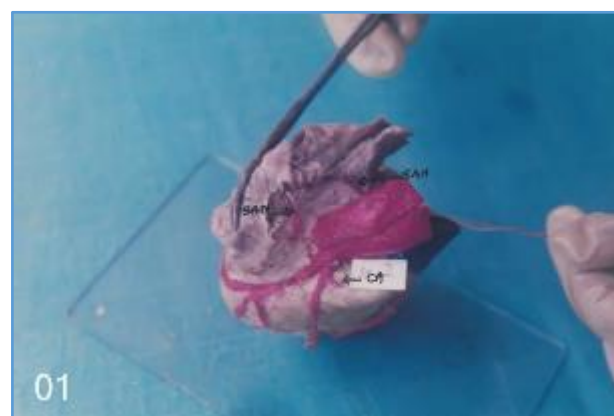
Sl. No.	Age	Male	Female	Total
1.	Foetal	6	4	10
2.	First decade	5	Nil	5
3.	Second decade	2	3	5
4.	Third decade	10	1	11
5.	Fourth decade	20	2	22
6.	Fifth decade	10	0	10
7.	Sixth decade	7	3	10
8.	Seventh decade	10	0	10
9.	Eighth decade	5	0	5
10.	Nineth decade	0	2	2
	<b>Total</b>	<b>75</b>	<b>15</b>	<b>90</b>

**Table 1. Number of Heart Specimen Collected for Gross Dissection**

Sl. No.	Age	Male	Female	Total
1.	Foetal	1	1	2
2.	Third decade	4	1	5
3.	Fourth decade	3	3	6
4.	Fifth decade	6	0	6
5.	Sixth decade	4	1	5
6.	Seventh decade	1	0	1
	<b>Total</b>	<b>19</b>	<b>6</b>	<b>25</b>

**Table 2. Number of Heart Specimen Collected from Various Decades of life for Coronary Cast**

**Dissection Method-** The Origin of right and left coronary arteries from respective aortic sinuses were examined and It was found that the right coronary ostium was at a higher level from aortic annulus and smaller compared to the left ostium. The right coronary artery was found to terminate at the left of crux of the heart in 56.5% cases, at the crux in 27.8% cases and right of the crux 15.6% cases, in the present study (Table 3). It originates from anterior aortic sinus in all cases except one case, where it takes origin from posterior left aortic sinus. The conus artery was the first branch and it supplies the pulmonary conus and in 13% of cases, it originates as a separate branch from the anterior aortic sinus and named as third coronary artery (Figure 1). This artery was found to anastomose with left conus artery in 6% of cases around the pulmonary conus.



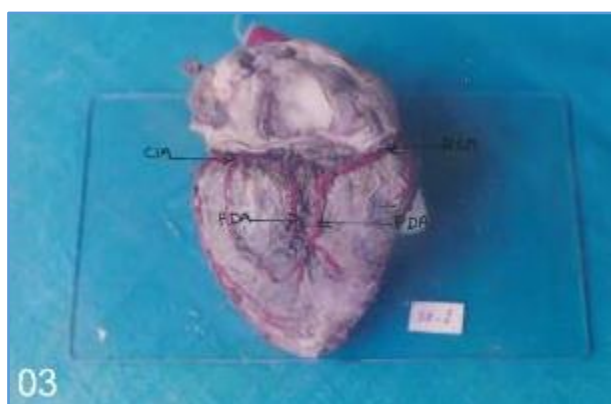
**Figure 1. Right Conus Artery (CA) having Separate Origin from Anterior Aortic Sinus**

The sinoatrial nodal branch was traced towards the nodal tissue. In one case it was found to anastomose with sinoatrial nodal branch of circumflex artery. It was found that in 73% of cases SA nodal artery arise from first segment of the right coronary artery. The atrial, right ventricular, right marginal, A V nodal and posterior interventricular branches were also studied. The posterior interventricular arteries 2-3 in number arising from right coronary at or near the crux of the heart (Figure 2) were also observed. In such cases it supplies the inferior surface of left ventricle as well as posterior third of interventricular septum. Such a pattern of arterial supply is considered as right coronary preponderance. Out of 115 cases studied, 83% cases found to be right preponderant, 11% of cases were found to be left preponderant and 6% balanced type (Figure 3).



