**Original article:**

# The debatable aspect of the coronary ostia and their off - shoots : an attempt to solve it, based on cadavers in eastern India

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**Abstract:**

**Background**: Integrity of coronary circulation is the primary requisite for optimum functioning of heart. With advancement of lifestyle coronary interventions are also being sophisticated. Perfection in instrumentation needs perfect knowledge of relevant morphometry and knowledge of coronary arteries with specific racial and demographic variations.

**Objective**: 1) To observe the topography & morphometry of ostia of coronary arteries . 2) Measure intia-media thickness (IMT) of coronary arteries

**Materials & Methods:** Gross cadaveric dissection was done in forty (40) adult human heart specimens in a government institution of eastern India. Dissections were done with target to measure the dimensions of the ostia of the coronary arteries and to locate the ostia in respect of sino-tubular junction (STJ). Finally IMT & diameter were determined histologically.

**Result:** All the specimens showed 3 coronary sinuses. Most of the ostia were transversely oval (67%) and sinus in position (71.12%). The mean maximum diameter of RCO and LCO were 4.19 ± 0.36 mm and 4.41 ± 0.4 mm respectively. RCA maximum mean IMT was 0.36 ± 0.02 mm and for LCA was 0.29 ± 0.01 mm. Similarly, internal diameters of RCA and LCA were 1.22 ± 0.09 mm and 1.28 ± 0.09 mm respectively.

**Conclusion:** Position and shape of the coronary ostia are very important factors in determining the events of myocardial ischaemia as well as for guidance of cardiac catheters in coronary arteries. Sexual dimorphism exists above 40 years regarding IMT and internal diameters of coronary arteries.

**Key words:** Coronary ostia , intima-media thickness, sino-tubular junction.

## Introduction:

With urbanisation and modernisation of society, need as well as practice of cardiac instrumentation has also increased to a remarkable level. Procedures are being sophisticated necessitating the sophistication of instruments. For optimum benefit of the procedures, skilful hands are also needed. To strengthen the skill as well as to modify the instruments, specifically to those targeted patients, one needs proper knowledge of the morphometry of the relevant areas with respect to racial and demographic variations.

Junction between ascending aorta and left ventricle contains three aortic sinuses - Right, left and

posterior (non-coronary sinus)[1]. Right coronary artery arises from right sinus,left coronary artery from left sinus. No coronary artery arises from non-coronary sinus. Junction between aortic sinuses and the ascending aorta is called sino-tubular junction. Morphology of coronary ostia is important for various types of cardiac instrumentation like incision for aortic valve exposure, direct delivery of cardioplegia through the coronary orifice, percutaneous aortic root valve replacement, aortotomy, preparing coronary button in aortic root replacement, approachfor aortic root enlargement and surgical ostioplasty. [2]

Some type of morphological variations of ostia of coronary arteries are responsible for myocardial ischaemia leading to angina, arrhythmia and even sudden cardiac death.[3,4]

Lastly, for all kinds, coronary angioplasty and bypass surgeries deal with the topography and morphometry of coronary ostia. Incidence of the surgeries has increased to a large scale in eastern India in last few years. Now, to minimise the iatrogenic complications of all these procedures relevant morphological knowledge of specific demographic group is also needed. Our present study was carried out by cadaver dissection in eastern India to know the topography and morphology of the coronary ostia and coronary sinus of this specific group of population. These kinds of data will definitely enrich the knowledge of the manufacturers of catheters in designing it in accordance with the requirement of the eastern Indian population.

Moreover, measurements of intima-media thickness (IMT) of coronary arteries are the cornerstones for determining the normal anatomy of these vessels. Any change in such thickness might pose serious threat to the individual in form of partial or complete occlusion of the concerned artery, leading to the patho-physiology of ischaemic heart disease. We also aim at determining any variation of the maximum-IMT of RCA & LCA with respect to morphometry and topography of their ostia of origin.

