Int J Biol Med Res. 2012; 3(4): 2489-2496

BioMedSciDirect Publications

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International Journal of Biological & Medical Research

Journal homepage: www.biomedscidirect.com

Original article

Measurements and location of coronary ostia

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ARTICLE INFO

Keywords:
Coronary ostia
Aortic root
Right coronary ostium
Left coronary ostium.

ABSTRACT

Aims: Classic anatomical dissection of 100 human heart specimens was performed to study the morphometric and topographic aspects of the coronary ostia. **Method:**The gross dissection was done by following the guidelines of Cunningham's Manual. The pericardium involving the root of aorta was removed, and the origin of right and left coronary arteries was traced. The parameters included in the study were Number of coronary ostia, Location of coronary ostia in relation to intercommissural line (ICL), Diameter of coronary ostia, Distance of the coronary ostia from the bottom of the aortic sinus, Distance of the coronary ostia from the commissures of aortic leaflets on right and left sides of the ostia. **Results:** 71% specimens showed normal number of the coronary ostia i.e., one in anterior aortic sinus(AAS) and one in left posterior sinus (LPS). Third coronary artery (TCA) was found in 19%. 1specimen showed one ostium in the AAS and the ostium for left coronary artery (LCA) was absent in the LPS. 1 specimen showed two ostia in the LPS, one each for left anterior descending (LAD) and left circumflex (LCx). Right coronary ostium (RCO) was found arising below ICL In 62% and left coronary ostium (LCO) was below ICL in 44%. The mean diameter of RCO was 2.77mm and that of LCO was 4.11mm. The mean distance of the RCO from the bottom of the aortic sinus was 14.46mm and that of LCO was 14.3mm. The RCO was shifted more often from its normal position towards the commissure between anterior aortic sinus (AAS) and right posterior sinus (RPS). The LCO were more or less centrally placed in the left posterior sinus (LPS). **Conclusion:** Knowledge of and ability to recognize and identify the variety of sites of origin of coronary arteries of the human heart may help to overcome the potential difficulties in cardiothoracic surgical procedures.

1. Introduction

Adequate irrigation of the heart depends fundamentally on the good morphological condition of the coronary arteries. Anatomic integrity of the aortic valve, absence of valvular malformations and anatomic malformations of the coronary arteries effect the blood flow to the myocardium. The clinical relevance of the anomalies varies from insignificant to potentially lethal[4]. For many years, mostly based on the necropsy series , researchers have related angina, dyspnoea, syncope, palpitations, acute myocardial infarction and sudden death to the coronary anomalies which could be due to the abnormal course of the variant artery leading to the compression between the aorta and the pulmonary artery[5].The major role of the coronary angiography in the interventional cardiology and coronary surgery underscores the importance of having the knowledge of these variants in coronary anatomy, as failure to recognise these anomalies may at times create challenges during coronary angiography like prolonged arteriographic procedures, repeated catheterisations in many cases. So, there is lot of significance in having the knowledge of the coronary arterial pattern in cardiac surgeries. Other factors that effect and possibly involved in the reduction of the coronary blood flow are the variations in the position of the coronary ostia in relation to the aortic leaflets and the diameter of the ostia, also the angle of origin of the coronary arteries. Minor variations in the location of the ostia within the coronary sinuses of the aorta are observed frequently and are of no clinical significance. But there are variations in the coronary artery origin which can cause sudden death or other symptoms of myocardial ischaemia. The medical

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community and the general public are aware of this fact, but the reasons for the sudden fatal event and the frequency with which it occurs are generally unclear[4].Keeping in mind the ever evolving and yet unexplored facets of this subject, the present study was undertaken to shed more light on this topic of coronary ostia. We studied the coronary ostia in the aortic sinuses of valsalva, observed for variants and anomalies of the coronary artery origin in 100 formalin fixed human heart specimens.

2. Materials and Methods

SPECIMEN STUDY

The coronary ostia were studied in 100 formalin fixed human hearts with their great vessels attached. This material originated from south Indian adult population irrespective of their sex and whose cause of death was not recorded. The specimens were obtained from the Department of Anatomy, Kakatiya Medical College - Warangal, Bhaskara Medical College – Moinabad, Hyderabad, Gandhi Medical College – Secunderabad, Osmania Medical College – Hyderabad, Deccan College of Medical Sciences – Hyderabad.(photographI)

METHOD The gross dissection was done by following the guidelines of Cunningham's Manual. The pericardium involving the root of aorta was removed, and the origin of right and left coronary arteries was traced. Then the ascending aorta was sectioned transversly approximately 1cm above the commissures of the aortic leaflets. Next the aorta was longitudinally opened at the level of right posterior aortic leaflets with their respective coronary ostia can be visualised and analysed.

