Cadaveric Study of Morphology of Coronary Arteries in North Coastal Andhra

Dr. K.Lakshmi Kumari, Dr. B.Sireesha , Dr.D.Asha latha

[1]Associate professor, Dept of Anatomy, Andhra Medical college, Visakhapatnam, A.P, India.
[2]Postgraduate, final year, Dept of Anatomy, Andhra Medical college, Visakhapatnam, A.P, India.
[3]Professor & HOD, Dept of Anatomy, Andhra Medical college, Visakhapatnam, A.P, India.
Corresponding Author: Dr. K.Lakshmi Kumari

I.   Introduction

Heart is a pair of valved muscular pumps combined in a single organ[1]. Blood supply of the heart is by it's own vascular system, called coronary system. Coronary arteries are main arteries arising from Aorta are supplying Heart.The Right coronary artery is supplies blood mainly to the right side of the Heart. Whereas left side of Heart which is the larger size and more muscular supplied by Left coronary artery. The name corona means " Crown '' from Latin. Name derived from notional resemblance. The main parts of the heart are the chambers, the valves, the electrical nodes and its coronary vessels .Humans have known about the heart since ancient times. Greeks were considered to have been the primary seat of scientific understanding of the heart in the ancient world. The nature, function and anatomy of the heart have been extensively studied since 3500 B.C. Greek and Egyptian science developed a basic understanding of the heart, although this was primarily related to religious beliefs. The Alexandrian, Roman, Medieval Islamic, and European eras included turning points in the history of cardiac anatomy. The cardiovascular system is the first major system to function in the embryo. The primordial heart and vascular system appear in the middle of the third week of embryonic life, but the heart actually starts functioning at the beginning of the fourth week. Since then it undergoes rhythmic and regular contractions and relaxations completing the 'cardiac cycle' which never stops until the cardiac death. Each coronary artery is a vasa vasorum of the ascending aorta, because heart is developed from the fusion of two primitive endothelial tubes which represent the ventral aorta . Coronary artery Anatomical variations has important clinical manifestations, including sudden death, especially in young athletes.[2,3] Some authors have indicated the need to establish diagnostic screening protocols for athletes and other young individuals subjected to extreme exertion.[4,5,6] it is desirable to determine the incidence of the variations, which are potentially capable of inducing sudden cardiac death.since coronary arteries are supplying Heart, any variation in origin , branching and morphology can have serious implications to the Heart, lead to cardiac arrest. . It was well known that CAD was observed more in LCA predominance than in RCA / Co-dominant types of dominance .

II. Aims & Objectives

The aim of the present study is to analyse anatomy of the coronary arteries with reference to its origin, course, branching pattern, the dominance, variations supplemented by morphometric observations and also to study the variations of coronary arteries to assess the risk factors for occurrence of coronary artery disease.
1.To study the origin of coronary arteries and level and diameter coronary ostium with respect to sinotubular junction and it's relation with aortic sinus.
2.To study the left main coronary artery with respect to length, diameter and branching pattern.
3.To observe the dominance pattern of the coronary arteries.

III. Materials and Methods

The study was done on 40 embalmed cadaveric heart specimens. Cadaveric specimens were collected and preserved, from cadavers which are used for routine dissections for undergraduates and postgraduates for three years in the Department of Anatomy, Andhra medical college, Visakhapatnam. The specimens thus collected were serially numbered from 1to 40. All the hearts were preserved in 10% formalin of adult human cadavers used for the routine dissection procedure. The epicardium and fat were removed carefully from the surface of the heart. The origin and the course of all the coronary arteries and their important branches were carefully delineated Normal hearts with age group 20 to 72years were included. Damaged and putrefied hearts were excluded from study . The great vessels were ligated and the specimen of heart along with great vessels was removed from thoracic cage. The visceral pericardium was removed to expose the coronary arteries. Further

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dissection is done on the hearts and coronary arteries to locate the origin, diameter of ostium in relation with sinotubular junction, branching pattern and coronary predominance .

