

## A STUDY OF CORONARY DOMINANCE

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### ABSTRACT

**Context :** Different authors have studied coronary arterial dominance by different methods like dissection, corrosion cast, radiographic, perfusion or by heart mass method. By dissection method different parameters have been used to determine dominance pattern.

**Aim :** The present study was aimed at determining coronary dominance pattern using all the parameters used by different authors i.e coronary artery giving origin to posterior interventricular artery, atrioventricular nodal artery and coronary artery crossing the crux cordis. A new parameter "coronary artery giving origin to sinoatrial nodal artery" was also used in the present study for the first time.

**Setting and design :** The dominance patterns were observed by studying the coronary arteries by dissection method. The findings were compared with each other and with the findings of other authors.

**Materials and Methods :** 50 hearts procured from dissection room cadavers, were dissected meticulously. Both the coronary arteries were studied, their individual branches were noted and also followed to their distal ends to note their detailed course.

**Statistical analysis used :** Not applicable

**Results:** The incidence of right coronary arterial dominance was found to range between 60-78%, left dominance ranged between 12-24% and co-dominance was found to be between 10-24%.

**Conclusion:** Higher incidence of right coronary arterial dominance was seen by dissection method using any/all of the 4 parameters.

**Key Words:** Coronary arterial dominance, Co-dominance, posterior interventricular artery, crux cordis, SA Nodal artery, AV Nodal artery

### INTRODUCTION

Earliest studies on coronary artery dominance were reported in 1<sup>st</sup> half of 19<sup>th</sup> century. Since then there have

been various reports claiming right or left coronary artery dominance. It has been studied using various methods like angiography, corrosion casts dissection etc. Various parameters were used individually in dissection method to establish the dominance pattern.

### Aim

The present study is aimed at studying coronary artery dominance pattern using following parameters:

Coronary artery

1. giving origin to posterior interventricular artery
2. crossing the crux cordis
3. giving origin to Atrioventricular Nodal artery
4. giving origin to Sinoatrial Nodal artery

### Abbreviations used

**RCA-** Right coronary artery, **LCA-** Left coronary artery, **RCAD-** Right coronary arterial dominance, **LCAD-** Left coronary arterial dominance, **PIV-** Posterior interventricular, **SA-** Sinoatrial, **AV-** Atrioventricular

### MATERIALS AND METHODS

A total of 50 adult hearts procured from dissection room cadavers from Department of Anatomy, preserved in 10% formalin, were included in this study irrespective of sex. The right and left coronary arteries (RCA, LCA) were traced by cleaning the epicardium and fat piecemeal. Their branches were dissected and the sinoatrial (SA) nodal, atrioventricular (AV) nodal and posterior interventricular (PIV) branches were noted. The arteries were followed to their most distal ends to note if they crossed the crux cordis.

### RESULTS

**Findings in case of the right coronary artery were as follows:**

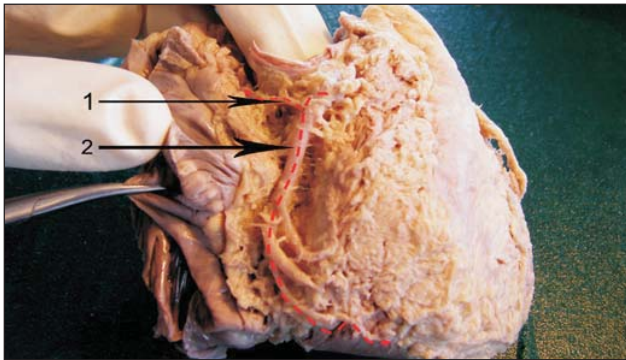
- In 78% hearts the SA nodal artery was seen arising from RCA (figure 1).
- In 76% hearts the AV nodal artery was a branch of the RCA (figure 2).

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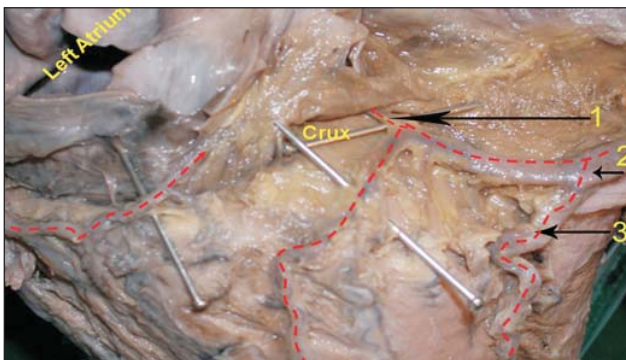
- In 88% posterior interventricular artery was found to be a branch of RCA (figure 3).
- In 24% hearts the RCA reached the crux, while in 60% hearts it crossed the crux to supply part of left ventricle and left auricle (figure 4).

