

A STUDY OF VARIATIONS IN CORONARY OSTIA

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ABSTRACT

Introduction: The year 1928 saw the first human coronary angiograph when Werner Forssmann inserted a ureteral catheter into his left anticubital vein and advanced it to the heart. Today coronary angiographies and selective coronary angiographies are being done quite frequently. Presence of supernumerary ostia can make it difficult to correctly interpret angiographic films. Also during selective angiography such ostia are difficult to cannulate. The knowledge of position of coronary ostia with respect to aortic sinuses and possible variations in their locations will aid in carrying out these procedures as well as in interpreting them.

High position of ostia in comparison to the aortic sinuses has been found to be related to poor filling of coronary arteries during diastole. The knowledge of position of ostia, could help in correct interpretation of patient's symptoms and could help in channalizing the further line of treatment

Aim: To study the variations in the number and position of coronary ostia in relation with aortic sinuses.

Materials and Methods: A total of 50 human hearts were included in this study irrespective of sex. The hearts were procured from dissection room adult cadavers of Dr D Y Patil Medical College, Pune and were preserved in 10% formalin.

The origins of both the coronary arteries were noted while looking out for presence of any extra ostia in either of the three aortic sinuses. Depending on whether the ostia were situated below, at or above the cuspal margin they were classified as those taking origin from the sinus, sinuaortic junction or ascending aorta.

Results: In this study the ostium for right coronary artery was located in the anterior aortic sinus in 98% cases and in right posterior aortic sinus in 2% cases. The ostium for left coronary artery was located in the left posterior aortic sinus in 100% cases. The maximum height of ostium from the sinuaortic junction in case of coronary arteries taking origin directly from aorta was found to be 1.5mm.

Regarding study of number of ostia found in the aortic sinuses-22% hearts showed presence of 2 ostia, 2% hearts showed 3 separate ostia and 2% hearts showed 5 ostia in the anterior aortic sinus region. No supernumerary ostia were found in the left posterior aortic sinus region. 2% incidence of circumflex artery taking origin from the anterior aortic sinus was observed.

Keywords: Right coronary artery, left coronary artery, 3rd coronary artery, Right conus artery, SA nodal artery, anterior interventricular artery, Circumflex artery, anterior aortic sinus, right posterior aortic sinus, left posterior aortic sinus.

Abbreviations

AAS - anterior aortic sinus, AIV - anterior interventricular, LCA-left coronary artery, RCA-Right coronary artery, RPAS- Right posterior aortic sinus, SA-Sinuaortic.

INTRODUCTION:

The year 1928 saw the first human coronary angiograph when Werner Forssmann¹ inserted a ureteral catheter into his left anticubital vein and advanced it to the heart. Today, selective coronary angiography is done with special catheters designed

to enter coronary ostia. The knowledge of position of coronary ostia with respect to aortic sinuses and possible variations in their locations will directly aid in this procedure and also help in subsequent roentgenologic interpretation of the films obtained.

In the present study the number and position of coronary ostia in 50 hearts have been studied and variations if any were noted.

AIMS AND OBJECTIVES:

1. To study the origin of coronary arteries from the three aortic sinuses

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2. To study the positions of coronary ostia in relation to aortic sinuses
3. To study variations in the number of coronary ostia.

MATERIALS AND METHODS:

A total of 50 human hearts were included in this study irrespective of sex. The hearts were procured from dissection room adult cadavers from Department of Anatomy Dr D Y Patil Medical College, Pune and were preserved in 10% formalin.

The hearts were obtained by longitudinally incising the fibrous and serous layers of pericardium in the midline from root of great vessels upto the diaphragm.