IV. Observations and Results

The present study was done on 40 cadaveric hearts and subsequent results were noted and analyzed. Left Coronary arteries ostium diameter is ranged between 3.40mm – 5.49mm.Right coronary artery ostium diameter is ranged in between 0.9 mm - 5mm. In the present study we have observed the diameter of the left coronary ostium was greater than right coronary ostium. The mean diameter of left coronary ostium is more than the right coronary ostium.

Origin of Right And Left Coronary Arteries: -In the present study, it was observed that in all the 40 specimens, 3 aortic sinuses were present and all the ostia were related to the aortic sinuses. Right coronary artery was found to be arising from the anterior aortic sinus and left coronary artery was arising from the posterior aortic sinus. No coronary artery was found to be arising from right posterior aortic sinus.In the present study it was observed that   right coronary ostium   was present below the sinotubular junction in 33 specimens (82.5 %) and at sinotubular junction in 5specimens (12.5%) and above sinotubular junction in 2 specimens(5%).In the present study it was observed that the left coronary ostium was present at the sinotubular junction in 23 specimens (57.5%) and below sinotubular junction in 13 specimens (32.5%) and above sinotubular junction in 4 specimens (10%).

Left Main Coronary Artery trunk was exposed. The length, diameter and branching pattern of main trunk bypass graft surgery were excluded from the study. Measurements of left main coronary trunk mean length and diameter were observed 4.04mm- 11.01mm respectively. The maximum length of LCA recorded was 21.9mm and its diameter was7.07mm. Maximum diameter was 5.85mm and minimum diameter was 3mm. Mean length and diameter of LMCA was 11.01mm and 4.04mm respectively. Branching pattern of LCA main trunk .In the present study, the main trunk of LCA showed bifurcation in   28 Specimens i.e. 70% and trifurcation in 11specimens i.e. 28%. LEFT ANTERIOR DESCENDING ARTERY :- In the present study left anterior descending artery terminated anterior to the apex just in four specimens (10%) out of 40 specimens. In 73% of the specimens the LAD crossed the apex and traversed the PIVS up to lower 3-5cm. In 10% of the specimens it just crossed the apex but in 8% it traversed above lower 5cm of the PIVS and meets the PIVA of RCA. TERMINATION OF LEFT ANTERIOR DESCENDING ARTERY :- In the present study termination of left Anterior Descending Artery observed 3-5cm up PIVS in 72.5% , Anterior to apex in 10%, Posterior to apex in 10% and 7.5% cases more than 5cm up PIVS.LEFT CIRCUMFLEX ARTERY (LCX) : - In the present study, the circumflex artery originated as one of the three terminal branches of the trifurcation of LMCA in 28% of specimens and the other two are LAD . In 70% of specimens the LCxA is one of the branches of bifurcation. In most of the cases the circumflex artery ended between margo obtusus or crux cordis. In a few cases the circumflex artery reached upto the crux and in three cases it has given the PIVA at the crux which traversed the PIVS upto its middle. The variability of termination of LCXA were noted in all hearts. Trifurcation and quadrification of Left circumflex artery were found in one specomen each.

Right Coronary Artery: RCA showed variations in its course in 2 specimens. The maximum length of RCA recorded was 19.6mm and its diameter was5.01mm. Maximum diameter was 5.85mm and minimum diameter was 3mm. Mean length and diameter of LMCA was 8.97mm and 3.64mm respectively. Branching pattern of RCA In the present study, third coronary artery found In three specimen. The RCA after crossing the right atrio ventricular groove entered the atrioventricular sulcus and gives the PIVA at the crux. A large branch of RCA which was given in right atrioventricular sulcus crossed across the diaphragmatic surface of the heart and reached the middle of the PIVS and terminated in the middle of the groove. In another specimen the RCA crossed the inferior border of the heart. Anatomy of Right Coronary artery is normal in remaining specimens.