**Material and methods:**

This is an observational study done in a government institution in Kolkata. We have collected 45 cadaveric heart specimen donated to the institution. Those aged between 40-60 years were taken irrespective of attention to their sex. Those which showed evidence of previous cardiac interventions or deformities of any kind were excluded from the study. Specimen collected from 10% formalin fixed bodies by proper dissection following the steps as stated in Cunningham's Manual. Now each specimen was cleaned properly then ascending aorta was sectioned transversely 2cm above the level of sino-tubular junction. The aortic sinuses were now visible to locate the non-coronary aortic sinus. A longitudinal incision was now given through the area of non-coronary or right posterior sinus. At this stage the ostia of coronary arteries were exposed to such extent that they can be measured properly. Finally number, shape and location of ostia were noted. Location was noted depending on two points - on which sinus it is situated and its distance from sino-tubular junction or inter-commisural line. We have also searched for presence of any accessory ostia in any of the sinuses. Using slide callipers diameters of the ostia and the distance of the ostia from the sino-tubular junctions were measured.

To add to this, the proximal 1 centimetre of Right Coronary artery (RCA) as well as Left Coronary artery (LCA) were sectioned and processed for histological study. In around 8 specimens the Left Coronary Artery bifurcated into Left anterior



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descending (LAD) and Left Circumflex (LCx) branches immediately after arising from the left coronary ostium. In those specimens the proximal 1 centimetre of LAD was sectioned and processed for histological examination. Tissue fixation was done with 10% formalin and subsequent processing was done with graded alcohols and xylene. Subsequently paraffin embedding and block preparation was done, followed by sectioning using Rotor Microtome @ slice thickness of 3-5 microns. Finally they were stained using Haematoxylin and counterstained with Eosin, and studied under compound light microscope. Digital photography of the sections studied under microscope was done and they were transferred to a personal computer. Images were analysed with IMAGE J software and maximum diameters (intima-to-intima) and intima-media thickness of both the arteries (Right & Left) were measured at their origins, as shown in Figure 1.

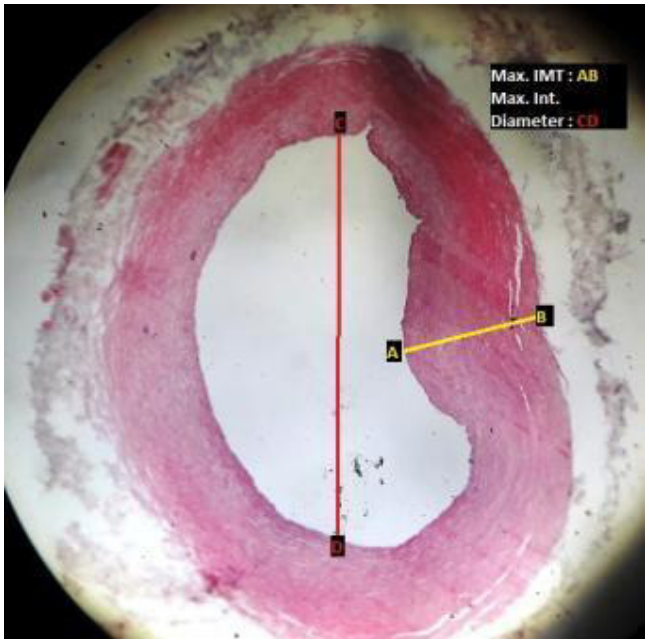


**Figure 1** : Digital Image of H&E stained coronary artery showing the Intima-Media Thickness and Internal Diameter (Intima to intima)

**Results & Analysis :**

All the specimens showed 3 (three) coronary sinuses as mentioned in text books[1]. Among them only 2 (two) were coronary sinuses, meaning the coronary arteries were arising from those sinuses specifically: right and left coronary sinuses. The other one was posterior with respect to the previous two, and termed non-coronary sinus. Each coronary sinus revealed single opening termed "Coronary Ostium". Thus, for each specimen there were 2 (two) coronary ostia : right and left, as shown in figure 2.



