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Original Article

Study of Anatomical Variation in Origin of Coronary Arteries

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ABSTRACT

Introduction: Beneficial therapeutic options are increasingly available for coronary arterial disease. To take full advantage of these options, those performing the interventions require a thorough knowledge of the normal arrangement, and likely anatomic variations, of the coronary arterial system. Hence the study of variation in origin of coronary arteries in cadavers was conducted to generate data of assistance in therapeutic and diagnostic activities. **Material and Methods:** Using conventional dissecting techniques, 60 hearts from embalmed cadavers were dissected and studied for presence, location and number of coronary ostia. **Results:** Both right coronary artery (RCA) and left coronary artery (LCA) were most commonly found to be originating from sinus (80% and 65% respectively) region. Presence of one, two and three ostial openings in right aortic sinus was found in 53 (88.33%), 6 (10%) and 1 (1.67%) heart specimens while all heart specimens had single ostial opening in left aortic sinus except one heart showing two openings. **Conclusion:** The findings in this study may favorably add to the sparsely available data of variation in coronary ostia variables in Indian population.

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1. Introduction

Since human dissections began, thousands of variations have been observed in distribution of blood vessels. Wide variations are still being recorded in origin, length, branches, distribution and dominance of coronary arteries by investigators across the world. New variations in coronary artery distribution are detected regularly during course of routine dissection by medical students. While some of these variations could be benign, some are serious anomalies and could cripple the patient's day-to-day activities. Anatomic variations in the origin and course of the coronary arteries in otherwise normal hearts are rare, with the incidence of such variations assessed at 0.3% in a necropsy series reported by Alexander and Griffith (1956), and 1.6% in a large series of patients undergoing coronary arterial angiography. [1]

The worldwide leading cause of death is ischemic heart disease (IHD). It is caused due to coronary artery disease mediated reduced blood supply to the heart. In 2001 alone, 7.1 million deaths were attributed to ischemic heart disease. As per the medical and public health professionals, there will be a rapid increase in the IHD cases of males and females of developing countries. [2]

Beneficial therapeutic options are increasingly available for coronary arterial disease. To take full advantage of these options, those performing the interventions require a thorough knowledge of the normal arrangement, and likely anatomic variations, of the coronary arterial system. A comprehensive appreciation of the architecture of the coronary arterial system, therefore, is crucial to optimal cardiac care. Simple attention to potential variations in the origin and course of the major coronary arteries can greatly enhance clinical outcomes. [1]

Thus the data on variations of this coronary vasculature observed in Indian population may be important in clinical and surgical practice and this has prompted us to carry out "A study of anatomical variation in origin of coronary arteries".

2. MATERIAL AND METHODS

The study was conducted in the department of Anatomy, B. J. medical college, Pune. 60 hearts from embalmed cadavers and preserved in 10% formalin were dissected using conventional dissection techniques. Heart specimens from both adult male and female cadavers were considered for the study. Heart specimens from cadavers with coronary bypass, angioplasty or other such surgical procedures of heart affecting the study parameters were excluded from this study. Coronary arteries were dissected out and the presence and location of coronary ostia was noted.

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The aortic root was opened longitudinally and the origins (ostia) of the coronaries were observed in the aortic sinuses. The number and positions of the ostia were noted with reference to the sinutubular ridge (sinoaortic junction) and the cusps. The heights of ostia, if present above the sinoaortic junction, were measured from the ridge with the help of a divider and measuring scale. The ostia present at the height of 5 mm above the sinoaortic junction were labeled as high takeoff.

A sample size of 60 was considered for this study taking into consideration the feasibility of getting heart specimens for the study in due course of time and the sample size included in previous studies on variation in coronary ostia.

3. RESULTS

The right and left coronary arteries arise from the ascending aorta in its anterior and left posterior sinuses. In the present study all the heart specimens had the right coronary artery (RCA) originating from the anterior or right coronary sinus while left coronary artery (LCA) originating from left posterior or left aortic sinus. The number of ostia observed in aortic sinus is depicted in the table 1. Table 1 shows that most of the specimens (52 i.e. 87%) had two openings for right and left coronary artery respectively. 7 (11.67%) specimens showed three ostia while 1 (1.67%) heart specimen (Photograph 1) had presence of four ostial openings.