Photograph I : Formalin fixed human heart specimens

The calibre of the Right coronary ostium and the Left coronary ostium was measured using the sliding callipers in specimen study. The following measurements were taken in the study.

· The diameters of the coronary ostia

· The distance between the coronary ostia and the bottom of aortic sinus

· The distance from the coronary ostia to the commissures of aortic leaflets.

From a series of such measurements of coronary ostia, an average percentage was obtained, listed in tables, standard deviation calculated and statistically analysed.

Also the number of Ostia, the relation of the coronary ostia to the inter commissural line (sinutubular junction) was observed and the hearts grouped according to the following parameters.

Based on the number of Ostia

Hearts showing single coronary ostium, two coronary ostia, three coronary ostia, More than three coronary ostia

Based on the position of Ostium in relation to Inter Commissural Line (ICL)

Hearts with ostium -above ICL, below ICL, at the level of ICL

After observation, in specimen study, the moisture over the ostia and nearby areas was removed with filter paper. All the specimens were duly numbered and photographed. The data obtained was recorded, analysed and compared with that of the previous studies.

3. Results

All the hearts studied had trileaflet aortic valves. Isolated nourishing artery of the right ventricular infundibulum (right conus artery) was observed in 19 of 100 hearts studied. The observations that were made as per the parameters, have been listed below and the number of coronary ostia, diameters of the ostia, distance of the ostia from the bottom of the sinus, distance of the ostia from the commissures on the left and right sides have been tabulated in the master chart. Also relation between the ostia and the inter commissural line (sinutubular junction) has been noted in the master chart. The observations, findings and analysed data of the undertaken study have been represented in the following

Number of ostia in various aortic sinuses:

71 out of 100 specimens showed the normal number of coronary ostia i.e., one each in anterior aortic sinus and left posterior sinus[photograph II].

Photograph II :In this specimen normal location of the coronary ostia was seen. RCO in AAS and LCO in LPS.

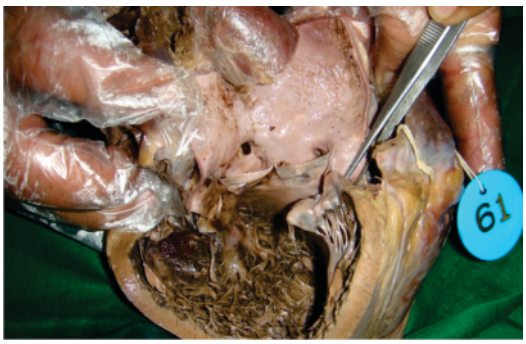
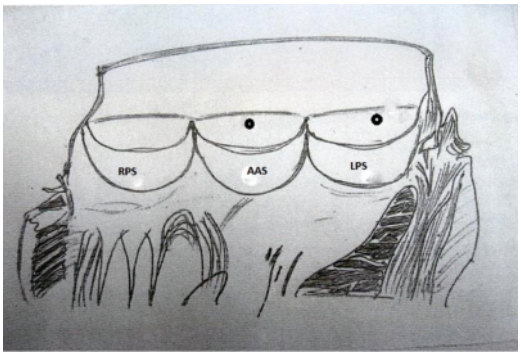


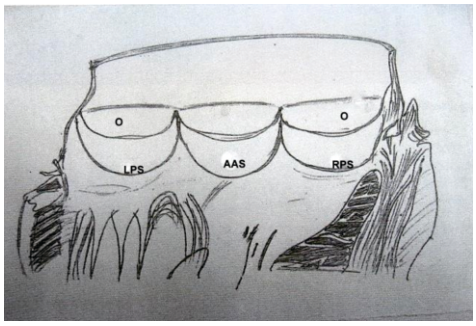
Figure I : Diagrammatic representation of photograph II.