All specimens obtained were numbered. The Aorta was cut open from its right-posterior side above the level of coronary sinuses. The origins of both the

coronary arteries were noted, so also presence of any extra ostia in the aortic sinuses. The distance between the base of the cusp and the lower edge of the ostium was measured carefully using a thread. The length was noted. Depending on whether the ostia were situated below, at or above the cuspal margin they were classified as 1. those taking origin from the sinus, 2. sinuaortic junction or 3. ascending aorta. The distance of "ostia with aortic origin" from the sinuaortic junction was measured.

OBSERVATIONS:

1. Origin of coronary arteries from the three aortic sinuses:

Normally the right coronary artery arises from

	Sinus	Sinuaortic junction	Aortic
RCA	10-18mm	9-18mm	11-20mm
LCA	10-13mm	8-19mm	10-18mm

Table No.I. Chart showing location of ostium and its height from the base of corresponding cusp in cases of Right Coronary & Left Coronary Arteries (The findings in the given chart appear deceptive due to variable sizes of hearts studied)

	Location of ostium	Percentage of incidence in case of	
		RCA	LCA
Present study (2011)	Sinus	22%	10%
	Sinuaortic	62%	66%
	Aortic	16%	24%
Banchi ⁷ 1904	Sinus	10%	18%
	Sinuaortic	71%	48%
	Aortic	19%	34%
Wilkins ⁸ 1988	Aortic	8%	8%
Reig ⁹ 2003	Sinus	56%	56%
	Sinuaortic		

Name of artery	Percentage
3 rd coronary artery.	22%
Vasa Vasorum to pulmonary trunk	4%
SA Nodal artery	2%
Circumflex artery	2%

Table no.II. Extra ostia seen in the Anterior Aortic Sinus

Table No.III. Incidence of various locations of coronary ostia

Author	Percentage of incidence
Present study (2011)	22%
Blake ¹¹ 1964	23%-50%
Miyazaki ¹² 1986	36.80%
Reig ⁹ 2003	33%-51%
Stankovic ¹³ 2004	34.80%
Koenig ¹⁰ 2006	50%
Gray's Anatomy ⁴ 2008	36%

Chart no.IV. Incidence of third coronary artery

Present study (2011)	From AAS: SA Nodal, Circumflex, vasa vasorum to the Pulmonary trunk From RPAS: RCA
McAlpine ¹⁴ 1975	From AAS: SA Nodal, ventricular branch of RCA
Das ¹⁵ 1986	From AAS:AIV
Alexander ² 1995	From AAS: duplicate AIV, LCA, duplicate Conal arteries
Beach ¹⁶ 2001	From AAS: Circumflex, AIV, ramus branch to left ventricular wall
Rigatelli ¹⁷ 2003	From AAS: LCA
Bergman ¹⁸ 2004	From AAS: Circumflex (0.37%)
Shirani ¹⁹ 2004	From AAS: Circumflex (0.33%) separate origins of AIV and From LPAS: Separate origins of AIV and Circumflex (1%)
Francisco ²⁰ 2005	From AAS: AIV
Ishizawa ²¹ 2006	From AAS: LCA

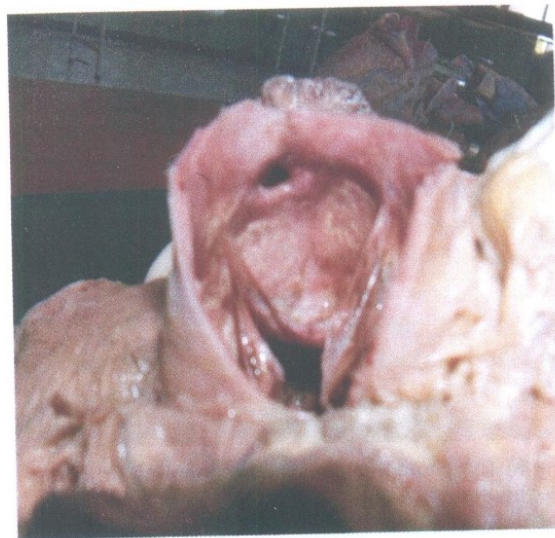
Table No.V. Reports of anomalous origins of different arteries from aortic sinuses (besides the third coronary artery)

