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Original Research Article

ANATOMIC VARIABILITY OF CORONARY OSTIA IN ADULT HUMAN CADAVERIC HEARTS

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ABSTRACT

Introduction: In the light of increased incidence of coronary arterial diseases, knowledge of the variations in the number and location of coronary ostia is essential in the planning of various interventional and surgical procedures on the coronary arteries as well as aortic valve replacements.

Aim: To investigate the variations in the origin, number, size and location of coronary ostia in relation to aortic leaflets.

Methods: Eighty adult human cadaveric hearts with great vessels in situ were studied for coronary ostia.

Results: 78 hearts had tricuspid aortic valve and two hearts had bicuspid aortic valve. Anomalous origins of right coronary artery from the left posterior aortic sinus in one heart and the left coronary artery from the non-coronary sinus in another heart were noted. Both right and left coronary arteries arose from the anterior aortic sinus in two hearts with bicuspid aortic valve. Single right coronary ostium was seen in 63 hearts (78.75%), two right coronary ostia were found in 14 hearts (17.5%), three right coronary ostia were found in two hearts (2.5%), and four were found in one heart(1.25%). The left coronary ostium was single in all hearts. The mean diameter of right coronary ostium (RCO) was 3.17±0.87 mm and of the left coronary ostium (LCO) was 4.1±0.83 mm. The relation of the right and left coronary ostia to the sinu-tubular junction, to the bottom of the related sinus and to the commissures was also analyzed in detail.

Conclusion: This study provides data on normal coronary ostial morphometry and topography and there were significant differences in the number of right coronary ostia than of the left coronary ostium. The observed large variations of coronary ostial position in relation to the sinu-tubular junction and to the bottom of the aortic sinus emphasize the importance of considering such anatomic variations in the development of treatments for coronary artery occlusion.

KEY WORDS: Coronary Ostia, Sinu-Tubular Junction, Aortic Sinuses, Right Coronary Ostium, Left Coronary Ostium.

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INTRODUCTION

The right and left coronary arteries supply oxygenated blood to the heart and originate from the aortic sinuses. Usually, the right coronary artery originates from the anterior aortic sinus and the left coronary artery from the left posterior aortic sinus (left aortic sinus) [1]. Accurate knowledge of the location of the coronary ostia and their relation to the aortic sinuses is important, in view of the fact that

peculiarities and variations of the coronary ostia pose a potential risk for myocardial ischemia - resulting in arrhythmia, angina and sudden death especially during strenuous exercise. In recent times, coronary artery anomalies as a cause of coronary artery disease are gaining importance in diagnostic work up. This is essential especially in young athletes [2,3]. Some authors have indicated the need to establish diagnostic screening protocols for athletes and young individuals subjected to extreme exertion [4,5].

The position of coronary ostia and their relation to the sinu-tubular junction (STJ) is valuable in a number of interventional and surgical cardio-vascular procedures, including cannula-tion or catheterization of the coronary arteries, aortic graft repair or root replacement and implanta-tion of percutaneous aortic valves (PAV) or trans-apical valve replacement [6]. With the proximity of the coronary ostia to the aortic annulus and valve leaflets, a particularly challenging issue is the risk of obstruction of the coronary ostia during PAV replacement [6-8].

The aim of our study is to determine the number and size of the coronary ostia and their relation to the STJ and to the bottom of the sinuses. We also compare our study results to others' work on the anatomical pattern of coronary ostia, in order to discuss what may be the 'normal' range.

MATERIALS AND METHODS

Eighty adult human hearts from the cadavers used for undergraduate teaching, collected and preserved in the department of anatomy, Bhaskar Medical College, over a period of ten years, were taken into the present study. The ascending aorta was transversely sectioned 2 cm above the inter-commissural line. The aortic root was opened and the origins of the coronary arteries were observed. The number and position of the coronary ostia were noted with reference to the sinu-tubular junction (STJ) and the cusps. The diameters of the coronary ostia were measured with Vernier callipers. The position of the coronary ostia was noted in relation to the STJ, the bottom of the sinus and the commissures **(Fig. 1a and 1b)**.