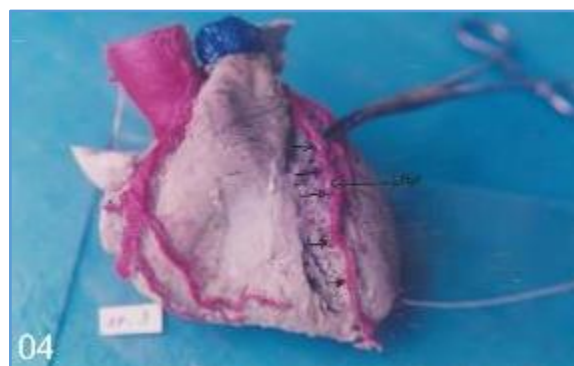
**Figure 2. Right Preponderance Posterior Descending Artery (PDA) four in Number arising from Right Coronary Artery**

The average luminal diameter of right coronary artery 2 cms from its origin was 2.15 mm and 2.87 mm. for the left coronary artery. (Table 3 and Table 4).



**Figure 3. Heart Showing Balanced Arterial Supply. Posterior Descending Artery (PDA) Arising from Right and Left Coronary Artery (RCA, LCA)**

The origin of left coronary artery was from left posterior aortic sinus in all specimens. It was found that the artery bifurcates into anterior descending and circumflex branches in 60%, trifurcates into anterior descending, intermediate and circumflex branches in 32%, and quadrifurcates into anterior descending, two intermediate branches, and circumflex branch in 8% specimens (Figure 6) The anterior descending branch in majority of cases winds round the apex of heart to reach the lower third of posterior interventricular groove with or without anastomosing with posterior descending branch of right coronary artery. The septal branches of anterior interventricular artery were 9-12 in number (Figure 4) and diagonal branches were 4-5, having an acute origin. The intermediate branches of left coronary which was observed in the present study accounts for 40%. Few of them runs parallel with anterior interventricular artery. The left conus branch was found to arise from this vessel and supplies the pulmonary conus and anastomose with right conus artery in 6% cases. The circumflex branch was found to terminate either before reaching the crux or at the level of crux or to the right of the crux (Table 4). The posterior descending artery arising from circumflex artery in 11% of cases (Figure 8) showed Left preponderance.

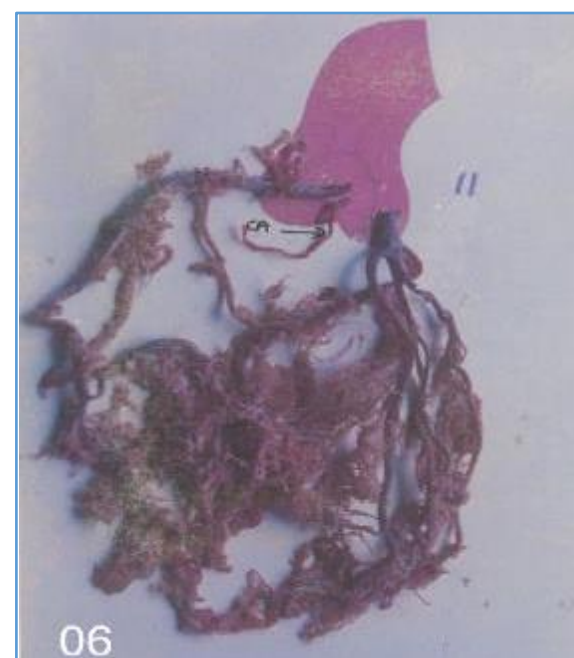


**Figure 4. Septal Branches Arising from Anterior Descending Artery (LAD) to Inter Ventricular Septum**

The SA nodal branch arises from circumflex branch in 27%, and AV nodal branches in 11% cases. The Kugel's anastomotic artery was found to arise from circumflex artery in two of the cases, which runs towards the interatrial septum and anastomosed with Atrioventricular nodal artery around the crux (Figure 5).