	Percentage of incidence
Present study (2011)	2%
Wilkins ⁸ 1988	0.48%
Reig ⁹ 2004	0.45%-0.70%
Rigatelli ¹⁷ 2003	0.13%
Shirani ¹⁹ 2004	0.33%
Pelech ²³ 2006	0.67%

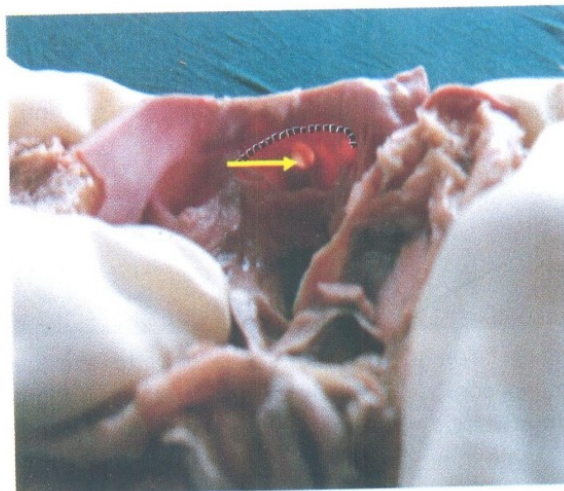
Table No.VI. Incidence of anomalous origin of circumflex artery from anterior aortic sinus



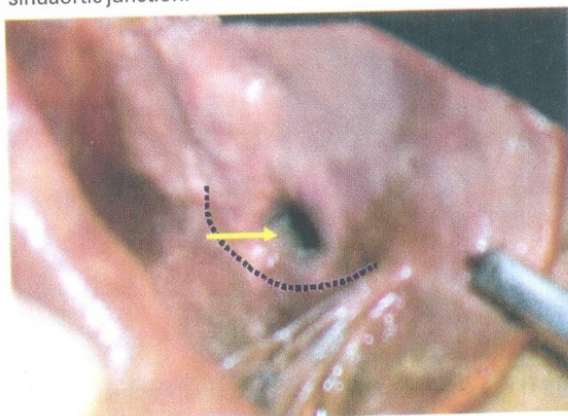
(Fig 1) The arrow indicates the ostium of right coronary artery in the right posterior aortic sinus region.



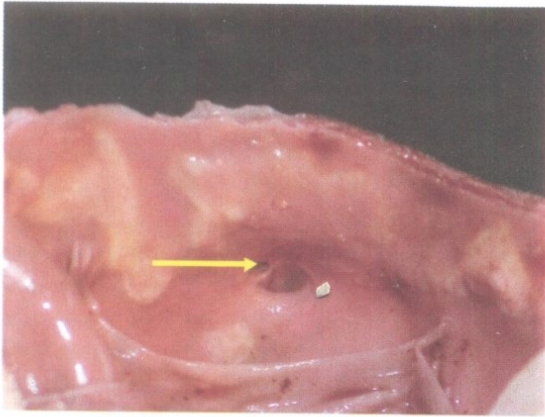
(Fig 2) The arrow indicates the ostium of right coronary artery at the sinuaortic junction which is shown by the black dotted line.



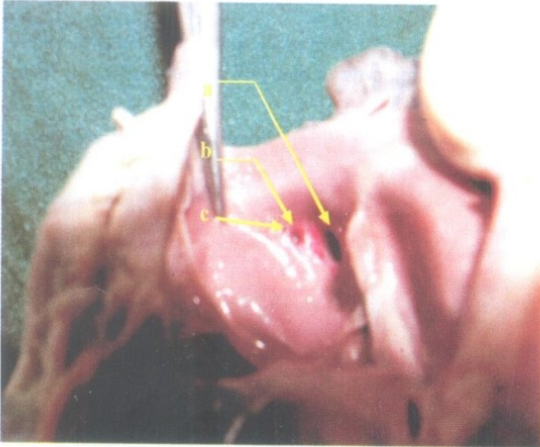
(Fig 3) The arrow indicates the ostium of right coronary artery within the sinus. The black dotted line indicates the sinuaortic junction.