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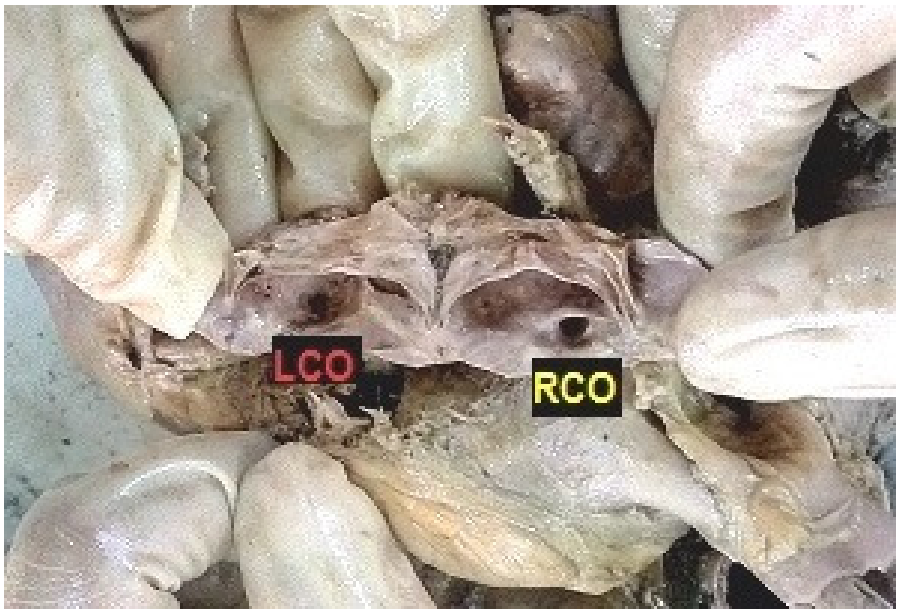


**Figure 2** : Digital image of Aortic root showing simultaneous presence of both coronary ostia (RCO = Right coronary ostia ; LCO = Left coronary ostia)

Most of the ostia (71.12%) were located between the sino-tubular ridge and the base of the aortic valves i.e "Sinus Ostia". Only a few (7.78%) were present above the sino-tubular ridge called "Tubal Ostia". Surprisingly, the percentages of Sinus Ostia were similar for left and right coronary arteries, both showing 71%. There was also no gender variation in this regard. However, notable percentages (11%) of right coronary ostia were tubal in position as shown in Figure 3.