19 showed 2 ostia in the anterior aortic sinus, (one is RCO and the other right conus artery), 1 in left posterior sinus. [photograph IV]

PHOTOGRAPH III: In this specimen the RCO was found in RPS. No ostium was seen in anterior aortic sinus. LCO was found in LPS

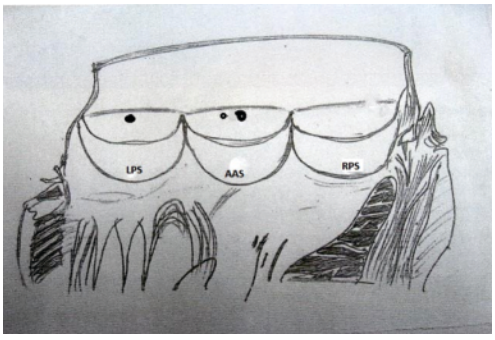
Figure II: Diagrammatic representation of photograph III.



3 showed 3 ostia in the anterior aortic sinus and 1 in left posterior sinus. 2 showed 1 ostium in left posterior and one in right posterior sinus for RCA. No ostium was seen in anterior aortic sinus. [photograph III]

Photograph IV : In this specimen the ostium for the right conus artery was found in the anterior aortic sinus along with RCO. LCO was found in LPS.

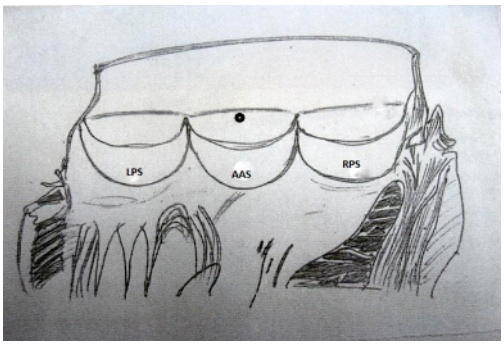
Figure III : Diagrammatic representation of photograph IV.



1 specimen showed one ostium in anterior aortic sinus and the ostium for LCA was absent in left posterior sinus. [photograph V]

Photograph V : In this specimen LCO was absent (absent left main trunk). A single coronary ostium was seen in AAS. LAD and LCx arose from RCA.

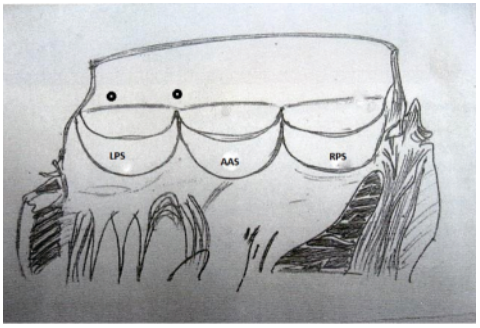
Figure IV : Diagrammatic representation of photograph V



1 specimen showed 2 ostia in left posterior sinus, one each for RCA and LCA [photograph VI]. One specimen showed one ostium in left posterior sinus and one ostium 10mm above the anterior aortic sinus, in line with the commissure on left side of the sinus[photograph VII].

Photograph VI : In this specimen, two ostia were seen in LPS for LCO and RCO. No ostium was seen in AAS

Figure V : Diagrammatic representation of photograph VI.

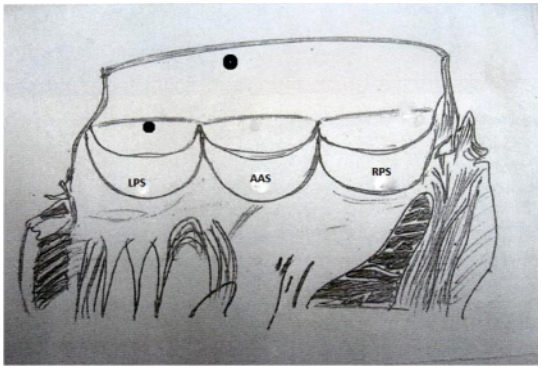


1 specimen showed one ostium in left posterior sinus for LCA, no ostium is seen in AAS. Right coronary in this case was found to arise from the left anterior descending artery.

1 specimen showed 2 ostia in LPS, one each for LAD and LCx, one ostium in AAS for RCA [photograph IX].

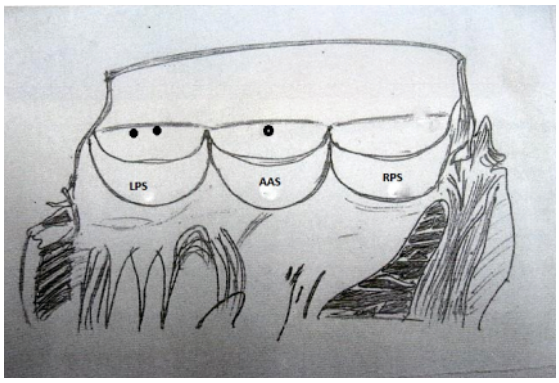
Photograph VII :In this specimen, there was high origin of RCO 10mm above the STJ in line with commissure to the left of AAS. LCO was found in LPS.