**Findings in case of the left coronary artery were as follows:**

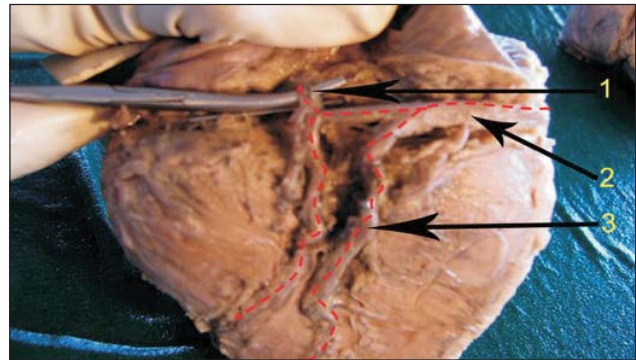
- In 20% hearts the SA nodal artery was seen as a branch of circumflex branch of LCA (figure 5).
- In 24% hearts the AV nodal artery was found to be a branch of circumflex artery (figure 6).
- In 22% hearts PIV artery was a branch of LCA (figure 7).
- In 10% hearts the circumflex branch of LCA reached the crux and in 16% hearts it crossed the crux.
- In 10% hearts the PIV artery was found to be a branch of both the right and left coronary arteries (figure 8).



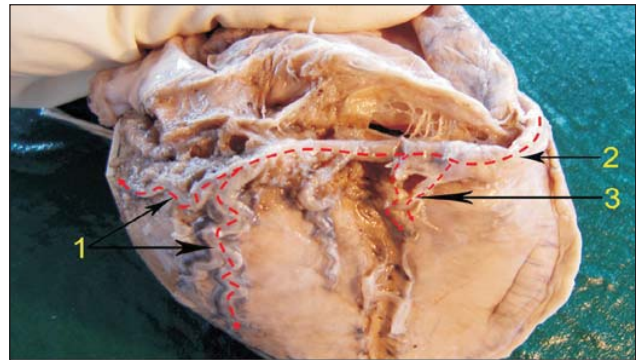
(Figure 1) : Heart showing right coronary artery giving origin to SA nodal artery  
 1. SA nodal artery                      2. Right coronary artery



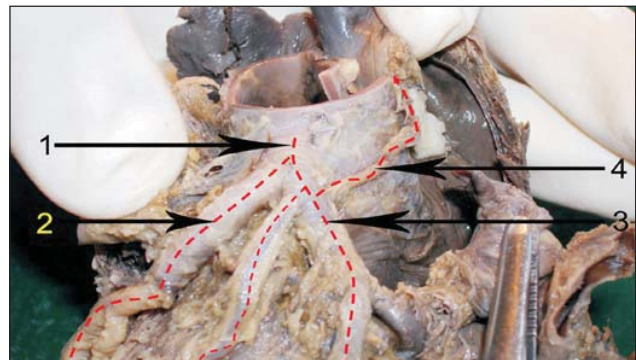
(Figure 2) : Heart showing right coronary artery giving origin to AV nodal artery  
 1. AV nodal artery                      2. Right coronary artery  
 3. Posterior interventricular artery



(Figure 3) : Heart showing Right coronary artery giving origin to posterior interventricular and AV nodal arteries  
 1. AV nodal artery                      2. Right coronary artery  
 3. Posterior interventricular artery

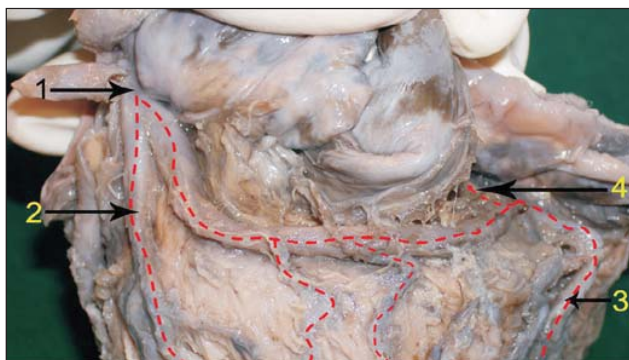


(Figure 4) : Heart showing right coronary artery crossing the crux to supply parts of left ventricle  
 1. Ventricular branches of right coronary artery supplying left ventricle  
 2. Right coronary artery  
 3. Small posterior interventricular branch of right coronary artery



