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Topography, morphology and morphometry of coronary ostia – a cadaveric study

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SUMMARY

The right and left coronary ostia are located in relation with the sinus of Valsalva. The coronary ostia are located close to the aortic root, which is an important area for interventional cardiologists and radiologists. This study encompasses the topography, morphology and morphometry of the coronary Ostia. 90 cadaver heart specimens fixed in 10% formalin were dissected. Shape and location of the coronary ostia was determined. The diameter of the ostium and distance from the base of the cusp up to the ostium was measured with the help of a measuring scale. 76.6% of Right coronary ostia (RCO) and 73.3% of Left coronary ostia (LCO) were horizontally oval in shape. 16% of RCO and 23% LCO were circular and 7% of RCO and 10% of LCO were vertically oval in shape. The mean diameter of RCO & LCO was 2.5±1 mm and 2.8±1 mm respectively. 56.6% of Right coronary ostia and 52.2% of Left coronary ostia were located in the central (middle 1/3rd) position of the cusp. The ostia were located at a distance of 5-18 mm from the base of the cusp. The average diameter was 2.5 mm. The most common location was sinotubular and central, and the most common shape was horizontally oval. Occasionally, more than one ostium was seen in the right coronary sinus. Study of the topography, morphology and morphometry of coronary ostia is essential for cardiac interventional procedures done for diagnostic and therapeutic purposes.

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Key words: Left coronary artery – Ostium – Right coronary artery – Sinus – Sinotubular – Tubular

Abbreviations: LCO, left coronary ostium; RCO, right coronary ostium.

INTRODUCTION

The ascending aorta has three aortic sinuses as follows – right sinus, left sinus and non-coronary sinus. The ostium of the right coronary artery lies in the right sinus. The ostium of left coronary artery lies in the left sinus. No artery arises from the non-coronary sinus. Adequate perfusion of the heart depends on the topography, morphology and morphometry of coronary ostia. The coronary artery ostia are in close proximity to the aortic annulus. Knowledge of the topography, morphology and morphometry of the coronary ostium is essential for a number of interventional cardiovascular procedures such as catheterisation of coronary arteries, percutaneous aortic root valve replacement, aortotomy, incision for aortic valve exposure, preparing coronary button in aortic root replacement, direct delivery of cardioplegia through the coronary orifice, approach for aortic root enlargement and surgical ostioplasty. A large number of angiographic procedures and bypass surgeries are done in India. However, the data available regarding the location, shape and diameter of the coronary ostia amongst the Indian population are very scarce. Hence, the present study was carried out to study the topography, morphology and morphometry of coronary ostia by cadaver dissection. These data can add to the reference for designing of catheters

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in accordance with the requirements of the Indian population. It can also help understand and solve the difficulties encountered during the catheterisation for various cardiac interventional procedures.

MATERIALS AND METHODS

Cadaver heart specimens fixed in 10% formalin were used for the present study. 90 specimens were dissected. The heart was dissected out from the middle mediastinum. A longitudinal incision was given on the ascending aorta on its posterior wall, and the aorta was cut open through the non coronary sinus. The shape and location of the coronary ostia were determined. The diameter of the ostium and the distance from the base of the cusp up to the ostium were measured with the help of measuring scale and mean diameter was calculated.

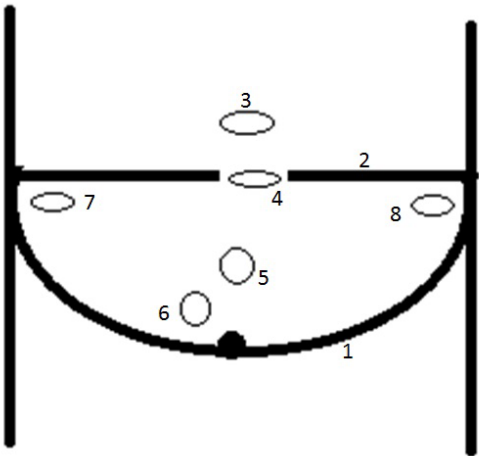


Fig. 1. 1: aortic cusp, 2: Sinotubular junction, 3: Tubular ostium, 4: Sinotubular ostium, 5 & 6: Sinus ostium, 7 & 8: Ostial location close to the commissure.