Fig. 1a & 1b: Position of coronary ostia in relation to the aortic sinuses (RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, ICL-Inter Commissural Line, STJ-Sinu Tubular Junction, AAS-Anterior Aortic Sinus, RPS-Right Posterior Sinus, LPS-Left Posterior Sinus, 1- Below STJ, 2-At STJ, 3-Above STJ)

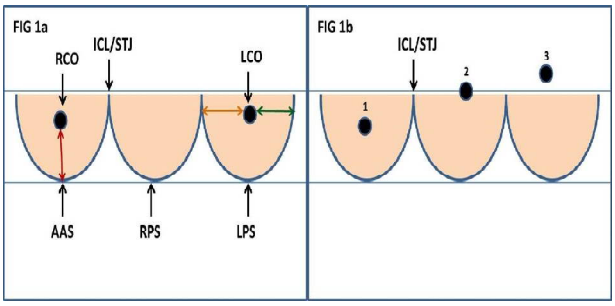


Fig. 2a: Tricuspid Aortic Valve (1-Anterior aortic sinus, 2-Right posterior aortic sinus, 3-Left posterior aortic sinus), FIG 2b: Bicuspid Aortic Valve (4-Anterior aortic sinus, 5-Posterior aortic sinus)

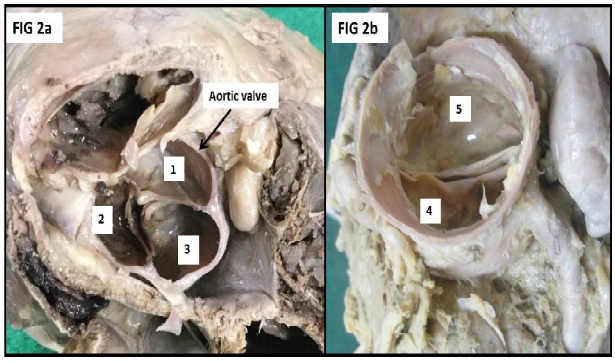
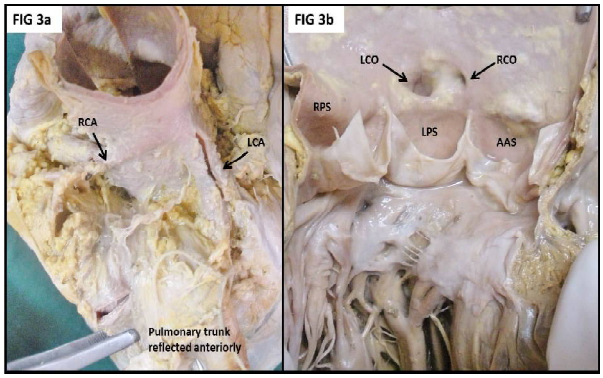


Fig. 3a & 3b: Anomalous origin and course of right coronary artery from left posterior aortic sinus (RCA-Right Coronary Artery, LCA-Left Coronary Artery, RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, RPS-Right Posterior Sinus, LPS-Left Posterior Sinus, AAS-Anterior Aortic Sinus).



RESULTS

Three aortic sinuses (anterior, right and left posterior) were observed in 78 hearts and two sinuses (anterior and posterior) were seen 2 hearts **(Fig. 2a and 2b)**. The right coronary artery originated from the anterior aortic sinus in 77 hearts. In one heart it was from the left posterior aortic sinus and coursed behind the

pulmonary trunk horizontally towards right coronary sulcus **(Fig. 3a and 3b)**. The left coronary artery arose from the left posterior aortic sinus in 77 hearts. It arose from right posterior aortic sinus in one heart **(Fig. 4)**. Both right and left coronary arteries arose from the anterior aortic sinus in two hearts with bicuspid aortic valve **(Fig. 5a & 5b)**. Single right coronary ostium was seen in 63 hearts (78.75%), two right coronary ostia were found in 14 hearts (17.5%), three right coronary ostia were found in two hearts (2.5%) and four were found in one heart (1.25%) **(Fig. 6a, 6b, 6c and 6d)**. The left coronary ostium was single in all hearts.