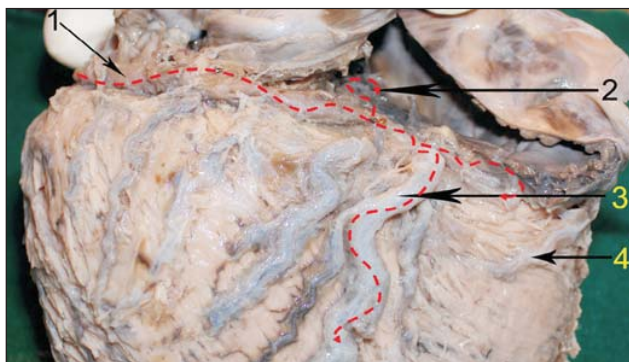
(Figure 5) : Heart showing SA nodal branch of circumflex branch of Left coronary artery  
 1. Left coronary artery                      2. Anterior interventricular artery  
 3. Circumflex artery                      4. SA nodal artery





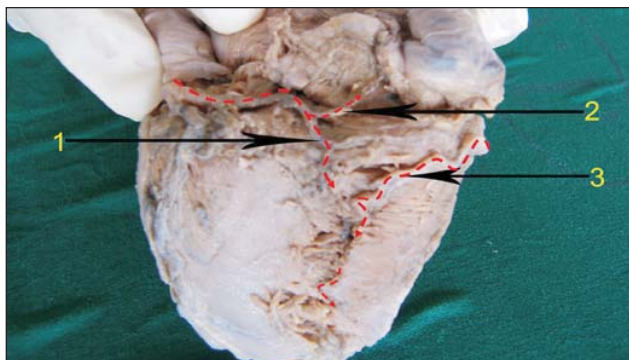
(Figure 6) : Heart showing circumflex branch of left coronary artery giving origin to posterior interventricular artery

1. Circumflex branch of left coronary artery
2. Left marginal branch of left coronary artery
3. Posterior interventricular branch of circumflex artery
4. AV nodal branch of circumflex artery



(Figure 7) : Heart showing left coronary artery crossing the crux and giving origin to the AV nodal and posterior interventricular arteries

1. Circumflex branch of Left coronary artery
2. Lateral ventricular branches of 1
3. Posterior interventricular branch
4. AV nodal branch



(Figure 8) : Heart showing both right and left coronary arteries giving origin to posterior interventricular arteries.

1. Posterior interventricular branch of circumflex branch of Left coronary artery

2. AV Nodal branch of circumflex artery
3. Posterior interventricular branches of right coronary artery

## DISCUSSION

The earliest studies of coronary dominance in the heart, described in 1<sup>st</sup> half of 19<sup>th</sup> century were based on the single criterion as to which coronary artery crossed the crux.<sup>[1,2]</sup> While most earlier studies described higher incidence of right coronary dominance, a study in 1961 considered majority of hearts to be left coronary dominant on the basis of percentage of myocardium supplied by each coronary artery.<sup>[3]</sup> Thus various authors have used different parameters to determine dominance of coronary arteries.

**Total of 4 parameters have been used in the present study.**

### 1. Determination of dominance pattern in the present study using the parameter of "coronary artery giving origin to posterior interventricular artery".

According to Gray's Anatomy the term 'dominant' is used to refer to that coronary artery which gives origin to the "posterior interventricular artery".<sup>[4]</sup>

In 'right coronary artery dominance' (RCAD) the PIV artery arises from the right coronary artery and in 'left coronary artery dominance' (LCAD) it arises from the left coronary artery. In case of 'codominance' the PIV artery is seen originating from both right and left coronary arteries.

In the present study in 78% hearts the PIV artery was exclusively a branch of RCA, in 12% hearts the PIV was exclusively a branch of LCA and in 10% of these hearts it was a branch of both RCA and and left coronary arteries.

The dominance pattern was determined on the basis of these observations and compared with that of various authors who have used the same parameter for determining coronary arterial dominance (Table 1).<sup>[5,6,7]</sup> The present study reports the highest incidence of right coronary dominance i.e 78% as compared to the other authors.