RESULTS

As seen from Table 1 the coronary ostia showed variation in the shape. The various shapes observed were circular, horizontally oval and vertically oval (Fig. 1). The vertical oval shape in one case was very narrow giving a chink appearance. Predominantly, the shape of both the coronary ostia was horizontally oval. 73.3% of the left coronary ostia and 76.6% of the right coronary ostia were horizontally oval in shape (Fig. 2). The Left coronary ostium was circular in 23.3% of the cases and vertically oval in 10% of the cases. The right coronary ostium was circular in 16.6% of the cases (Fig. 3) and vertically oval in 6.6% of the cases. The mean diameter of RCO was 2.5±1 mm and

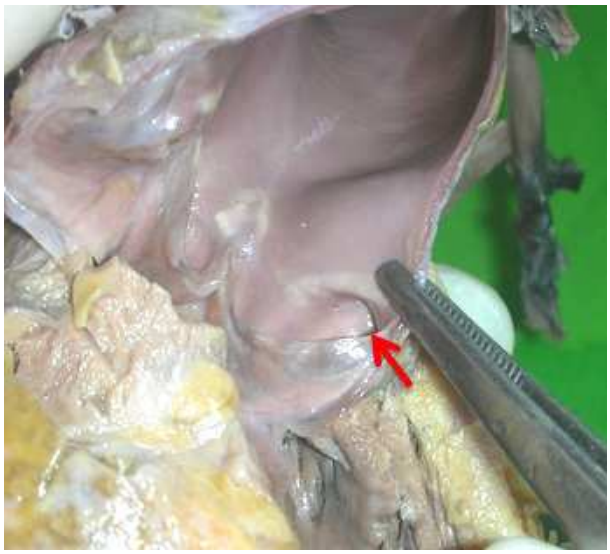


Fig. 2. Right coronary ostium located in the right sinus at the sinotubular junction close to the right side of the commissure, horizontally oval in shape.

Table 1. Shape of the coronary ostium

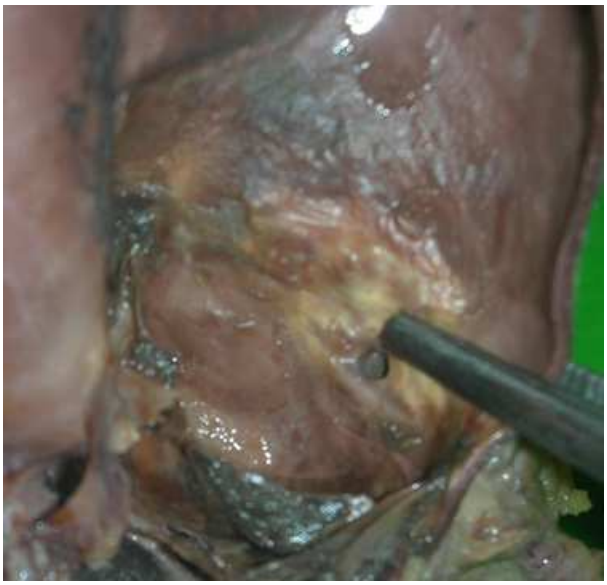
	Circular	Horizontally oval	Vertically oval	Mean diameter	Range of diameter
Right coronary ostium	15 (16.6%)	69 (76.6%)	6 (6.6%)	2.5 ±1 mm	1-7 mm
Left coronary ostium	21 (23.3%)	66 (73.3%)	9 (10%)	2.8 ±1 mm	1-8 mm

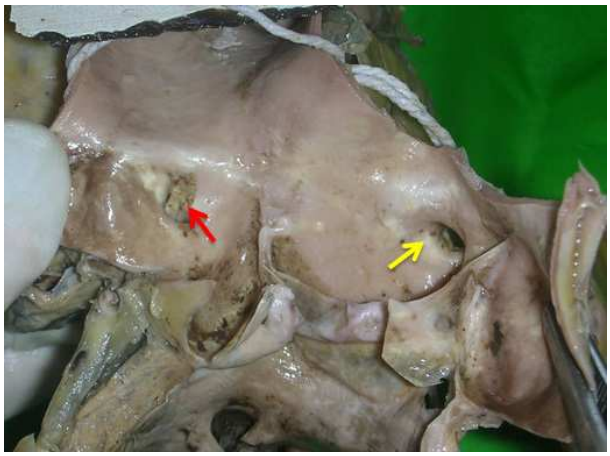
Table 2a. Location of the coronary ostium

	Right sinus	Left sinus	Non coronary sinus	Accessory ostia
Right coronary ostium	90 (100%)	nil	Nil (0%)	22 (24.4%) in the right sinus.
Left coronary ostium	nil	90 (100%)	Nil (0%)	Nil in the left sinus.