The mean diameter of right coronary ostium (RCO) was 3.17±0.87 mm and the left coronary ostium (LCO) was 4.1±0.83 mm. This has been compared with other studies in **Table 1.**

RCO was above the sinu-tubular junction (STJ) or inter-commissural line (ICL) in 9 hearts (11.25%), below the STJ in 52 hearts (65%) and at the STJ in 19 hearts (23.75%). LCO was above the STJ in 7 hearts (8.75%), below the STJ in 42 hearts (52.5%) and at the STJ in 31 hearts (38.75%) **(Fig. 7a, 7b, 7c & 7d)**. The comparative position of the right and left coronary ostia in relation to the STJ is shown in the **Tables, charts 2 & 3.** The relation of the right and left coronary ostia to the bottom of the sinus and to the commissures was analyzed in detail. Distance from the bottom of the sinus to the RCO was 11.73±2.92 mm and to the LCO was 12.67±2.1 mm. This was compared with other studies in **Table 4**.

Fig 4: Anomalous origin of left coronary artery from right posterior or non-coronary sinus (RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, RPS-Right Posterior Sinus, LPS-Left Posterior Sinus).

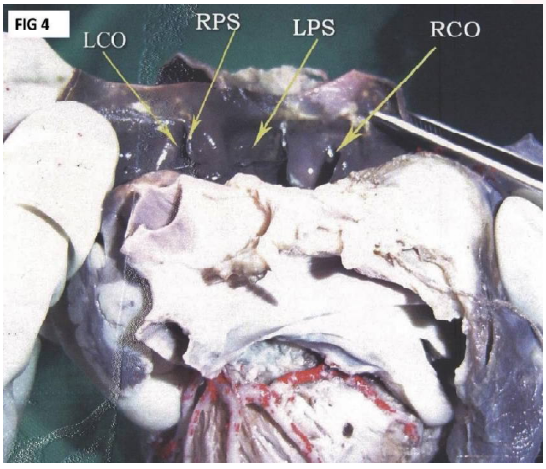


Fig. 5a & 5b: Both coronary arteries from the anterior aortic sinus in bicuspid aortic valve (RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, AAS-Anterior Aortic Sinus, PAS-Posterior Aortic Sinus).

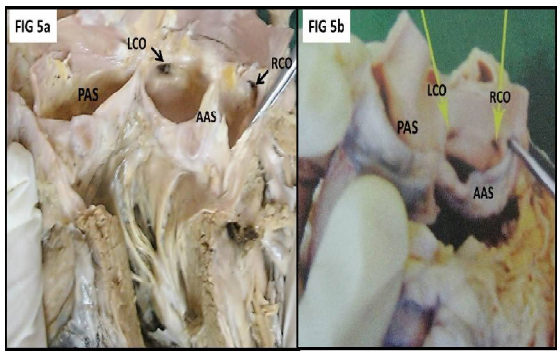


Fig. 6a & 6b: Anterior aortic sinus with two Right Coronary Ostia (RCO).

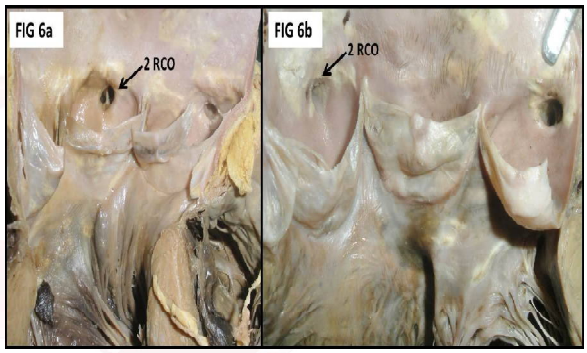


Fig. 6c: Anterior aortic sinus with three right coronary ostia (RCO), FIG 6d: Anterior aortic sinus with three right coronary ostia (RCO).