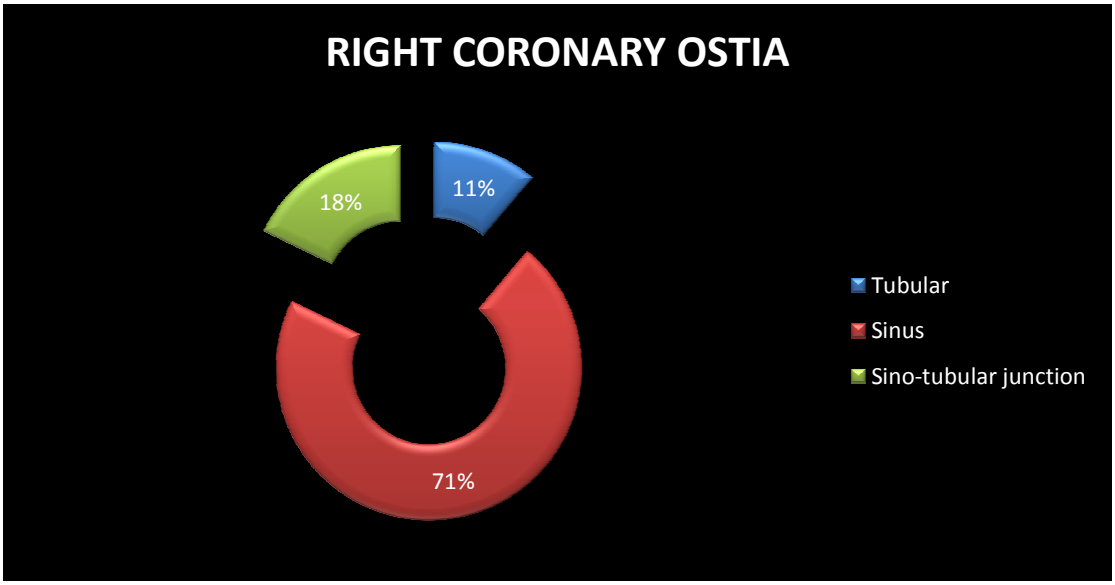


**Figure 3** : Pie diagram showing positions of left coronary ostia



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Most of the ostia were transversely oval (elliptical) in shape (67%), followed by circular ostia (22%) and lastly very few vertically oval (elliptical) also (11%), without any significant gender variation. However, none of right coronary ostia were vertically oval in shape (Figure 4 & 5).