Table 1: Number of ostia opening in aortic sinus

No. of Ostia in Aortic Sinus	No of Specimens (%)
Two	52 (86.67)
Three	7 (11.67)
Four	1 (1.67)

Photograph 1. Superior view of the heart specimen showing four ostia in aortic sinus

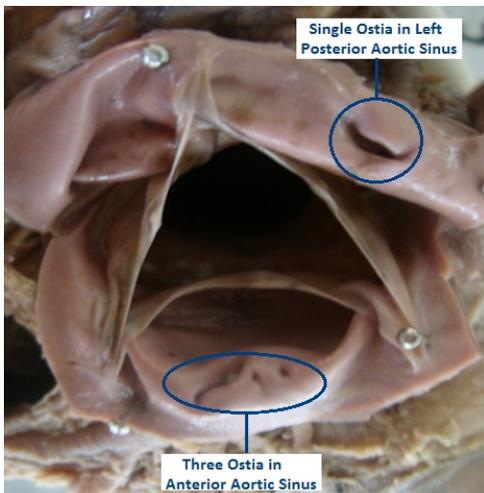


Table 2 shows the presence of one, two (Photograph 2) and three ostial openings in right aortic sinus in 53 (88.33%), 6 (10%) and 1 (1.67%) heart specimens.

Table 2: Number of ostia opening in right aortic sinus

No ostia in Right Aortic Sinus	No of Specimens (%)
One	53 (88.33)
Two	6 (10)
Three	1 (1.67)

Photograph 2. Superior view of heart specimen showing two ostia in anterior aortic sinus

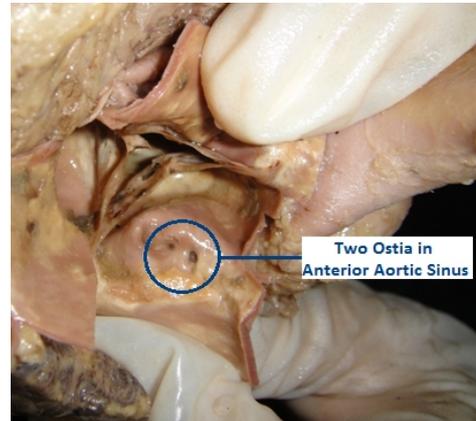


Table 3 shows that all heart specimens had single ostial opening in left aortic sinus except one heart showing two openings (Photograph 3).

Table 3: Number of ostia opening in left aortic sinus

No ostia in Left Aortic Sinus	No of Specimens (%)
One	59 (98.33)
Two	1 (1.67)

Photograph 3. Superior view of heart specimen showing two ostia in left aortic sinus

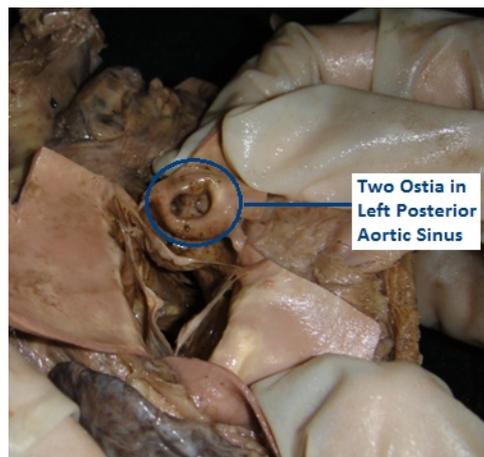


Table 4 and Figure 1 show that the location of ostium i.e. origin of right coronary artery was found in the sinus region in 46 (76.67%) cases, at the sinuaortic junction (Photograph 4) in 9 (15%) cases and in the aortic region in 5 (8.33%) cases while for the left coronary ostium the location in respective regions was found to be in 41 (68.33%), 11 (18.33%) and 8 (13.33%) cases.