**Figure 5. Kugel's Anastomotic Artery (KA) Anastomosing with AV Nodal Artery**



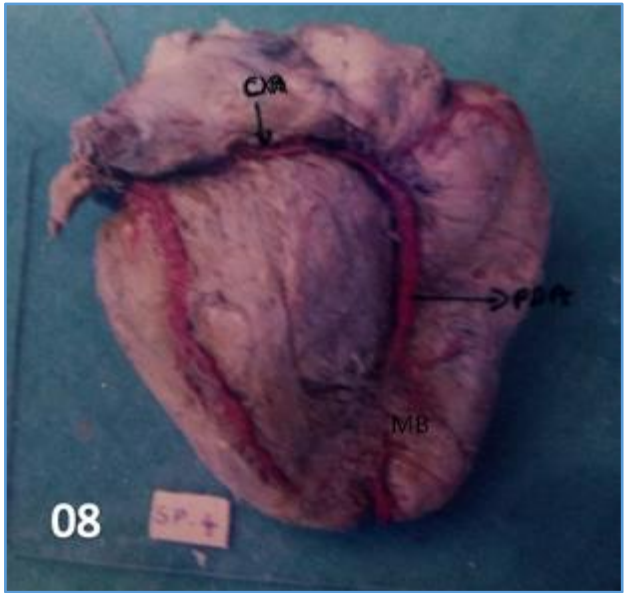
**Figure 6. Coronary Cast Showing Profuse Inter Coronary Anastomosis at Apex, Crux, Inter Ventricular Septal Region Separate Rt. Conus Artery (CA)**



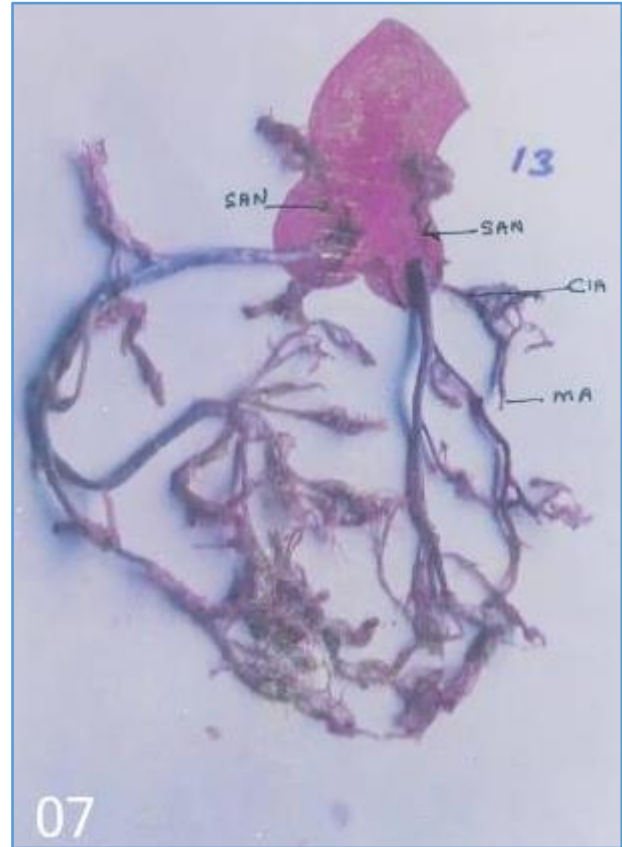
**Coronary Cast-** Twenty five specimens of hearts, including foetal hearts were utilized for this study. This method helps to study the branching pattern of the vessels more clearly and the anastomosis at the capillary levels (Figure 6) at the level of crux (6 and 7) and around the apex. Inter coronary anastomosis was also observed in foetal specimens. Bilateral SA nodal artery, profuse anastomosis between terminal branches of right marginal, posterior interventricular, and anterior interventricular arteries at apex of the heart were observed (Figure 6, 7).

Left conus artery was found to originate from the anterior descending branch of left coronary artery in four out of twenty five coronary cast preparations, out of which in one specimen, left conus artery sends septal branches to interventricular septum. Bilateral conus branch, bilateral sinuatrial nodal branch and very short circumflex branch were shown in (Figure 7).