V. Discussion

The present study was done on 40 cadaveric hearts . The findings are compared with the findings of some of the authors .the coronary ostiumThe number, location, level, size and shape of the ostium are very important in successful performance of coronary angiogram. The ostium anomalies are related to surgical difficulties encountered in cannulating coronary vessels during open aortic surgery or in performing coronary Angiography .In an Angiographic study of an Indian population Garg and Tiwari[7] observed anomalous coronaries in 0.95% of individuals. Harikrishnan et al [8] reported an incidence of 0.45%. In present study no coronary artery was arising from pulmonary or posterioraortic sinus. Schlesinger et al[9] and James[10] (1961) have described the origin of the SA nodal artery directly from the aortic sinuses in some instances. The origins of the coronaries show great variability[11] .Occasional cases documenting the anomalous origins of the coronary

arteries from the pulmonary artery14,25,26 and from the right posterior (non-coronary) sinus13 have been documented in the literature.   Standring et al have reported the incidence of extra openings in 34.8% of male hearts and 27.8% of female hearts. Wolloscheck et al[12] (2001) reported extra ostia in 65% of cases in anatomic and trans thoracic echocardiograpic study. In the present study, it was observed that   in all the 40 specimens 3 aortic sinuses were present and all the ostia were related to the aortic sinuses. Right coronary artery was found to be arising from the anterior aortic sinus and left coronary artery was arising from the posterior aortic sinus. No coronary artery was found be arising from right posterior aortic sinus. , knowledge of the frequency of circumferential deviation and also of measurements of cusp height and ostial height from the bottom of the sinus will be of help to radiologists in interpreting images of the coronary origins and to clinicians during procedures like angiography and angioplasty. In the majority of cases the positions of the coronary ostia were below the sinotubular ridge. Vlodaver et al[13] reported a 44% incidence of ostia being present above the tubular ridge, while Pejhovic et al [14] reported a very high incidence of ostia at or above the level of sinutubular junction (82% left and 90% right). Turner and Nava Ratna[15] found that 62 of the 74 main coronary ostia lay either at or immediately below the sinutubular ridge. Occasional cases documenting the anomalous origins of the coronary arteries from the pulmonary artery[16,17,18]

In the present study, the coronary ostium was present in all the specimens in the right anterior aortic sinus. In the present study it was observed that   right coronary ostium   was present below the sinotubular junction in 33 specimens (82%) and at sinotubular junction in 5 specimens (12%) and above sinotubular junction in 2 specimens(5%). In no case high take off was observed (refers to coronary ostium situated 1cm above the STJ).In the present study, the position of ostia of RCA and LCA was at or below the STJ in 90% of specimens. This observation suggests that the position of the ostium within the sinus,rather than above the ridge, is functionally advantageous. The position of the ostia above the ridge or below the level of cusps is disadvantageous to coronary filling. The shape of the ostium was not slit like in any specimen observed. They are oval or round in shape. It was said that slit like ostia are often associated with angulations of the initial part of the coronary artery and predispose individuals to ischemia of the myocardium. The filling of the coronaries occur mostlyduring diastole and so there is no effect of systolic stretching and further reduction in the osteal size can have any significant effect on m This observation suggests that the position of the ostium within the sinus, rather than at or above the ridge, is functionally advantageous. The position of the ostia at or above the ridge or below the level of cusps is disadvantageous to coronary filling. The shape of the ostium was not slit like in any specimen observed. They are oval or round in shape. It was said that slit like ostia are often associated with angulations of the initial part of the coronary artery and predispose individuals to ischemia of the myocardium. Multiple orifices in the right aortic sinusThe most frequent variation is the presence of an accessory orifice for the conal artery.Schlesinger et al called it the 3rd coronary artery. Its presence varies between 33% and 51% (Banchi, 1904; Crainicianu, 1922; Schlesinger et al, 1949). The diameter varies between0.5 and 1.5mm. In the present study the right anterior aortic sinus showed two ostia in 12.5% of hearts. The presence of 2nd ostium belongs to the 3rd coronary artery.Multiple orifices in the left aortic sinus The most frequent variation was absence of common trunk of LCA. If 2 orifices were found, they are the orifices of LAD and LCxA. The prevalence ranges between 0.5% and 1% according to James. In the present study the left posterior aortic sinus has only one orifice from which the trunk of the LCA originated.