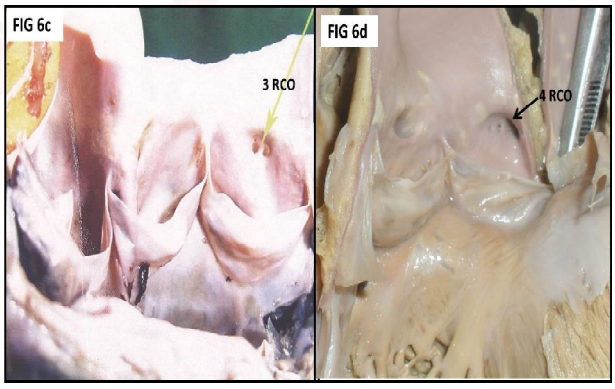


Fig. 7a: Both coronary ostia above STJ, FIG 7b: Both coronary ostia below STJ (RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, STJ-Sinu Tubular Junction).

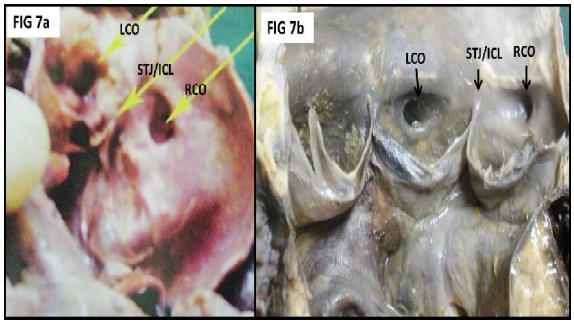


Fig. 7a: Both coronary ostia above STJ, FIG 7b: Both coronary ostia below STJ (RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, STJ-Sinu Tubular Junction).

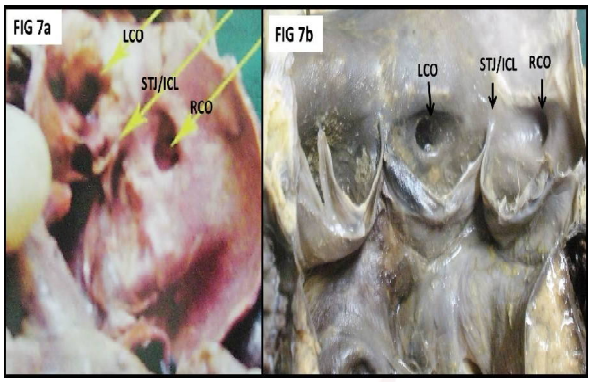


Fig. 7c: Right ostium below and left ostium at STJ, FIG 7d: Both coronary ostia at STJ (RCO-Right Coronary Ostium, LCO-Left Coronary Ostium, STJ-Sinu Tubular Junction).

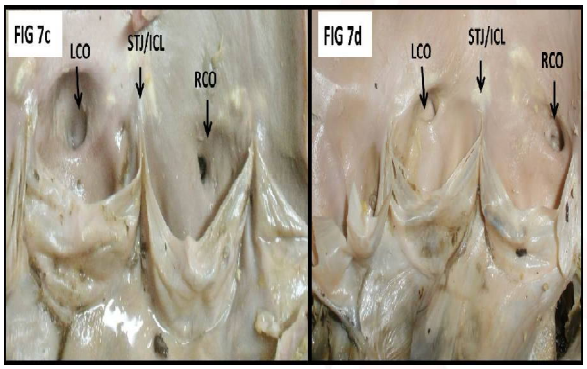


Table 1: Mean diameters of Right and left coronary ostia.

Study	RCO	LCO
JS Cavalcanti et al. 2003 [27]	3.46±0.94	4.75±0.93
Kohlar et al 1981 [28]	3.83	4.83
Bhimali et al. 2011 [29]	2.38±1.33	3.17±0.34
Present	3.17±0.87	4.1±0.83

Table 2 & Chart: Position of coronary ostia in relation to STJ.

	Relation to STJ	Cavalcanti et al. 2003 [27]	Muriago et al 1997 [30]	Gosva F et al. 2010 [26]	Present study
RCO	Above	28%	13%	13%	11.25%
	Below	60%	78%	78%	65%
	At	12%	2%	9%	23.75%
LCO	Above	40%	13%	29%	8.75%
	Below	42%	78%	58%	52.50%
	At	18%	2%	13%	38.75%

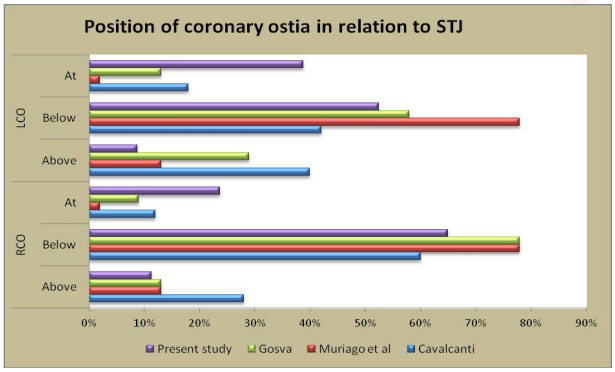


Table 3 & Chart: Comparative position of right and left coronary ostia in relation to STJ.