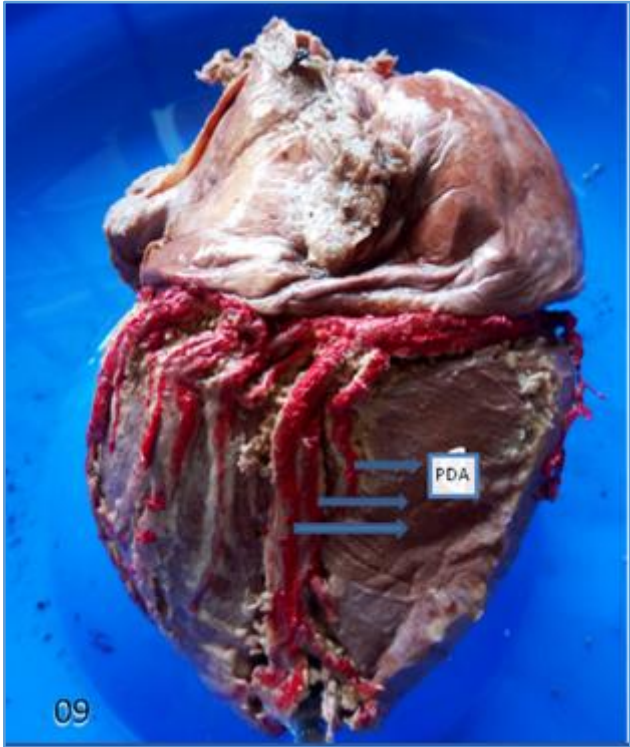
Myocardial bridges were observed in 63.3% of dissected specimens of which 61.4% were observed in anterior interventricular artery, 15.8% in posterior interventricular artery (Figure 8).



**Figure 8. Showing PDA arising from Circumflex Artery (CXA), Left Preponderance and Myocardial Bridge (MB)**



**Figure 7. Coronary Cast Showing Bilateral SA Nodal Artery (SAN) Circumflex Artery is Small and Ends as Left Marginal (MA)**



**Figure 9. Showing Multiple Posterior Descending Artery (PDA)**

Observation		No. of Cases	Total No. of Cases	Percentage
Preponderance	Right Preponderance	95	115	83%
Origin	Anterior aortic sinus	114	115	99.1%
Branching pattern	Conus branch	100	115	87%
	Sinuatrial nodal	84	115	73%
	Right ventricular	115	115	100%
	Right atrial	115	115	100%
	Right marginal	115	115	100%

Terminations	Atrioventricular nodal	95	115	83%
	Posterior descending	95	115	82%
	At crux	32	115	27.8%
	Right of crux	18	115	15.65%
Anastomosis	Left of crux	65	115	56.5%
	Around apex of heart	80	115	69.5%
	Around crux of heart	40	115	34%

**Table 3. Showing Right Coronary Artery Preponderance, Origin, Branching Pattern, Terminations and Anastomosis and its Percentage**

Observation		No. of Cases	Total No. of Cases	Percentage
Preponderance	Left Preponderance	13	115	11%
Origin	Posterior left sinus	115	115	100%
Branching pattern	Left Anterior descending	115	115	100%
	Circumflex	115	115	100%
	Intermediate	47	115	40%
	Left conus	32	115	28%
	Sinu atrial nodal	31	115	27%
	Atrioventricular nodal	13	115	11%
	Posterior descending	13	115	11%
	Above the apex	10	115	8.6%
Termination of anterior descending	At the apex	35	115	30%
	Lower third of posterior interventricular groove	70	115	60.8%
Termination of circumflex	At crux	40	115	34%
	Right of crux	10	115	8.6%
	Left of crux	65	115	56.5%
	Around apex of heart	80	115	68%
	Around crux of heart	40	115	34%

**Table 4. Showing Left Coronary Artery Preponderance, Origin, Branching Pattern, Termination of Anterior Descending and Termination of Circumflex and its Percentage**

## DISCUSSION

In the present study, an attempt was made to reveal the branching pattern, variation in arterial distribution, extent of inter coronary anastomosis and arterial preponderance based on dissection and coronary cast.

Right coronary artery arises from the anterior aortic sinus in 99.1% of specimens while 0.89% cases it arises from left aortic sinus. This anomalous origin of Right coronary is a rare congenital anomaly which was first described in 1948.<sup>5</sup> It was well established that an anomalous origin of right coronary can lead to angina pectoris, myocardial infarction, or sudden death in the absence of atherosclerosis.<sup>6</sup> The artery runs in the coronary sulcus and terminates at the crux in 27.8%, left of crux in 56.5% and right of the crux in 75.6% of cases in the present study. The conus artery was the first branch in all cases and this artery arise separately from anterior aortic sinus in 13% of cases, of which 3 cases it is double and shows separate ostium for each. The conus artery provides collateral circulation when anterior interventricular artery is occluded, and is seen in 45% of human population.<sup>7</sup> The conus artery when arise separately from anterior aortic sinus is considered as Third coronary artery.<sup>8</sup>