Table 2b. Location of the coronary ostia in the aortic sinus with respect to the sinotubular ridge and the commissures

	Sinus location	Height (mm) from cusp base	Tubular location	Height (mm) from cusp base	Sino Tubular location	Height (mm) from cusp base	Central location	Close to the cusp right side	Close to the cusp left side
Right coronary ostium	24 (26%)	5-8 mm	15 (16.6%)	13-18 mm	51 (56.6%)	9-12 mm	63 (70%)	21 (23%)	6 (10%)
Left coronary ostium	27 (30%)	5-8 mm	16 (17.7%)	13-17 mm	47 (52.2%)	9-12 mm	66 (73%)	12 (13%)	12 (6%)





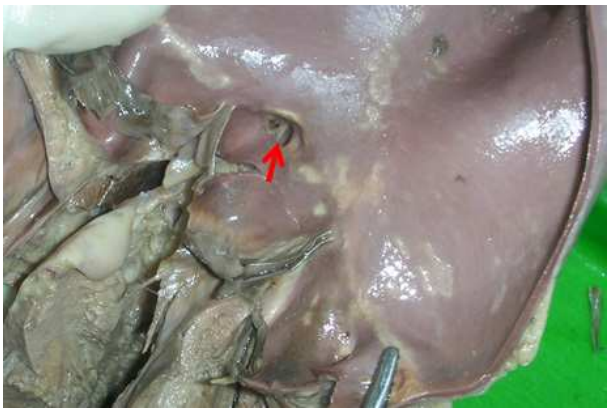


Fig. 3 (top). Right coronary ostium in the right sinus, circular in shape, sinotubular location, eccentric in position.

Fig. 4 (middle). Yellow arrow pointing towards right coronary ostium in the right sinus, horizontally oval in shape, tubular location, close to the right side of the commissure. Red arrow pointing towards the left coronary ostium in the left sinus, sinotubular central location, horizontally oval in shape.

Fig. 5 (right). Red arrow pointing towards the accessory ostium at the sinotubular junction close to the left side of the commissure in the right sinus.

LCO was 2.8±1 mm.

As depicted in Table 2a in all the 90 hearts dissected, the right coronary ostium was located in the right sinus and the left coronary ostium was located in the left sinus. The non-coronary sinus did not show presence of any ostium. The right sinus showed presence of a tiny accessory ostium in 22 cases (Fig. 5), from which the conus artery was arising independently. Normally, the conus is the first branch of right coronary artery. No such accessory ostium was seen in the left sinus & non coronary sinus.

In the aortic sinus of Valsalva, the coronary ostia showed variation in the vertical as well as horizontal placement (Table 2b). In the vertical placement, it was located either in sinus or at sinotubular junction or in the tubule just above the commissure. In the horizontal placement, the ostium was located in the centre or close to the right side or left side of the cusp. Ostial location at a distance of 5-8 mm from the base of the cusp was found to be sinus, while at a distance of 8-12 mm from the base of the cusp was found to be sinotubular and ostial location at distance of 12-15 mm from the base of the cusp was found to be tubular. The most preferred location of the ostia was sinotubular junction and central location. 56.6% of the right coronary ostium and 52.2% of left coronary ostium were located at the sinotubular junction (Figs. 2 and 3). 26% of the RCO and 30% of the LCO were located in the sinus while 16.6% of the RCO & 17.7% of LCO were located above the sinotubular junction. 70% of the RCO and 73% of LCO were centrally placed while rest 30% of the ostia were close to the right or left of the commissure (Figs. 3 and 4).