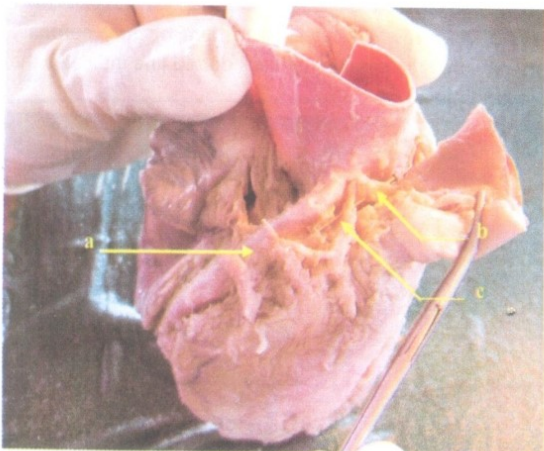
(Fig 4) The arrow indicates the "aortic origin" of the ostium of right coronary artery, the black dotted line indicating the sinuaortic junction.



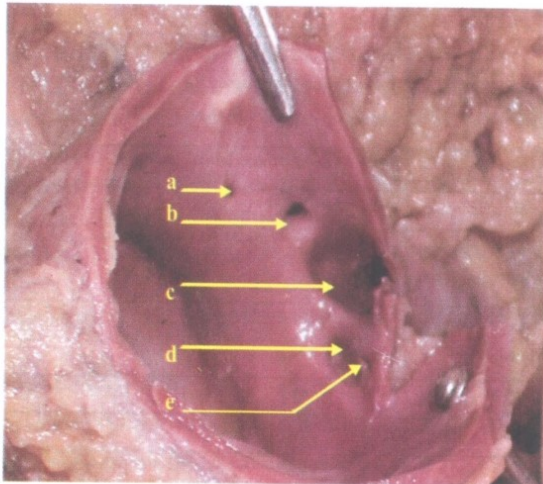
(Fig 5) The photograph shows the origin of 3rd coronary artery indicated by the arrow.



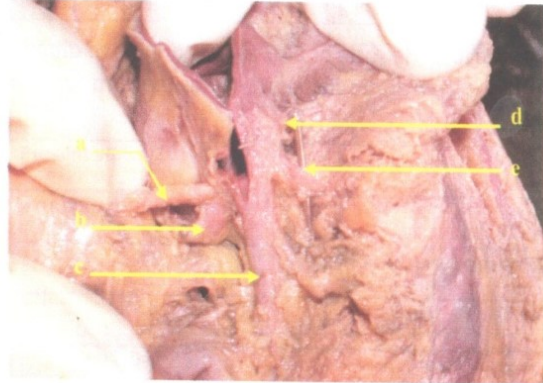
(Fig 6) The photograph shows ostia for 3 arteries in the anterior aortic sinus. a. right coronary artery, b. Right conus artery, c. vasa vasorum to pulmonary trunk.



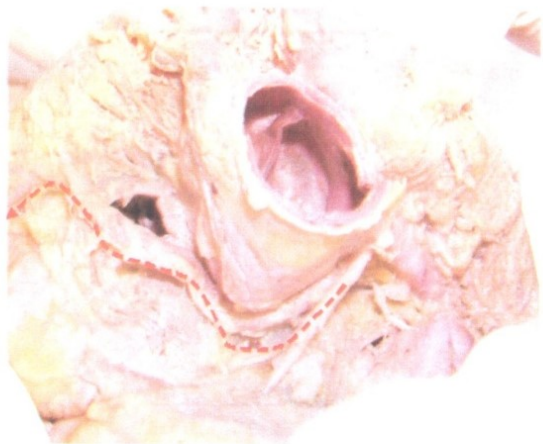
(Fig 7) The external view of heart showing 3 arteries from fig 6 taking origin from the anterior aortic sinus. a. right coronary artery, b. vasa vasorum to pulmonary trunk, c. Right conus artery.