Figure VI : Diagrammatic representation of photograph VII



Photograph VIII: In this specimen two ostia were found in LPS one for LAD and one for LCx. RCO was found in AAS.

Figure VIII : Diagrammatic representation of specimen number 93.



In 3% of cases, multiple openings were seen in anterior aortic sinus. The extra openings were pin head size. Only in 1% were double openings observed in the left posterior sinus, one each for LAD and LCx in specimen study. (Table I)

Table I: Number of coronary ostia in various aortic sinuses

Number of openings	Anterior aortic sinus	Left posterior sinus	Right posterior sinus
0	4	1	98
1	74	97	2
2	19	2	0
3	3	0	0

Relation between the location of the coronary ostiaand theIntercommissural Line

RCO was found arising below the Intercommissural line(ICL) in 62%, at ICL in 11%, above ICL in 26% of cases. LCO was found below ICL in 44%, at ICL in 19%, and above ICL in 36% of cases. RCO was absent in specimen number 79 and LCO was absent in specimen number 34. (Table II)

Table II: Location of coronary ostia in relation to the ICL

Relation to the Intercommissural Line	No.of Specimens (out of 100)	Percentage
Right & Left below	37	37
Right & Left above	19	18
Right above & Left below	1	1
Right below & Left above	14	14
Right at ICL & Left below	5	5
Right below & Left at ICL	11	11
Right at ICL & Left above	4	4
Right above & Left at ICL	6	6
Right & Left at ICL	2	2

Mean diameter of the right and left coronary ostia

The mean diameter of RCO was 2.77mm in specimen study. The mean diameter of LCO was 4.11mm in specimen study (Table III)

Table III : Diameters of the coronary ostia

Coronary ostia	Mean diameter ± SD
Right	2.77 ± 0.905
Left	4.11 ± 0.88

The diameter of the LCO was more than the RCO in majority of the cases.

Distance of the ostia from the bottom of the aortic sinus

The mean distance of the ostia from the bottom of aortic sinus was 14.46 for RCO and 14.3 for LCO in specimen study.The mean distance of both the ostia were almost equal. (Table IV)

Table IV : Distance of the ostia from the bottom of the aortic sinus

Coronary ostium	Distance from the bottom of the aortic sinus	
	Range	Mean ± standard deviation
Right	11-18	14.46 ± 2.94
Left	10-19	14.3 ± 2.28

Positions of the coronary ostia with reference to the commissures in respective aortic sinuses

The mean distance of RCO from the commissure on right was 9.53mm and that from left commissure was 12.65mm. The mean distance of LCO from the commissure on right was 11.11mm and from the commissure on left was 10.84mm in specimen study.

The RCO was shifted more often from its normal position towards the commissure between the anterior and right posterior aortic sinuses. The left ostia were more or less centrally placed in the left posterior sinus. (Table V)

Table V: Distance between the coronary ostia and the commissure of the aortic leaflets (mm)

Coronary ostium	Commissure	Mean distance ± standard deviation
Right	Commissure to right	9.53± 2.53
Left	Commissure to left	12.65± 2.65
	Commissure to right	11.11 ± 2.40
	Commissure to left	10.84 ± 2.83

4. Discussion

In the present study, the coronary ostia were studied in 100 formalin fixed heart specimens. Coronary anomalies have been implicated in various clinical conditions that may at times lead to pathological state, which usually originate suddenly and may have catastrophic consequences. The aortic root is a frequent site of interventional procedures in both adults and children. Understanding the precise nature and relation of the anatomical structures composing the aortic root, including coronary orifices is valuable in per-cutaneous and transcatheter therapeutic techniques for valve or device implantations as well as in various open-heart procedures. Coronary blood flow may be affected by changes in morphological and topographical features of the coronary ostia. The present study is a humble effort to highlight the same.

Number of coronary ostia, ostial relation to the sinutubular junction (intercommissural line) was observed. Measurements of coronary ostial diameter, distance of the ostia from the bottom of the sinus, distance of the ostia from the commissures of aortic leaflets were made meticulously in each specimen. The observations were compared with the available literature.

Number of coronary ostia
Relation to ICL
Diameter of coronary ostia
Distance from the bottom of sinus.
Distance of ostia from commissures of aortic leaflets.