Authors	Right Coronary arterial Dominance	Left Coronary arterial Dominance	Codominance
Present study (2011)	78%	12%	10%
DiDio <sup>[5]</sup> 1975	73.50%	19.40%	7.10%
Cavalcanti <sup>[6]</sup> 1995	69.09%	11.82%	19.09%
Reig <sup>[7]</sup> 2003	50-60%	10-15%	30-40%

## 2. Determination of dominance pattern in the present study using the parameter of “coronary artery crossing the crux”.

The original concept of coronary artery predominance was based on which artery crossed the crux of heart which is the point where the coronary sulcus, atrioventricular and interventricular sulci meet. If none of the arteries crossed the crux then heart was said to have a balanced circulation.<sup>[1,2]</sup>

In the present study in 60% hearts right coronary arteries and in 16% left coronary arteries were found to be crossing the crux of heart. Thus right coronary arterial dominance (RCAD) can be said to be 60% and left coronary arterial dominance (LCAD) 16%. In 24% hearts right or left coronary arteries reached the crux of heart but did not cross it and all these hearts (24%) where the arteries did not cross the crux can be said to be having a balanced circulation.

This dominance pattern was compared with that of various authors who have used the same parameter for determining coronary arterial dominance (Table 2).<sup>[1,3,8,9]</sup>

Author	Right Coronary arterial Dominance	Left Coronary arterial Dominance	Balanced circulation
Present study (2011)	60%	16%	24%
Banchi <sup>[1]</sup> 1904	80%	Not specified by the author	
James <sup>[3]</sup> 1961	82%		
Baroldi <sup>[8]</sup> 1956	81%		
Venkateshu <sup>[9]</sup> 2004	68.75%	16.66%	14.58%

In the present study the incidence of RCAs crossing the crux to supply parts of left ventricle was 60% which is lower than that reported by most authors. The significance of this finding lies in the fact that most myocardial infarcts occur due to the occlusion of the LCA. More the percentage of RCAs crossing the crux to supply part of left ventricle, lesser will be the effect of LCA block on the left ventricular myocardium. Thus according to the present study in 60% of hearts, if LCA is blocked RCA is

there to compensate the supply to the left ventricular myocardium, whereas the incidence is higher (68% to 82%) in other studies.

As the SA and AV nodes are parts of conducting system of heart responsible for origin and propagation of heartbeat, their arterial supply is of great significance. Critical narrowing of arteries supplying these nodal tissues would hamper impulse generating ability of heart. Hence arteries to both SA and AV nodes were studied in detail.

## 3. Determination of dominance pattern using the parameter of “coronary artery giving origin to AV nodal artery”.

The AV nodal artery was a branch of RCA in 76% hearts and a branch of LCA in 24% hearts. Thus using this parameter dominance pattern determined was 76% RCAD, 24% LCAD.

## 4. Determination of dominance pattern using the parameter of “coronary artery giving origin to SA nodal artery”.

The SA nodal artery was a branch of RCA in 78% hearts, a branch of LCA in 20% hearts and originated directly from anterior aortic sinus in 2% hearts. Thus using this parameter dominance pattern determined was 78% RCAD, 20% LCAD.

No co-dominance was observed using either of the above 2 parameters.

The comparison of incidence of origin of SA nodal and AV nodal arteries in the present study with reports by various authors is depicted in Table 3.<sup>[2,3,10,11]</sup>

	SA Nodal artery from			AV Nodal artery from		
	Right coronary artery	Left coronary artery	Both	Right coronary artery	Left coronary artery	Both
Present study (2011)	78%	20%	(2%)*	76%	24%	Nil
Hutchinson <sup>[10]</sup> 1978	65%	35%	Nil	80%	20%	Nil
James <sup>[3]</sup> 1961	54%	42%	2%	86%	12%	2%
Spalteholz <sup>[2]</sup> 1924	68%	32%	Nil	Not specified by the author		
Shirani <sup>[11]</sup> 2006	Not specified by the author			90%	10%	Nil

\* In the present study in 2% hearts SA Nodal artery took origin directly from anterior aortic sinus

In the present study higher percentage of AV nodal arteries are seen taking origin from LCA compared to observations by other authors, indicating that a greater percentage of AV nodal tissue may be at risk of being affected by a myocardial infarct which has been found to occur most frequently due to left coronary block.