(Fig 8) The photograph shows ostia for 5 arteries in the anterior aortic sinus. a. vasa vasorum to pulmonary trunk, b. right conus artery, c. right coronary artery, d. Circumflex artery, e. SA Nodal artery.



(Fig 9) The photograph shows origin of 5 arteries from fig 8 taking origin from the anterior aortic sinus. a. SA Nodal artery, b. Circumflex artery, c. Right coronary artery, d. Vasa vasorum to pulmonary trunk, e. right conus artery.



(Fig 10) Superior view of heart showing the retroaortic course of circumflex artery.

anterior aortic sinus, the left coronary artery from the left posterior aortic sinus, the position of the ostia of origin being within the sinus of Valsalva or at the junction of the sinus and tubular portions of the aorta (Alexander²).

In the present study in 49 hearts the ostia for right coronary artery were seen situated in the anterior aortic sinus region. One case (fig.1) had ostium for the right coronary artery situated in the right posterior aortic sinus region. The ostia for the left coronary artery in all 50 hearts were situated in the left posterior aortic sinus region.

2. Positions of coronary ostia in relation to aortic sinuses:

The ostium of right coronary artery was located at the sinuaortic junction in 62% hearts (fig2), in the sinus (fig.3) in 22% and in the aortic region (fig.4) in 16% hearts. The ostium of left coronary artery was located at the sinuaortic junction in 66% hearts, in the sinus in 10% and in the aortic region in 24% hearts.

The height of ostium from the base of respective cusp (Table No.I) ranged between 9-20mm for the right coronary artery, and 8-19mm for the left coronary artery.

The height of "coronary ostia with aortic position" was measured from sinuaortic junction and the maximum height of ostia taking origin from aorta was found to be 1.5mm.

3. Extra ostia seen in the Anterior Aortic sinus. (Table No.II)

22% hearts showed more than one ostia in the anterior aortic sinus region.

2 ostia in the anterior aortic sinus were observed in 18% of the hearts. Here the ostia were seen to be for right coronary and right conus artery. The right conus artery arising separately from the anterior aortic sinus is also called as "third coronary artery" (Schlesinger³). Incidence of 3rd coronary artery was found to be 22% (fig 5).

3 ostia in the anterior aortic sinus were seen in 2% of the hearts. They were for the right coronary artery, right conus artery and a vasa vasorum to the pulmonary trunk. (fig 6,7)

5 ostia in the anterior aortic sinus were seen in 2% of the hearts (fig 8,9). One of the ostia was for the right coronary artery. The extra four ostia were for the right conus artery, SA nodal artery, circumflex artery and vasa vasorum to pulmonary trunk. Here though the circumflex artery (fig 10) was taking origin from the anterior aortic sinus and winding around the aorta and pulmonary artery, it did not show any narrowing

or constriction.

DISCUSSION:

The observation "100% left coronary arteries taking origin from the left posterior aortic sinus" matches the documentation by standard books of anatomy.(Gray⁴) While 98% right coronary arteries took origin from the anterior aortic sinus in 2% cases the ostium for right coronary artery was located in the right posterior aortic sinus. Though origin of coronary artery from right posterior aortic sinus is often found associated with transposition of the great arteries (Neufeld⁵) no such anomaly was noted in this case. This finding is rarely observed in hearts with no other alterations (Vlodaver⁶) as was seen in the present case.

Ostial locations seen in the present study in comparison with other authors (Table no III).