The sinuatrial nodal branch is from right coronary artery in 73% of cases, from left coronary in 27% of cases and 4% of cases from both. The knowledge of anatomic characteristic and variations of SA nodal artery is highly essential to avoid iatrogenic injury during interventional cardiology and cardio surgical procedures involving the right

atrium.<sup>9</sup> The posterior descending artery was a branch of right coronary in 83% of cases, hence called right preponderance. The right coronary preponderance is most prevalent 87-89%, and left preponderance is 7-8% and balanced type is 4% in a study.<sup>10</sup> It was reported that there was a higher prevalence of three vessel disease in patients with right dominance.<sup>11</sup> In the coronary cast studies on 25 specimens, shows intercoronary anastomosis and the anastomotic vessels are found to be straight. Studies conducted in 10 foetal hearts also showed anastomosis at the apex as well as at the crux. These findings were in accordance with the previous study of intercoronary anastomosis which are present even from birth.<sup>12</sup>

Left coronary artery originate from left posterior aortic sinus in all cases. The main stem was short and 1-2 cms in length and divides in to two, three or four branches. The trifurcation was about 32% in this study. The trifurcation of coronary artery is more prevalent in dark races and is a protection against coronary ischemia.<sup>13</sup> The trifurcations were found to be 49% in studies done earlier.<sup>14</sup> The anterior interventricular artery was virtually the continuation of main trunk and runs in the anterior interventricular sulcus and left conus artery arising from this in 28% cases. The right and left conus arteries (in 6% cases) around the pulmonary conus provide collateral circulation if one of the major vessel was blocked. Artery in 60% of cases runs towards the apex of heart and curve around to enter the posterior interventricular sulcus and anastomose with posterior interventricular branch of right coronary artery to establish

micro circulation to support myocardium. It gives acute diagonal branches to supply the left ventricle and septal branches, usually 6-8 in number supplying the anterior two-thirds of interventricular septum. In one case the septal branch anastomoses with a branch from right conus artery establishing an alternate channel of blood supply to interventricular septum. The anterior interventricular artery near its origin gives off a branch to the sinuatrial node in 27% of cases. In this study, atrioventricular nodal branch arises from circumflex branch of left coronary in 11% of cases.

In 8% of cases there are two intermediate branches associated with myocardial bridges were seen. The Kugel's artery was observed in 2 cases arising from circumflex artery in the posterior part of coronary sulcus seen connected with terminal branch of right coronary.<sup>15</sup> In the present study left coronary preponderance was found in 11% which was almost same in literature and studies by Didio and Wakefield.<sup>16</sup> In the left preponderance, the posterior interventricular artery belongs to left coronary. It was also seen that all the 11% of left preponderance were male hearts and all of 31 female hearts dissected are right preponderant. This finding is in accordance with Schlesinger (1940) who postulated that left coronary preponderance is more frequent in males than females.

## CONCLUSION

A gross anatomical study of human coronary arteries was conducted in 115 hearts of different age groups, among male and females. The origin, course and distribution were studied in detail, by dissection and coronary cast. It was found that right coronary artery originates from anterior aortic sinus in all cases except one case, where it takes origin from posterior left aortic sinus. All left coronary arteries take origin from left posterior aortic sinus. It was found that 13 % of cases, right conus artery arises separately from anterior aortic sinus as third coronary artery. Left conus artery was found in few cases, all are found to arise from anterior descending branch of left coronary artery. Bilateral conus branch also noticed. Sinoatrial nodal artery was seen originating from right coronary artery in 73% of cases studied. In 27% of hearts, it was a branch of circumflex artery and in 4% cases from both these vessels. Right coronary preponderance was noticed in 83% of cases, 11% of cases were left coronary preponderant and 6% balanced. It was seen that all 11% cases of left preponderance are male hearts. All the 21 female hearts dissected are right coronary preponderant. The coronary cast help to study the origin, branching pattern, distribution and anastomoses more clearly. The coronary circulation through the pre-existing anastomotic channels can be accentuated by the haemodynamic factors and provides support to myocardium from ischemic heart disease.

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