SA node is the impulse generating tissue of heart. In case of a block in its arterial supply i.e the SA nodal artery, impulse will not be generated leading to conditions like "sick sinus syndrome".

In the present study only 20% of the SA nodal arteries were seen originating from LCA. This is the least incidence reported. Thus in only 20% of the hearts being supplied, the SA nodal tissue was likely to be critically affected in case of left coronary occlusion.

When both the nodal tissues are irrigated by the same coronary artery, in case of occlusion of that artery the effect of the ischaemia on the conducting system could be severe enough, to result in cardiac arrest. Hence incidence of the same coronary artery supplying both SA and AV nodal tissues was also studied and the findings were compared with those of a study in 2004 as displayed in Table 4.<sup>[12]</sup>

	Right coronary artery	Left coronary artery
<b>Present study (2011)</b>	<b>62%</b>	<b>8%</b>
<b>Bergman<sup>[12]</sup> 2004</b>	50%	7%

A greater incidence of 62% of RCAs supplying both the nodes was reported in the present study versus the incidence of 50% reported in 2004.<sup>[12]</sup> Incidence of LCA supplying both the nodes was found to be almost the same.

Thus a higher incidence of 62% could indicate greater chances of the conducting system being severely affected in case of an occlusion of RCA.

Table 5 depicts incidence in the present study of cases where either right or left coronary arteries supplied either SA or AV node in comparison with the study done in 2004.<sup>[12]</sup>

**Table 5. Incidence of cases where either right or left coronary arteries supplied either SA or AV node**

<b>Present study (2011)</b>	<b>30%</b>
<b>Bergman<sup>[12]</sup> 2004</b>	43%

In these cases even if one of the coronary arteries was occluded only one of the two main pacemakers of the heart would be affected and the other would take over automatically. The finding of such an alternate supply to the nodal tissue is lesser in the present study compared to that reported in 2004.<sup>[12]</sup>

Besides the dissection method, dominance pattern of coronary arteries has been studied using other methods as well (Table 6).

**Table 6. Results of dominance studies by various authors using methods of study different from those used in present study**

Authors	Method used	RCAD†	LCAD‡	Codominance
Ahmed <sup>[13]</sup> 1972	Injection corrosion method	18.09%	11.70%	70.20%
Decio <sup>[14]</sup> 2009	Injection corrosion method	72%	20%	8%
Omar <sup>[15]</sup> 1977	Radiographic method	53.30%	16.70%	30%
	Perfusion method	16.70%	20%	63.30%
	Heart mass method	16.60%	70%	13.30%

† RCAD-Right coronary arterial dominance  
‡ LCAD-Left coronary arterial dominance

Thus each method of studying dominance seems to give varied results. As observed three different incidences of dominances were observed in the same study using three different parameters with varied results.<sup>[15]</sup> Highest incidence of codominance of 70.20% and lowest of 8% were reported using the same injection corrosion method by 2 different authors. In the present study 10% incidence of codominance has been reported by using dissection method.

As observed there have been various parameters used by different authors for studying the 'dominance' of coronary arteries with wide ranging results making any comparison between their results difficult.

The final dominance pattern determined using the 4 parameters in the present study is shown in Table 7.

Table 7. Results of dominance pattern observed by present study using different parameters

Parameters used	RCAD§	LCAD	Codominance
Parameter 1- "Coronary artery giving PIV artery"	78%	12%	10%
Parameter 2- "coronary artery crossing the crux"	60%	16%	24%
Parameter 3- "coronary artery giving origin to AV nodal artery"	76%	24%	No codominance observed
Parameter 4- "coronary artery giving origin to SA nodal artery"	78%	20%	No codominance observed
§ RCAD-right coronary arterial dominance    LCAD-Left coronary arterial dominance			

In the present study the incidence RCAD using parameters 1 to 4 was between 60-78%. The incidence of LCAD ranged between 12-24% and codominance between 10-24%.

The RCA supplies the right ventricle (except a small region to the right of anterior interventricular sulcus), a small part of left ventricular diaphragmatic surface, right atrium, part of left atrium and postero-inferior third of interventricular septum. Thus obstruction of RCA in a RCAD heart will affect these regions of heart but much of left ventricle, left atrium and interventricular septum supplied by left coronary artery will remain unaffected.