Comparative position of RCO and LCO in relation to STJ	JS Cavalcanti et al. 2003 [27]		Present study	
	Number	%	Number	%
Both above STJ	9	18%	5	6.25%
Both below STJ	16	32%	31	38.75%
Both at STJ	1	2%	11	13.75%
Right above, left below	3	6%	4	5%
Right at, left below	2	4%	7	8.75%
Right below, left above	8	16%	1	1.25%
Right below, left at	6	12%	20	25%
Right at, left below	3	6%	1	1.25%
Right above, left at	2	4%	0	0%

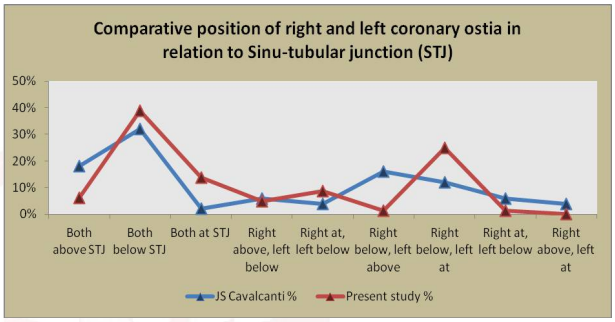


Table 4: Distance from the bottom of the sinus to the coronary ostia.

	Jatene et al. 1999 [34]	Gosva et al. 2010 [26]	Joshi SD et al. 2010 [32]	Present study
RCO	14.8mm	13.1±3.2mm	14.08mm	11.73±2.92mm
LCO	13.3mm	11.8±3.2mm	13.3mm	12.67±2.1mm

Distance of the RCO from the commissure to right was 7.77±3.08 mm , and from the commissure to left was 13.27±3.99 mm. Distance of the LCO from commissure to right was 10.8±3.63 mm, and from the commissure to left was 10.87±2.75 mm.

DISCUSSION

Knowledge about the precise nature and relation of the anatomical structures comprising the aortic root, including the coronary orifices is essential in percutaneous and trans-catheter therapeutic techniques for aortic valve as well as for open heart procedures. The aortic valve usually consists of three sinuses namely anterior, right posterior or non-coronary, and left posterior or left sinus. But sometimes there may be two cusps in which case it is called a bicuspid aortic valve. The incidence of bicuspid aortic valve is described as 0.9% to 1.36% in the general population [9,10,11]. In the present study it was 2.5% which was slightly high. A bicuspid aortic valve (BAV) usually

includes unequal cusp size, due to fusion of two cusps leading to one larger cusp. The direction of the two cusps is usually latero-lateral, and rarely anteroposterior. Anomalous origin and course of the coronary arteries is rarely seen in subjects with BAV and depends on the spatial orientation of the two cusps. When it is latero-lateral, the right coronary artery takes origin from the right sinus and the left coronary artery from the left sinus; when the orientation is antero-posterior; both coronary arteries originate from the anterior sinus [12]. In the present study, both the hearts had anterior and posterior cusps and both coronary arteries originated from the anterior aortic sinus. The importance of an anomalous origin of the coronary arteries associated with BAV is that it poses an increased risk of sudden cardiac death during exercise [13].