According to literature, coronary anomalies affect 0.3 to 5.6% of general population. The incidence of coronary anomalies is generally reported to be about 1%. However, the incidence was found to be 5.6% in a recent prospective angiographic study of 1950 consecutive cases which was performed according to clearly stated criteria and a strict classification scheme[5].Present study results are similar to the results of Angelini and co-workers.

Number of ostia

Normally the anterior aortic sinus shows the presence of one ostium of origin of the right coronary artery and the left posterior aortic sinus shows the presence of one ostium for the left coronary artery. The variations of origin of coronary arteries and the presence of multiple anomalous ostia could cause certain clinical consequences. An abnormal location or an accessory origin of the coronary orifices may disturb performing an aortotomy incision for aortic exposure, preparing a coronary button, in root replacement, direct delivery of cardioplegia through the coronary orifices and approaches for aortic root enlargement.

Solitary coronary ostium

Solitary coronary arteries can be a substrate for sudden cardiac death, and carries the potential to precipitate severe ischemic heart disease, including myocardial infarction in younger patients. Vlodaver et al. 1975: Koizumi et al., 2002

Leuguerrier A et al. (1976)., Antonellis J et al (1996)., Fiorelli R et al (1998)., Neil D A et al. (2000)., Mavi A et al (2002)., Gowd R M et al. (2005)., Arteaga R B et al (2006)., Larsen A et al. (2007)., Dr Hale Yilmaz et al (2009)., Franz Von Ziegler et al (2009)., PrashanthPanduranga et al. (2010) reported cases of single coronary artery arising from either of the aortic sinuses.

In the present specimen study there were 2 cases of solitary coronary ostium of which one had absent left main and the other with absent RCA.

Third coronary artery (TCA)When multiple ostia are observed in the anterior aortic sinus, the most common variation observed is an accessory orifice for right conus artery. The third coronary artery usually forms an anastomosis with the likewise branch of left coronary artery. This anastomosis lies on the distal part of the pulmonary trunk and is known as the " vieussens arterial ring" .The functional significance of the anastomosis is still under question. However, several authors have proposed that it functions as an important collateral path between the right and left coronary arteries. Several authors have reported multiple supernumerary ostia in anterior aortic sinus.

Leguerrier et al. (1976) .,Miyazaki M et al. (1998)., Subhash D joshi et al. (2010) reported incidence of TCA in anterior aortic sinus.

Present study value is correlating with that of Kevin Turner et al and Gajbe U L et al.

Anomalous origin of coronary arteries (AOCA)

Palomo A R et al.(1984) reported the separate origin of the first septal perforator from the left sinus of valsalva.

John M Mahowald et al. (1986) reported a case with LCA arising from right aortic sinus and another case with right coronary artery arising from left posterior sinus.

Bartorelli A L et al (1994).,Tedeschi C et al (2009)., Mathew Janik et al(2009) reported a case of absence of LM trunk with LAD and LCx arising by two separate ostia from the right aortic sinus.

Marcello Biscegli et al (1999) reported a case with two ostia in LPS.

Turkmen et al (2007).,VikramPalimer et al (2008)., Jae Youn Moon et al (2008)., Yuan S M et al (2009).,Andreas Y Andreou et al (2009)., Chirstina Basso et al (2010) reported both coronaries arising from LPS. Present study reports one such case.

Paoli Zeppili et al (1998) reported 3 cases of anomalous origin of coronary arteries (AOCA) where 2 showed RCA from LPS and 1 case with LCA from right aortic sinus.

In present study

3 specimens showed three ostia in the anterior aortic sinus and one in left posterior sinus.

2 specimens showed one ostium in left posterior and one in right posterior sinus for RCA.

1 specimen showed two ostia in left posterior sinus, one each for RCA and LCA. 1 specimen showed one ostium in left posterior sinus for LCA, no ostium is seen in AAS. Right coronary in this case was found to arise from the left anterior descending artery.

1 specimen showed two ostia in LPS, one each for LAD and LCx, one ostium in AAS for RCA.

Position of the coronary ostia in relation to Sinutubular junction (STJ)

The preoperative knowledge of position of coronary ostia in relation to the STJ is important in the management of patients with different pathologies involving the aortic root and coronary arteries. (Turken K et al.1996) (Ho Sy.,2009) (1)

The potential clinical disadvantage of high origin of the coronary orifices lying above STJ is myocardial ischemia and sudden death. In majority of the reported literature, the positioning of the ostia was above the cusp and below the STJ. This observation suggests that the positioning of the ostium within the sinus, rather than at or above the ridge is functionally advantageous.