In individuals with LCAD the entire left ventricle, part of right ventricle and left atrium and interventricular septum are under nutritional control of LCA. Obstruction of this artery therefore may produce a massive infarct which may produce output failure of the heart. Thus in case of a left coronary arterial block functioning of heart may be severely hampered in case of LCAD heart (only 12% in the present study) but less so in case of RCAD hearts.

LCAD is also found to be associated with increased prevalence of atherosclerosis and aortic stenosis<sup>[16]</sup>. Myocardial bridges are predominantly found on branches of left coronary arteries and higher incidence of myocardial bridges is seen in LCAD hearts<sup>[17]</sup>. The authors would like to state that correlation between myocardial Bridges and coronary dominance is a new thought process and there is need for further study in this direction.

The individuals with codominance have posterior interventricular arteries from both right and left coronary arteries. Thus even in case of obstruction of one coronary artery, the other artery is able to nourish the interventricular septum and region adjacent to it. These individuals may be least severely affected by coronary arterial obstruction.

## REFERENCES

- Bianchi A. Morfologia Delle Arteriae Coronariae Cordis. Arch Ital Anat Embriol. 1904;3:87-164. (Quoted by Ahmed 1972)
- Spalteholz W. Die Arterien der Herzwand, Leipzig, Hirzel. 1924;15. (Quoted by Ahmed 1972)
- James T.N. Anatomy Of Coronary Arteries, New York: Harper & Row. 1961:1-50. (Quoted by Ahmed 1972)
- Standing S, Ellis H, Healy JC, Johnson D, Williams A, Collins P, et al. Gray's Anatomy. Elsevier Churchill Livingstone Ltd, Spain. 2005; 39:1014-1018.
- DiDio LJ, Wakefield TW. Coronary Artery Predominance Or Balance On The Surface Of The Human Cardiac Ventricles. Anat Anz. 1975;137(1-2):147-58.
- Cavalcanti JS, de Lucena Oliveira M, Pais e Melo AV Jr, Balaban G, DE Andrade Oliveira CL, de Lucena Oliveira E. Anatomic Variation Of Coronary Arteries. Arq Bras Cardiol. 1995 Dec;65(6):489-92.
- Reig J, Vilallonga. Anatomical Variations Of The Coronary Arteries: I. The Most Frequent Variations. Eur J Anat. 2003; 7(1):29-41.
- Baroldi G., Mantero O., Scorzoni G. The Collaterals Of The Coronary Arteries In Normal And Pathological Hearts. Circ Res. 1956;4:223-9.
- Venkateshu K.V. Coronary Artery Dominance. Anatomica Karnataka. 2004;2(1):18-21.
- Hutchinson M.C.E.. A Study Of Atrial Arteries In Man. J. Anat. 1978;125(1):39-54.
- Shirani J, Brofferio A. Isolated Coronary Artery Anomalies. [Online]. 2003 [cited 2006 Jun 20]; [11 screens]. Available from: URL: <http://www.topmedconsultants.com/emedicine/evaluations/mainsurvey.cfm?ecik=0030445>.
- Bergman R A, Adel K A, Ryosuke M. Coronary Arteries. Illustrated Encyclopedia Of Human Anatomic Variations: Opus II: Cardiovascular System: Arteries: Head, Neck And Thorax. 2004; 1-19.
- Ahmed S H, El-Rakhawy M.T, Abdalla A, Harrison R.G. A New Conception Of Coronary Artery Preponderance. Acta anat. 1972;83:87-94.
- Decio Cavalet Soares Abuchaim, Carlos Alexandre Spera, Djalma Luis faraco, Jurandir Marcondes Ribas Filho, Oswaldo Malafia. Coronary Dominance Patterns In Human Heart Investigated By Corrosion Casting. Rev Bras Cir Cardiovasc. 2009 Dec; 24(4):514-518.
- Omar B.K. Coronary Artery Predominance-A New Parameter For Its Study. J Anat Soc India. 1977;26(2):85-90.
- Murphy ES, Rosch J, Rahimtoola SH. Frequency And Significance Of Coronary Arterial Dominance In Isolated Aortic Stenosis. Am J Cardiol. 1977 Apr;39(4):505-9.
- Loukas M, Curry B, Bower M, Louis RG, Bartozak A, Kiedrowski M, et al. The Relationship Of Myocardial Bridges To Coronary Artery Dominance In Adult Human Heart. Journal of Anatomy. 2006 Jul;209(1):43-50.