The incidence of the abnormal origin of the coronary arteries is low with reported value of 0.64% of births, and 0.17% in asymptomatic children and adolescents [14, 15]. The most common anomaly is the left circumflex originating from the right sinus of Valsalva; followed by a single coronary artery from the left sinus of Valsalva; then, both coronary arteries as well as the left anterior descending artery from the right sinus of Valsalva. Anomalous origin of both coronary arteries from the posterior (non-coronary) sinus was rare and may lead to sudden cardiac death [16]. Anomalous origin of both coronary arteries from left aortic sinus was rare and in these hearts, the right coronary artery runs tangentially towards the right between the aortic root and right ventricular outflow tract [17, 18,19]. We observed 1 such case in the present study. The left coronary from the right posterior sinus was also rare [20] and was observed in one heart in the present study. The left coronary artery when originating from the right posterior sinus runs horizontally between the aortic root and left atrium towards left coronary sulcus. The presence of anomalous course between the great vessels is more relevant than is ectopic origin of the coronary arteries, and may cause myocardial ischemia due to compression [21,22].

The anterior aortic sinus may have extra coronary ostia ranging from one to four in number. The extra ostia may give rise to infundibular branch or SA nodal arteries. In 50% of the cases, SA nodal artery arises as a branch from the proximal part of the right coronary artery. Some authors have described its origin directly from the anterior aortic sinus [23,24]. According to Standring et al, extra ostium was found in anterior aortic sinus in 36% of individuals [1]. Wolloscheck et al reported extra ostia in 65% of hearts in an anatomic and transthoracic echocardiographic study [25]. Extra ostia were found in the anterior aortic sinuses of 21.25% of hearts. Early diagnosis of anatomically unusual course of these arteries before the surgery is helpful in determining surgical strategy. For example, preoperative diagnosis of an aberrant infundibular coronary artery crossing the right ventricular outflow tract may change the surgical management of patients with small aortic root. In such cases, a posterior approach should be preferred. Any surgical procedures involving the aortic root, like Bentall's procedure, require preoperative knowledge about the course of coronary arteries as well as accessory coronary ostia or arteries [26].

The diameter of the left coronary ostium is more than that of the right coronary ostium in most of the earlier studies, as well as in the present study [27,28,29]

The position of the coronary ostia in relation to the sinu-tubular junction (STJ) varies widely and may be above, below or at the STJ or inter commissural line. In most of the studies, these would be below the STJ [26, 27, 30]. In the present study, the right coronary ostium was below the STJ in most of the cases, but left coronary ostium was at the STJ in most of the hearts. In the rare cases reported in the literature, the site of coronary artery origination has ranged from just above the STJ to the origin of the innominate artery, several centi-meters above the aortic valve. If the coronary arteries originate 1cm above the STJ, they are considered as high anomalous origin. The ectopic coronary arteries frequently have slit like orifices and a tangential proximal course along the aortic wall, on which they lie, loosely attached to the aortic tissue. The right coronary artery is the most frequently ectopic artery, but the left coronary artery (or, separately, the left

anterior descending and circumflex artery) may also originate ectopically. High anomalous origin of coronary arteries may associate with aortic stenosis [31].

It was observed that, the right coronary ostium was deviated towards the commissure to right and the left coronary ostium was deviated towards the commissure to left, which was similar to the observations of Joshi SD et al and Turner et al [32, 33].

The distance of the ostia from the bottom of the sinuses was studied by a few authors [32, 34] and in all their studies; the right coronary ostium was placed higher than the left ostium. But in contrast, the left ostium was placed a little higher than the right ostium from the bottom of the sinus, in our study. An abnormal localization of the coronary ostia is important in performing aortotomy incision for aortic valve exposure, preparing a coronary button in root replacement, and approaches for aortic root enlargement. Preoperative diagnosis of such coronary abnormalities is also important for surgical correction of congenital heart diseases such as tetralogy of Fallot and transposition of great arteries. Coronary artery anatomy is also essential in percutaneous and trans-catheter therapeutic techniques for repair or replacement of aortic valve, and other coronary artery interventions and invasive procedures [26].

CONCLUSION

Present study elucidates the variations in the origin, number and position of the coronary ostia in relation to the STJ as well as to the bottom of the sinuses. This may help the cardiologists and cardiac surgeons to achieve a precise management of aortic root pathologies. The awareness of anatomical relation of the coronary ostia would help to decrease the mortality and morbidity associated with coronary artery interventions and to improve the outcome of invasive and surgical cardiac procedures.

Conflicts of Interests: **None**

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