Kevin Turner et al (1996) and Subhash D Joshi et al. (2010) reported that majority of ostia lay below the STJ.

In the present study one specimen showed one ostium in left posterior sinus and one ostium 10mm above the anterior aortic sinus, in line with the commissure on left side of the sinus.

Values of the present study were correlating with those of most of the previous studies.

Diameter of the coronary ostia

The left coronary ostium, which is 3-5mm in diameter originates from left coronary sinus of valsalva. The right coronary ostium is normally 2-3mm in diameter and lies in the right coronary sinus of valsalva.

The proximal segment of each coronary artery is intramural; it courses through the aortic wall and is usually tapered or funnel shaped. Jennecy Sales Cavalcanti et al 2003 reported 16% reduction in juxtamural diameter of RCA compared to the ostial diameter and in LCA the reduction was 11%. This needs to be considered when designing stents for aorto-ostial coronary lesions in order to achieve optimal results avoiding retrograde aortocoronary dissection and reducing restenosis. The smaller dimension of some coronary artery segments has important diagnostic and therapeutic implications since for any interventional procedure the absolute size of the coronary arteries matters. It hasbeen reported that occlusion or thrombosis is more common in vessels less than 2.5 mm in diameter. A moderate (60%) stenosis in a 2.5 mm vessel would have more effects on flow than the same degree of stenosis in a 3.5 mm vessel as the cross sectional area in the former would be reduced to 1.76 mm2 as compared to 3.46 mm2 in the larger vessel. Thus a moderate plaque would cause significant obstruction in a small vessel with significant implications in coronary revascularization.

The present study values are correlating with almost all the studies in regard to LCO, where as in RCO we differ from the earlier studies.

Distance between the ostia and the bottom of the aortic sinus

The anatomical feedback about the height and width of the sinuses, their relation to the coronary ostia and the diameter of STJ may help in choosing appropriate size of grafts for ascending aortic replacement and associated aortic valve sparing techniques including non-coronary cusp extension.

Our study correlates with the earlier reported studies.

Relation between the coronary ostia and the commissures of aortic leaflet

Circumferential deviation does not seem to be functionally significant. However the knowledge of the frequency of circumferential deviation and also of measurements of ostial height from the bottom of sinus will be of help to Radiologists in interpreting images of the coronary origins and to Surgeons during procedures like angiography and angioplasty. Wolloscheck et al (2001) observed that attachment of aortic leaflet to be very useful as landmarks during transthoracic echocardiography. (TTE) [55]

Subhash D Joshi et al (2010) reported centrally located LCO in 80% and RCO shifted towards the right posterior sinus in 59%.

Our study is similar to the available literature.

5. Conclusion

This study provides data of normal coronary ostial origins. The observed variations of coronary ostia in our specimen study emphasize the importance of considering such anatomic variations in the development of treatments.

We must transcend our current predominant approach characterized by no more than the periodic publication of dramatic case reports. Our knowledge about the clinical expression of coronary anomalies could be greatly enhanced by a multicentre database capable of prospectively collecting information about the fundamental issues of coronary anomalies[5].

Detailed knowledge of the multiple variations to be found in the origin and epicardial course of the coronary arteries is important for those involved with provision of cardiac care. The manifold variations are readily understood on the basis of the normal sinusal origins and courses relative to the aortic roots of the right and left coronary arteries, combined with appropriate knowledge of the relationships of the arterial roots themselves.

A similar critical understanding of the other forms of coronary anomalies should also be sought so that sound criteria can be established for sub classifying these forms and for indicating intervention when necessary. The present anatomical data may help the cardiac surgeons to modify their surgical reconstruction of the aortic root in order to achieve satisfactory recovery. We believe that the results of our study will help cardiothoracic surgeons with their pre-operative anatomical analysis.

Acknowledgement

Thanks giving is a pleasant job, it is nonetheless difficult where one sincerely tries to put in words. These humble words of expression and gratitude wholly convey my feelings.

First I place on record, the interaction, constant supervision and support of my guide, Dr.S.Sreelatha, has provided for my work. I am extremely grateful to her able guidance; patience; critical evaluation, constant encouragement and support at every single step, which aided in the timely completion of this work. This study has acted as an eye-opener for me, in regard of further future work. It has also provided me a strong foundation.

I would like to express my deep and sincere feelings of gratitude for the encouragement given by my dad Dr.S.Narender Rao and my mom Padmaja, without them the research work would not have reached such a successful completion.

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