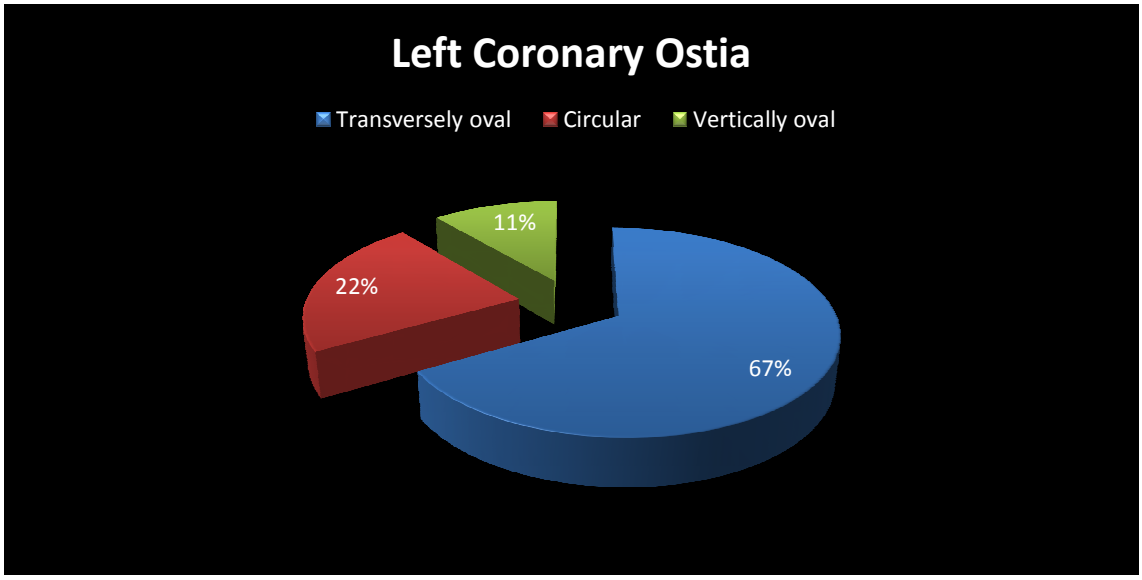


**Figure 4** : Pie diagram showing various shapes of left coronary ostia

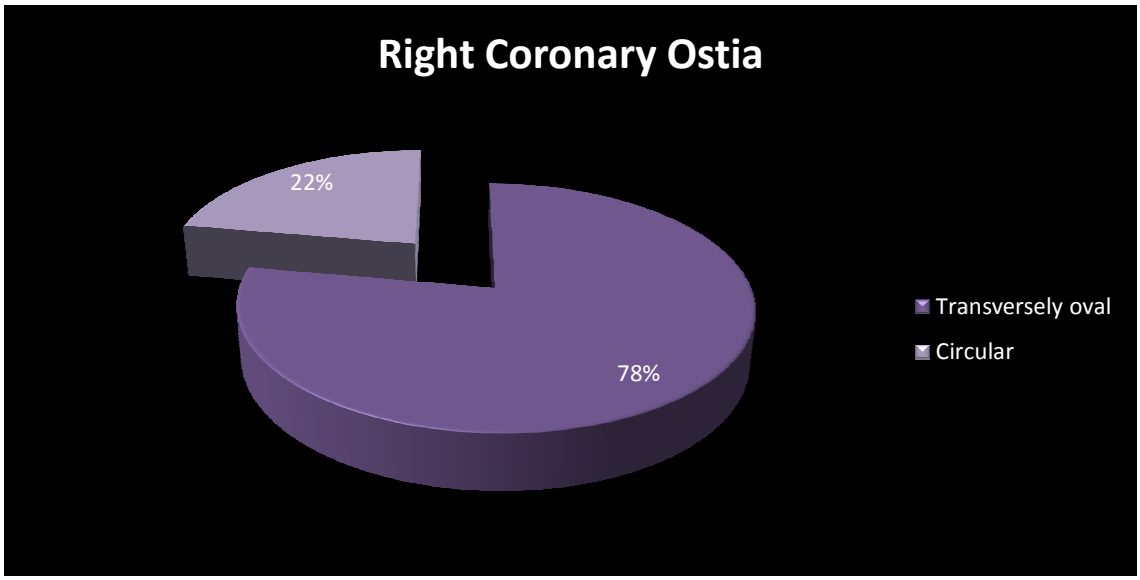


**Figure 5**: Pie diagram showing various shapes of right coronary ostia

Left ostia were wider than right, both in males and females. Overall, both right and left ostia were wider in males as compared to females (Table 1). The intima-media thickness was significantly more in RCA, maximum being found in males and minimum in the LCA of females (Table 2). Eventually, the intima-to-intima maximal



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diameter of RCA was significantly less than LCA in both sexes. To add to this, the maximal diameter was less in case of males than females (Table 3). All the p values were <0.0001.

**Table 1 :** Comparison between widest diameters of left and right coronary ostia in males and females

| Gender | Left Ostia (in milimeters) | Right Ostia (in milimeters) |
|---|---|---|
| **Males** | **4.51 ± 0.43** | **4.25 ± 0.41** |
| **Femlales** | **4.15 ± 0.12** | **4.05 ± 0.07** |

**Table 2 :** Comparison between IMT of Coronary arteries in both genders.

| Gender | RCA (in micrometers) | LCA (in micrometers) |
|---|---|---|
| **Males** | 0.37 ± 0.01 | 0.3 ± 0.01 |
| **Females** | 0.34 ± 0.01 | 0.28 ± 0.01 |

**Table 3 :** Comparison between maximal diameters of Coronary arteries in both genders.

| Gender | RCA (in micrometers) | LCA (in micrometers) |
|---|---|---|
| **Males** | 1.17 ± 0.01 | 1.23 ± 0.02 |
| **Females** | 1.36 ± 0.01 | 1.42 ± 0.01 |

**Discussion :**

Claude Bernard first placed catheters into the arteries and veins of horses. Forssmann and Cournand became the Nobel Lauretes[3] for the revolutionary catheterisation of human hearts dated back in 1929. Thirty years later (in 1959) Sones introduced the selective catheterisation technique for coronary artery angiography. Ampaltz and his associates (1967) described the femoral route of introducing selective coronary catheters perpendicular to aortic wall, so that their tips can enter the heart through perpendicularly placed coronary ostia[4]. Since last two decades, there has been much development and innovations in cardiac diagnostic and interventional protocols. As a result, the positions of coronary ostia and their relation to the sinu-tubular junction (STJ) are of prime importance for cannulation or catheterization of the coronary arteries, aortic graft repair or root replacement and implantation of percutaneous aortic valves (PAV) or transapical valve replacement etc[5].

Anomalies pertaining to the number of coronary ostia are very rare, viz, solitary coronary ostium[6] has an incidence of 0.024% while multiple anomalous coronary ostia are extremely rare. If multiple ostia are observed in the anterior aortic sinus, the most common variation observed is an accessory orifice for right conus artery[7]. However,



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in our study there were only two coronary ostia in each heart.