Table 3. Comparison of mean diameter in mm of present study with other studies

Studies	Right coronary ostium	Left coronary ostium
Present study	2.5 ± 1.0	2.8 ± 1.0
Kohler et al. (1981)	3.833	4.833
Cavalcanti et al. (2003)	3.46 ±0.94	4.75 ±0.93
Ortale et al. (2005)		5.0 ± 0.9
Ballesteros and Ramirez (2008)		3.58 ± 0.59
Bhimalli et al. (2011)	2.38 ± 1.33	3.17 ± 0.34
Kaur et al. (2012)	3.9 ± 1.0	4.6 ± 1.0

DISCUSSION

The history of coronary arteriography began over a century ago when Claude Bernard placed catheters into the arteries and veins of horses. Catheterisation in humans began in 1929, when Werner Forssmann a 25 year old surgical resident inserted a ureteral catheter into his left antecubital vein, advanced it to the right atrium and climbed several flights of stairs to radiology to document the intracardiac portion of the catheter. Forssmann and Cournand received Nobel Prize for discoveries concerning heart catheterisation (Bagchi and Asoke, 1988). The early works on coronary arteriography were characterised by the fact that the majority of the films published were incidental opacifications at the time of retrograde aortography, performed for reasons other than coronary artery visualisation. In 1952, Seldinger reported his technique of vascular access, in 1959 Sones began the era of selective coronary angiography, and Amplatz and associates in 1967 (see Gensini, 1975) pioneered the use of selective catheters from femoral approach with catheter tips designed to arise perpendicular to the wall of aorta and thus more easily enter the coronary ostia which is funnel shaped and is set perpendicular to the aortic sinus. The shape of the mouth of this funnel shaped ostium showed variations in the present study.

In the present study, 76.6% of RCO and 73.3% of LCO were horizontally oval in shape. 16.6% of the RCO & 23.3% of LCO were circular in shape. 6.6% of RCO and 10% of LCO were vertically oval in shape. In one case the vertically oval stomodeum was very narrow giving it a narrow chink like appearance. There is paucity of references in the available literature regarding the shape of the stomodeum of coronary ostium. In the present study, the range of the diameter of the right coronary ostium was 1 to 7 mm while that of left coronary ostium was 1 to 8 mm. The mean diameter of the RCO & LCO was 2.5 ± 1.0 mm & 2.8 ± 1.0 mm respectively. These values concur with the studies done by Bhimalli et al. (2011) and Kaur et al. (2012) (Table 3). However, they are lower than those in the studies done by Kohlar (1981), Cavalcanti et al. (2003), Ortale et al. (2005), Ballesteros and Ramirez (2008) (Table 3). Larger diameter in later mentioned studies could be due to racial difference. The present study was carried out in the Indian population. The shape and diameter of the stomodeum of coronary ostium is an important parameter in the designing of catheter for coronary angiography and angioplasty.

In 100% of the cases in the present study the RCO was located in the right sinus and LCO was located in the left sinus. The coronary ostia in the sinus of Valsalva showed variations in the vertical and horizontal placement in the sinus of Valsalva. In the vertical placement, the ostia were located at the sinus, tubular and sinotubular junction. In 56.6% of cases the RCO was located at the sinotubular junction. In 26% of the cases it was sinus location and in 16.6% of the cases it was tubular in location. In 52.2% of the cases the LCO was located at the sinotubular junction. In 30% of cases it was located in the sinus and in 17.7% of the cases it was tubular in location. These findings concur with the studies done by Valdover et al. (1975), Turner and Navartanam (1996), Pejkovic et al. (2008) and Roy et al. (2014) (Table 4). But in the studies done by Muriago et al. (1997), Cavalcanti et al. (2003), Kalpana (2003), Bhimalli et al. (2009) and Prajapati et al. (2013), sinus location of both the ostia was commonly seen (Table 4).