The Diameters of the Main Stem and the Longer Branches

The common trunk of LCA is described as long when it is above 15mm. A long common trunk is present in 11.5% and 18% (Helwing, 1967; Mc Alpine, 1975; Petit and Reig, 1993). The common trunk is considered short when it measures equal to or less than 5mm[8] . Its frequency varies between 7% and 12% (Mc Alpine, 1975; Leguerrier et al, 1976). Baroldi and Scomazzoni (1965) gave the mean diameter of LCA and right coronary artery as 4.0 and 3.2mm respectively. Reig J et al studied 100 autopsy heart specimens. He found the average diameter of LCA was 4.86±0.8mm. Dattatray D Dombe et al stated that the mean ostium diameter of theLCA was 3.3±0.56mm and the diameter of LMCA was 4.64±1.02mm. Jeffery mentioned that ballon angioplasty of aorto-ostial lesions and ostial lesions of LAD and LCx coronary arterieshave been associated with reduced success. Rex N et al measured the human coronary artery size by cine-arteriography in 99 patients. The mean diameter of LAD was 3.5±0.5mm and themean diameter of the LCx artery was 3.11mm.The short common trunk may be clinically relevant especially when a perioperative coronary perfusion or a coronary angiography is performed, because an incomplete image of the area of distribution of the left coronary artery may be seen onintroducing the catheter into only one of the terminal branches and the other does not show opacification (Vlodaver, 1976). It has also been observed that a short common trunk presents the same potential risk as the absence of the common trunk altogether (Mc Alpine, 1975). Other authors report the existence of a short common trunk as a risk factor for the development of coronary arteriosclerosis. In the present study the left common trunk measures was 21.9mm in length and its diameter was 7.07mm, and maximum diameter was

5.85mm and minimum diameter was 3mm. Mean length and diameter of Left main coronary artery was 11.01mm and4.04mm.

Branching Pattern of LCA Main Trunk: - The division of the common trunk into LAD, LCX and median / Ramus branch is a variation found in 28% of cases. LEFT ANTERIOR DESCENDING ARTERY According to Kalpana.R [14] study the LAD terminated beyond apex in the lower part of the posterior IV groove in 80% and at the apex in 8% and posterior to apex in 12% of the specimens . where the LAD branch crossed over the apex to reach 2-5 cms up to the posterior IV groove in 87%, at the anterior to apex in 13%. James(1961) stated that LAD terminates at before the apex in 17% and at the apex in 23% and the lower 1/3 rd of posterior interventricular groove in 87%.

Left Circumflex Artery :- The left circumflex artery begin from LCA at an angle nearly perpendicular to it. Circumflex artery is the one that presents the greater variability in terms of length and distribution. Two points of reference are generally used to situate the termination of the circumflex artery. The margo obtusus and the crux cordis (left border and crux). In 20-30% the circumflex does not reach the diaphragmatic surface of the heart and terminates as an artery of the margo obtusus (left border). The percentage of cases in which the circumflex artery reaches the crux cordis, or goes beyond it, is very low. In the present study, the circumflex artery originated as one of the four terminal branches of quadrifaction of lmca 2%of specimens and one of the three terminal branches of the trifurcation of LCA 28% of specimens and the other two are LAD and intermediate branch /median artery. In 70%of specimens the LCxA is one of the branches of bifurcation. In most of the cases the circumflex artery ended between margo obtusus/ crux cordis. In a few cases thecircumflex artery.