Regarding the position or topography of the coronary ostia, earlier studies have reported many variations in this respect. Presence of ostia close to the annulus or leaflets of aortic valves cause much difficulties during cardiovascular surgeries[8] while high up position increase the chances of ischaemic myocardial events[9]. Our study have found majority (71.12%) of the coronary ostia in the "Sinus" position, which is consistent with previous studies of Bhimalli et al[10]., Prajapati et al[11], Kalpana[12] ,Cavalcanti et al[13]. and Roy et al[14]. At the same time our results have negated few of the previous works like that of Pejkovic et al[15] and Jyoti P. Kulkarni et al[16]. These are depicted in Tables 4.

**Table 4** : Comparison between ostial positions of our study and previous literatures

| **Studies** | **RCO (%)** | | | **LCO (%)** | | |
|---|---|---|---|---|---|---|
| | **Sinus** | **STJ** | **Tubular** | **Sinus** | **STJ** | **Tubular** |
| **Present study** | 71 | 24 | 5 | 71 | 18 | 11 |
| **Cavalcanti et al.** | 60 | 28 | 12 | 42 | 40 | 18 |
| **Muriago et al.[17]** | 78 | 13 | 2 | 69 | 22 | 9 |
| **Kalpana** | 90 | 1 | 9 | 80 | 0 | 20 |
| **Bhimalli et al.** | 84 | 0 | 16 | 93 | 6.66 | 3.33 |
| **Prajapati et al** | 91 | 9 | 0 | 94 | 6 | 0 |
| **Pejkovic et al.** | 19 | 10 | 71 | 22 | 60 | 18 |
| **Jyoti P Kulkarni** | 26 | 16.6 | 56 | 30 | 17.7 | 52.2 |

There has not been much earlier literature depicting the shapes of coronary ostia and so this needs further studies, since the shapes are one of the major guiding factors for coronary catheterisation. However, our study findings (as evident in figure 6) in this respect (78% of RCO & 67% of LCO were transversely oval) are consistent with that of Jyoti P Kulkarni et al[16], as they have mentioned in their literature, 76.6% of RCO and 73.3% of LCO were horizontally oval in shape. They have also seen one case with vertically oval coronary ostia which is again substantiating our findings (11% LCO were vertically oval).



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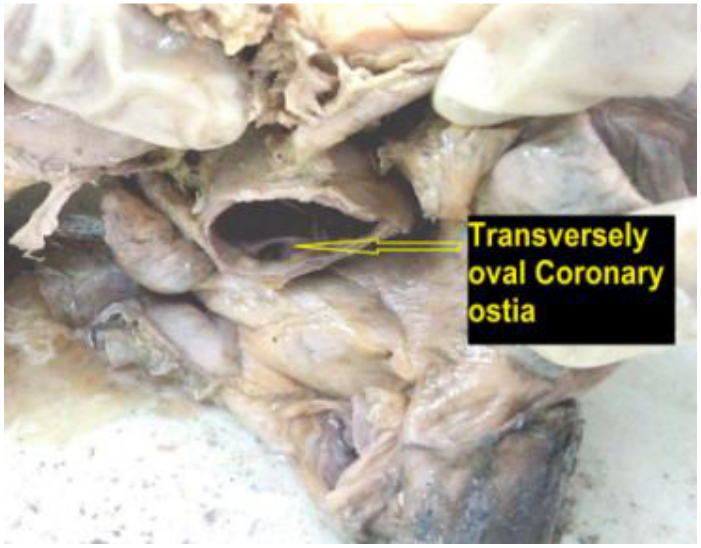


**Figure 6** : Digital image of Left Coronary Ostia showing it's shape as transversely oval.

The mean widest diameters of LCO & RCO of our study were corroborative with that of Cavalcanti et al[13], Kaur et al[18], Kohler et al.[19] and Ortale et al.[20], as they have also mentioned the diameters of these ostia to be > 3.5 mm in their literatures. To our surprise some of the other Indian studies have mentioned the diameter to be much less than that of our study, like Bhimalli et al[10] & Jyoti P Kulkarni et al[16]. The comparison is given in Table 5. These variations might be racial or depend upon the lifestyle or habits of people belonging to different topography. Thus it leaves a further scope for investigating this parameter.