In the present study, both the coronary ostia were most commonly placed at sinotubular location at a distance of 8-12 mm from the base of the cusp. In the previous study done by Joseph Knight et al. the aortic annulus was taken as the reference point to measure the distance of location of ostium. Both sinus and sinotubular location allows maximal coronary filling during ventricular diastole. Thebesian in 1708 stated that aortic valve in systole blocks the sinus ostia. Hurst's (Keller et al., 1998) has mentioned about a high take off coronary artery whose ostium was located at a distance of 2.5 cm above the sinotubular junction. The knowledge of shape and placement of ostium

Table 4. Location of the coronary ostia – comparison of present study with other studies

Studies	RCO			LCO		
	Sinus (%)	Tubular (%)	Sinotubular (%)	Sinus (%)	Tubular (%)	Sinotubular (%)
Present Study	26	16.6	56	30	17.7	52.2
Vlodaver et al. (1975)	40% had one or both ostia above commissural line as reference.					
Turner and Navartanam (1996)	84% at Sinotubular junction with commissural line as reference.					
Muriago et al. (1997)	78	13	02	69	22	9
Cavalcanti et al. (2003)	60	28	12	42	40	18
Kalpana (2003)	90	1	9	80	0	20
Pejkovic et al. (2008)	19	10	71	22	60	18
Bhimalli et al. (2009)	84	0	16	93	6.66	3.33
Prajapati et al (2013)	91	9	0	94	6	0
Roy et al. (2014)	-	-	-	65% below or at sinotubular junction and 35% above sinotubular junction		

Table 5. Accessory ostia - comparison of present study with other studies.

Accessory ostia	Right Sinus	Left Sinus
Present study	24.4%	nil
Wolloscheck et al. (2001)	65%	nil
Joshi et al. (2010)	8%	nil
Turner & Navartanam (1996)	6 out of 37 cases	nil
Muriago et al. (1997)	74%	nil
Vasudeva & Lokanadham (2013)	5%	nil

in aortic sinus is essential while manipulating a catheter in procedure of angiography, angioplasty and transcatheter aortic valve replacement procedures. The tubular location of the ostium may pose difficulties in catheterisation for angiographic procedures.

In the present study, and with respect to horizontal placement, the ostia were located at the centre or close to the right or left side of the cusp at sinus, tubular or sinotubular junction. In 70% of the cases, the right coronary ostium was centrally located. In 23% and 10% of cases, it was located close to the right side and left side of the cusp respectively. In 73% of the cases, the left coronary ostium was centrally placed, and in 13% and 6% of cases it was located close to the right side and left side of the cusp. These findings differ from the study done by Montero and Gomes (1989). According to their study, 50% of the ostia were located in the middle 1/3rd, which is equal to the central location in the present study. The rest of the 50% showed variation pattern. Knowledge of variation in the horizontal location of ostia is important while doing Jatene's procedure of catheterisation. During catheterisation, the aortic valvular leaflet may be damaged if the ostium is located close to the leaflet.

In the present study, the presence of accessory ostium was noticed in the right sinus in 24.4% of cases. No such accessory ostia were noticed in the left sinus. This accessory ostium was circular in shape and smaller in size as compared to the ostium for right coronary artery. The independent conus artery was arising from this ostium. In 1967, Baroldi and Scomazzoni (Gray's, 1995) described the prevalence of independent conus from the accessory ostium to be 36%. Similar findings were seen in the study done by Standring et al. (Gray's Anatomy 2005) and Sahini and Jit (1989). Waller and Schlant in 1998 have described five coronary ostia. Wolloscheck et al. (2001) reported extra ostia in 65% of cases in an anatomic and transthoracic echocardiographic study. Joshi et al. (2010) reported minute multiple extra ostia in the right sinus in 8% of the cases. Turner and Navartanam (1996) has reported accessory ostia in 6 out of 37 cases and Muriago et al. (1997) have reported it to be 74% and Vasudeva and Lokanadham (2013) have reported it to be 5%. Accessory ostia are quite frequently found in the right sinus. Myocardial perfusion is affected by the presence of multiple ostia. Failure to recognize variations in coronary arterial origin can prolong the arteriography procedure and lead to errors in the interpretation of the coronary angiograms.

In the present study, one case showed split left coronary ostium due to early bifurcation of the left coronary artery into left anterior interventricular and circumflex coronary artery.

The limitation of the present study is that the topography, morphology and morphometry of the coronary ostia have been studied on the cadaveric hearts, and no data on age and sex of the cadaveric hearts was available.

Conclusion: In the present study, the most preferred ostial location was sinotubular central, and the most preferred shape was horizontally oval. Variations in the morphology, morphometry and topography of the coronary ostia emphasize the importance of considering them in various interventional and surgical cardiovascular procedures.

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