Coronary Dominance:- Dominance pattern of heart has important clinical significance. Left dominance was found to have significantly higher mortality than right coronary artery dominance and balanced (mixed) types. The present study shows 95% of right coronary artery predominance and 5% left dominance. There was not even a single case of co-dominance (balanced type). In two cases where there is left dominance, the RCA was not traversing the coronary sulcus. It crossed the inferior border of the heart and entered the diaphragmatic surface of the heart. After crossing the diaphragmatic surface of the heart it entered the middle of the PIVS and disappeared deeply piercing the myocardium. Most of the literatures showed the right dominance in more than 70% of hearts, left dominance in 20% of hearts and 10% of balanced type of coronary circulation. Balanced type of circulation is more common in females. According to James 1961, the left coronary artery predominance is seen in males. In the present study right dominance was seen in 95% of hearts and left dominance in 5% of hearts and there was no balanced type.The comparison of our values with the previous authors reveals a higher percentage of right dominance and there is a steep fall in the percentage of left dominance. 95% right dominance in the present study tallied with the 90% right dominance values of James (1961) and 89% of right dominance stated by Kalpana R. The 5% left dominance in the present study tallied with the results 10%, 11.82% and 11% left dominance stated by James (1961). Results obtained in present study resemble with the results obtained by Kalpana R[19] and Kumar keshaw[20] who did not find the balanced or co -dominance type of coronary arterial pattern in any human heart.

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VI. Conclusions & Summary
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In the present study the origins of the coronary arteries does not show great variability.The origin of right coronary artery was from the right anterior aortic sinus and the left coronary artery from the left posterior aortic sinus. In the present study it was found that the diameter of left coronary ostium was greater than right coronary ostium in all the specimens. the positions of the ostia of RCA and LCA were below or at the STJ in 90% of specimens. This is functionally advantageous. In the present work, right coronary artery predominance was found in 95% of the cases in which the PIVA was given by RCA at the crux which was passing in the PIVS. The left coronary predominance was found in 5% of cases in which the PIVA was given by LCX .No balanced type / Co-dominance was observed in a single specimen.

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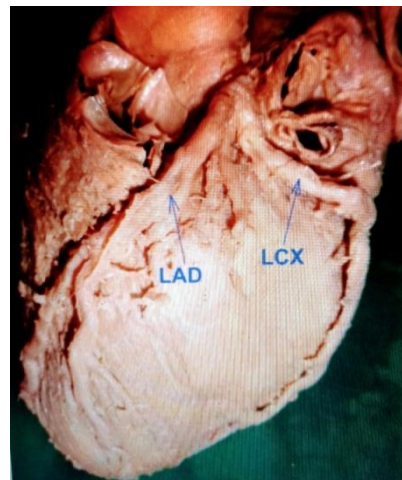
Figure 1 : Right coronary predominance

Figure 2 : Bifurcation of LCA
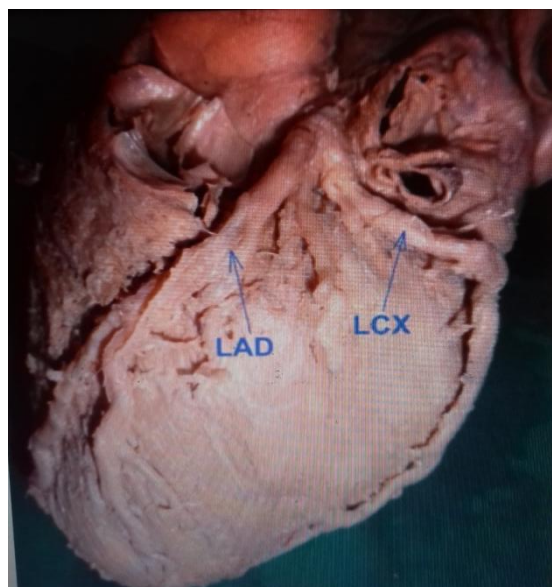

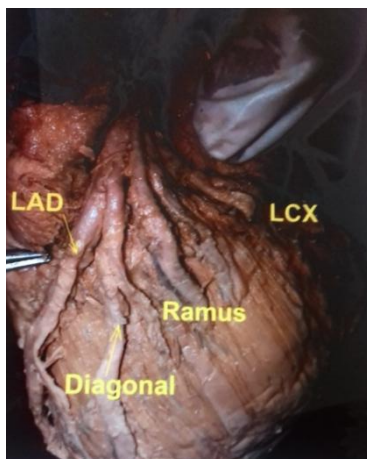**Figure : Third coronary artery (Rt. Conus art)**

Figure 4 : trifurcation of LCA

Figure 5: quadrification of LCA