**Table 5** : Comparison between ostial diameters of present study & earlier literatures

| Studies | Right Coronary Ostia | Left Coronary Ostia |
|---|---|---|
| **Present Study** | 4.19 ± 0.36 | 4.41 ± 0.4 |
| **Cavalcanti et al.** | 3.46 ± 0.94 | 4.75 ± 0.93 |
| **Ortale et al.** | - | 5.0 ± 0.9 |
| **Kaur et al.** | 3.9 ± 1.0 | 4.6 ± 1.0 |
| **Kohler et al.** | 3.833 | 4.833 |
| **Bhimalli et al.** | 2.38 ± 1.33 | 3.17 ± 0.34 |
| **Jyoti P Kulkarni** | 2.5 ± 1.0 | 2.8 ± 1.0 |

Cavalcanti et al[13] reported around 16% & 11% reduction in juxtamural diameter of RCA & LCA respectively, compared to the ostial diameter. Since they have mentioned the external diameter, we made an attempt to correlate the internal diameter (intima-to-intima) of these arteries at their origins. Parimala Sirikonda & Sreelatha et.al[9] has mentioned that the vessels with diameter < 2.5 mm are critical for thrombus formation and stenosis. Similarly, Deopujari R and Dixit A[21] performed



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studies on age related changes in the intima-media thickness of coronary arteries and concluded that there is gradual increase in the same up to 40 years. Also, they opined that the mean IMT was more in males than females leading to increased chances of developing atherosclerosis. Our study is consistent with their study since we have also recorded IMT to be more in males as compared to females (Table 2) in both the RCA & LCA. To add to it, we have additionally compared the IMT and diameters between RCA and LCA which is not done in the earlier works. The IMT can be directly attributed to development of ishaemic cardiac events since the tunica intima and greater part of tunica media are not supplied by any blood vessels and rather receive their nutrition by diffusion. As a result any increase in their thickness would result in endothelial dysfunction and be an important risk factor for development of atherosclerosis[22]. The sexual dimorphism[23,24,25,26,27] is also apparent in case of internal diameters as well, denoting male preponderance of ischemic events, since the diameters are larger in females as compared to opposite gender (Table 3). Thus from anatomical point of view, the RCA has more predilection for atherosclerotic events than LCA in males above 40 years of age. But, according to Seyeed Mohammad Bager Tabei et al.[28], CAD is more common in post-menopausal women (> 50 years) as compared to men of similar age. So, the sexual dimorphism relating to anatomical or structural aspects of coronary arteries can be of prime importance in earlier age groups as evidenced from the works of Deopujari P and Dixit A[21], but non-modifiable risk factors & biochemical (hormonal) factors take the upper hand in persons > 40 years.

**Conclusion :**

It is well known that topographic and morphometric variations in coronary ostia are of much importance in determining the events of myocardial ischaemia and one of the factors guiding shape of cardiac catheters and stents. Most of the studies done till date came up with more or less similar results regarding the shape and position of these ostia, however significant variations were also recorded pertaining to accessory ostia in many studies also. Present study is also an aid to those previous literatures. As an addendum, this study also focuses on measurements of intima-media thickness and the internal diameters of coronary arteries. Our study throws some light on, one age old ambiguity regarding the preponderance of coronary arteries for CAD, stating that the RCA has less internal diameter than LCA, making the former more susceptible to occlusive diseases. However, this hypothesis needs further clarification in view of less sample size of present study and one needs to include young adults as well for the purpose. Finally, sexual dimorphism has been evident in the present study but that is contradictory to previous findings, suggesting the anatomical factors of coronary arteries play minimal role in determining preponderance of CAD among women than men, above 40 years of age. There is further scope to pursue this study by determining the correlation among shapes of coronary ostia and the internal diameter of respective coronary arteries, at their origins as well as various segments.

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