Table: 4 Site of origin of coronary arteries

Coronary Artery	Origin (%)		
	Sinus	Sinuaortic	Aortic
Right	46 (76.67)	9 (15)	5 (8.33)
Left	41 (68.33)	11 (18.33)	8 (13.33)

Photograph 4. Superior view of heart specimen showing site of origin of coronary arteries

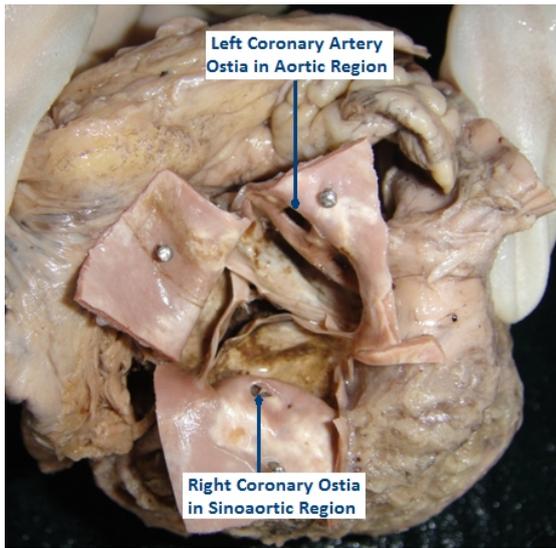


Table 5. Comparison of number of ostial openings in right aortic sinus in different studies.

Authors	No. of Ostia in Right Aortic Sinus			
	One (%)	Two (%)	Three (%)	Four (%)
Present Study (N=60)	53 (88.33)	6 (10)	1 (1.67)	0 (0)
Gajbe ULetal[4]	25 (83.33)	2 (6.67)	3 (10)	0 (0)
JoshiSDetal[5]	65 (61.9)	31 (29.52)	8 (7.62)	1 (0.95)
Udaya Sankari T etal ^[10]	23 (76.67)	5 (16.67)	2 (6.66)	0 (0)

Table 6. Comparison of incidences of third coronary arteries in various studies conducted by different authors.

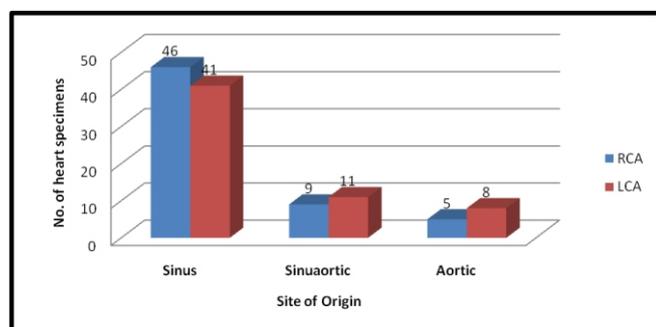
Authors	Incidence of Third Coronary Artery
Present Study	11.67%
Gajbe UL etal ^[4]	16.67%
Blake HU ^[11]	23%-50%
Bergmann RA ^[12]	50%
Gray's Anatomy ^[3]	36%
Kini S etal[9]	50%
Kosar P etal ^[6]	22%
Kalpana R ^[13]	24%
Udaya Sankari etal ^[10]	23.33%

Table 7. Comparison of incidence of various locations of coronary ostia in different studies

Authors	Location of Ostium	Incidence of Coronary Artery Origin	
		Right	Left
Present Study (N=60)	Sinus	76.67%	68.33%
	Sinoaortic	15%	18.33%
	Aortic	8.33%	13.33%
Joshi SD etal ^[5] (N=105)	Sinus	89.52%	80%
	Sinoaortic	6.67%	15.24%
	Aortic	3.81%	4.76%
Udaya Sankari T etal ^[10]	Sinus	73.34%	-
	Sinoaortic	23.33%	-
	Aortic	3.33%	-
Kalpana R ^[9] (N=100)	Sinus	90%	80%
	Sinoaortic	-	-
	Aortic	10%	20%

DISCUSSION

The right and left coronary arteries arise from the ascending aorta in its anterior and left posterior sinuses. The levels of the coronary ostia are variable. [3] The right coronary ostium is below the margin of the cusps in 10%. The artery is usually single, but as many as four right coronary arteries have been observed. Left coronary artery (LCA) arises from the left posterior (left 'coronary') aortic sinus and the ostium is below the margin of the cusps in 15%, and may be double, leading into major initial branches, usually the circumflex and anterior interventricular (descending) arteries.