Alexander³ in 1995 stated that the right and left coronary ostia arise normally within the aortic sinuses or at the junction of sinus and tubular portions of aorta. Such a location of ostium allows maximum coronary filling during ventricular diastole. The incidence of 62% of ostia being at sinuaortic junction and 22% being in the sinus for right coronary artery i.e., a total incidence of 84% and an incidence of 66% and 10% respectively for left coronary artery i.e., a total of 76% as found in the present study is higher than findings reported by Reig⁹. These findings can be taken to indicate that more number of individuals as per present study show better diastolic filling of coronary arteries. This finding could have ethnic or other issues related to it.

The incidence of aortic origin of ostia for right and left coronary arteries were found to be 16% and 24% respectively. Thus lesser diastolic filling of coronary arteries was seen in these hearts.

Location of ostium and its height from base of cusps (ref Table no. I) was found to be variable. The range of height of 10-18mm for right coronary artery for origin from sinus is more than 9-18mm range for sinuaortic origin. Similarly range of height of 8-19mm for left coronary artery for sinuaortic origin was more than 10-18 mm range for aortic origin. It was observed that this height depended upon relative size of heart. There seems to be no fixed height of sinuaortic junction from base of the cusps.

The coronary ostia have been described as originating in the sinus, at the sinuaortic junction or aorta. But a detailed study regarding the distances, has been carried out for the first time. Thus in the

present study the height of ostium from the base of cusp ranged between 9-20mm for the right coronary artery, and 8-19mm for the left coronary artery. Alexander² 1995 and Vlodayer⁶ 1975 described "high take-off coronary artery" as an artery whose orifice is situated 10mm or more above the line of the sinuortic junction. Alexander² described a record position of high take-off coronary artery as 2.5cm above the sinuortic junction. Vlodayer⁶ reported 6% incidence of these arteries and Reig⁹ claimed that the incidence of these arteries varies from 8% to 30%. In the present study maximum height of ostia from the sinuortic junction has been found to be 1.5 mm. Thus no "high take-off artery" was observed though aortic origin of right and left coronary arteries was observed to be 16% and 24% respectively. The detection of such high originating coronary arteries is clinically significant because:

1. High origin of coronary artery can decrease the diastolic coronary arterial filling. (Koenig¹⁰)
2. Such arteries are at a risk in case of low level clamping of aorta during surgeries like valve replacement. (Vlodayer⁶)
3. They can be missed during performing of procedures like coronary angiography.

When multiple ostia are observed in the anterior aortic sinus, the most common variation observed is an accessory orifice for the conus branch of the right coronary artery (Schlesinger³). Table no.IV reports the incidence of the third coronary artery in present study (ref. Table no.II) as compared with that of other authors.

It is observed that though the incidence of 1 supernumerary ostium for the third coronary artery is a frequent finding, the incidence of 2 or more supernumerary ostia in anterior aortic sinus is highly infrequent.

Table no.V reports the incidence of multiple supernumerary ostia in the present study (Table no.III) in comparison with the findings of other authors. (with their incidences wherever mentioned by the author). In the present study an ostium for the vasa vasorum for pulmonary trunk has been found from anterior aortic sinus and has been reported for the first time.

The present study reports 6 separate ostia in one heart, 5 of which are from a single coronary sinus (AAS). (Fig 6) One of the ostia was for the right coronary artery. The extra four ostia were for the right conus, SA nodal, circumflex artery and vasa vasorum to pulmonary trunk. This is a rare variation hitherto unreported except for a passing reference to 6 ostia

reported by Essenberg²² but details of these ostia were not reported.