Figure 1. Site of origin of coronary arteries

In the present study all the heart specimens had the right coronary artery (RCA) originating from the anterior or right coronary sinus while left coronary artery originating from left posterior sinus. Most of the specimens (52 i.e. 87%) had two openings for right and left coronary artery respectively. 7 (11.67%) specimens showed three ostia while 1 (1.67%) heart specimen had presence of four ostial openings. Presence of one, two and three ostial openings were seen in right aortic sinus in 53 (88.33%), 6 (10%) and 1 (1.67%) heart specimens respectively. The presence of right conus artery originating separately from right aortic sinus is known as 'Third coronary artery'. Thus the incidence of third coronary artery in the present study was found to be 11.67% (7 specimens). All heart specimens had single ostial opening in left aortic sinus except one heart showing two openings. Gajbe UL et al also got similar findings with all the 30 hearts in their study showing RCA originating from right aortic sinus and LCA originating from left aortic sinus.[4] Joshi SD et al in their study found that 98% (103/105) specimens had single ostial opening in the left aortic sinus. Only 2 hearts had dual openings in the left aortic sinus. [5]

Table 5 shows the comparison of number of ostial openings in right aortic sinus in present study versus other studies. The incidence is almost similar with most of the heart specimens showing a single ostium in right aortic sinus.

Table 6 shows that the incidence of third coronary artery in present study was found to be lower than most of the reported incidences in various studies.

The variations of the origin of coronary arteries and the presence of multiple anomalous ostia are rare and could cause certain clinical consequences.[4] When multiple ostia are observed in the anterior aortic sinus, the most common variation observed is an accessory orifice for the right conus artery. The 3rd coronary artery usually forms an anastomosis with the likewise branch of the left coronary artery. This anastomosis lies on the distal part of the pulmonary trunk and is known as the "anulus of Vieussens".[3] The functional significance of this anastomosis is still under question. However, numerous authors have proposed that it functions as a crucial collateral path between the right and left coronary arteries.[4] The knowledge of presence of multiple coronary ostia is

important and while performing coronary arteriography and angiography, a preliminary aortic root injection of the dye must be given to locate them so that the adverse outcomes of the procedure can be prevented.

A range of 0.5–2 cm has been reported as normal length of presence of ostia from sinotubular junction by some authors, while others gave 10 mm as the upper limit of normal.[6] Another study by Kim et al specified the ostia above the sinuaortic junction as high takeoff.[7] In a study by Menke et al the location of ostium 5 mm or above the aortic sinotubular junction is defined as high takeoff position.[8] Considering the 5 mm as the cut-off criteria, none of the specimen showed the high takeoff in the present study.

Normally, the coronary ostia are located within the sinuses of Valsalva permitting maximal opportunity for coronary diastolic filling. Location of ostia in the tubular portion of aorta i.e. above the sinuses of Valsalva, may decrease coronary perfusion.[8] Such coronary arteries can be at risk of being clamped during the valve replacement surgeries with low clamping of aorta. These kind of high takeoff origins are likely to be missed during the procedures like coronary arteriography or angiography if not borne in mind.

In the present study the location of ostium i.e. origin of right coronary artery was found in the sinus region in 46 (76.66%) cases, at the sinuaortic junction in 9 (15%) cases and in the aortic region in 5 (8.33%) cases while for the left coronary ostium the location in respective regions was found to be in 41 (68.33%), 11 (18.33%) and 8 (13.33%) cases. The other reported studies also show similar findings with ostia most commonly situated in sinus region and more incidence of left coronary ostium present in aortic region as compared to right (Table 7). Normally, the RCA arises from the right coronary sinus somewhat inferior to the origin of the LCA. [9] This could be the likely reason for more incidence of LCA ostia present in aorta than RCA.

CONCLUSION

The knowledge of variation pattern in origin coronary vessels prevalent in the population and the associated risks or precautions to be taken in the specific condition is of prime importance for a treating surgeon. The findings in this study may favorably add to the sparsely available data of variation in coronary ostia variables in Indian population.

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