The importance of these anomalous origins of arteries is clinically significant due to:

1. The surgical difficulties encountered in cannulating these vessels during open aortic surgery or in performing coronary arteriography.
2. In coronary arteriography to prevent overlooking one of these several orifices, a preliminary aortic root injection outlining the number of coronary arteries present is necessary.
3. Thorough knowledge of existence of such variations is also important to correctly interpret the angiographic findings.
4. Multiple coronary ostia may be associated with other coronary artery anomalies which should be watched out for. (Blake¹¹)

Presence of multiple ostia has not been convincingly associated with clinical symptoms in the cases reported in literature. This correlation needs to be studied in live subjects who are being investigated for multiple ostia by noninvasive techniques like ultrasonography. Therefore those having multiple ostia should be followed up regularly to watch out for any related symptoms. Although this process would be very expensive and time consuming, it will eliminate any selection bias associated with cardiac patients and help to confirm any association between presence of multiple ostia and clinical symptoms.

Anomalous origin of circumflex coronary artery was observed by many authors. In this study the initial course of the circumflex artery is posterior to the aorta (retroaortic). Incidence of this variation has been reported by various authors (Table no. VI) and has been compared with the present study. 2% incidence of retroaortic course of circumflex coronary artery has been observed in the present study.

The clinical significance of this anomaly is reported to be variable. While some authors claim that no pathological significance is to be attached to this finding (Neufeld⁶), others state that this anomaly can lead to alteration in cardiac perfusion by compression of circumflex artery during its retroaortic course (Gallet²⁴).

The artery is likely to be injured during surgery for replacing aortic or pulmonary valves or while stitching prosthesis. Recognition of this anomaly is vital for correct perfusion of heart during cardiac surgery. It has also been found to be associated with valvular heart disease (Reig⁹).

While Page²⁵ in 1974 reported no additional increase in incidence of atherosclerosis in the anomalous portion of circumflex artery, Wilkins⁸ and Tourmousoglou²⁶ reported that 71% of their patients with this anomaly had severe stenosis of the proximal portion of circumflex artery and 11% had severe atherosclerosis in this portion.

In the present study no stenosis of circumflex arteries having origin from anterior aortic sinus with a retroaortic course was observed.

SUMMARY AND CONCLUSION:

In the present study the number and position of coronary ostia in 50 hearts were studied in relation to aortic sinuses and the variations were noted.

The ostium for right coronary artery was located in the anterior aortic sinus in 98% cases and in right posterior aortic sinus in 2% cases. Though often found associated with situs inversus no such anomaly was noted in this case.

The ostium for left coronary artery was located in the left posterior aortic sinus in 100% cases.

The maximum height of ostium from the sinuoaortic junction in case of coronary arteries taking origin directly from aorta was found to be 1.5mm. Thus no high take-off arteries were observed.

Location of ostium was found to be in the aortic region in 16% of the specimens in right and 24% in left coronary arteries. Such high origin of coronary arteries allow lesser coronary filling during ventricular diastole.

22% hearts showed multiple ostia in the anterior aortic sinus region. One heart (2%) had 3 separate ostia in the anterior aortic sinus for the right coronary, right conus artery and a vasa vasorum to the pulmonary trunk. In the present study an ostium for the vasa vasorum for pulmonary trunk has been reported from anterior aortic sinus for the first time.

One heart (2%) had 5 ostia in the anterior aortic sinus. One of the ostia was for the right coronary artery. The extra four ostia were for the right conus, SA nodal and circumflex arteries and vasa vasorum to pulmonary trunk. Although there is a passing reference to presence of 6 ostia by Essenberg²² but details have been studied and documented in the present study for the first time.

Incidence of third coronary artery was found to be 22%, vasa vasorum taking origin directly from anterior aortic sinus was 4% while ostia for SA Nodal artery and circumflex artery were found taking origin directly from anterior aortic sinus in 2% cases each.

Presence of multiple ostia is a hazard in heart surgeries as the ostia of small arteries like third coronary artery are usually very small and barely get opacified in angiographies. Thus these arteries miss detection preoperatively and can get nicked during surgery.

2% incidence of circumflex artery taking origin from the anterior aortic sinus was observed. This artery was observed to be winding around the aorta. Such an anomaly can lead to alteration in cardiac perfusion by compression of circumflex artery during its retroaortic course. No stenosis was observed in the present study.

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