A Study of Course, Branches and Variations of the Coronary Arteries in the Human Cadaveric Heart

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ABSTRACT

Introduction: The myocardium is supplied by a pair of coronary arteries which arise from the ascending aorta. The term "Coronary" is derived from the Latin word "Corona", which means crown. The heart pumps the blood for the entire tissues in the human body through the aorta. However, the heart itself gets its nutrition through coronary arteriesa. The present study was conducted to observe the origin, branching pattern, termination and variations of coronary arteries in human cadaveric hearts.

Material and methods: The present observational descriptive study was conducted at Dept. of Anatomy; Government Medical College Yavatmal to observe the origin, course branching pattern and variations of the coronary arteries in human cadaveric hearts during August 2014 upto November 2016. Study includes hearts of adult cadavers from both genders (aged 25–70 years) that were fixed with 10% formaldehyde which were collected and used for the present study. Ethical clearance from college Institutional Ethical Committee was obtained.

Results: In all 50 cases, the dissected (RCA) right coronary artery arose from the anterior aortic sinus. Left coronary artery was found to arise from left posterior coronary sinus in 49 hearts and in one heart from right posterior sinus of the ascending aorta. In anterior aortic and left posterior sinus one opening was present in 35 (70%) and 46 (84%) cases respectively. Conclusion - It was observed that in 45 (90%) cases where the right ostia were situated just below the sinutubular ridge.

Keywords: Coronary Arteries, Human Cadaveric Heart, Cadavers

INTRODUCTION

The myocardium is supplied by a pair of coronary arteries which arise from the ascending aorta. The term "Coronary" is derived from the Latin word "Corona", which means crown. The heart pumps the blood for the entire tissues in the human body through the aorta. However, the heart itself gets its nutrition through coronary arteriesa.[1] As the arterial supply to the myocardium is very critical for the normal functioning of the heart, the variations which exist in its branches are gaining importance, more so, because of the angiographic procedures and the numerous bypass surgeries which are being done.[2]

There is a progressive path for cardiovascular diseases management in the last few decades. More than one incorrectable lesion is nowadays amenable to correction due to more and newer surgical and interventional techniques. in congenital and acquired cardiovascular diseases management a good and precise knowledge of normal and anomalies of coronary circulation crucial. Numerous data on the variations of the arteries have been reported, but still it is better to explore them further with respect to their clinical significance.[3] The recent coronary arteriography provides an accurate localisation of variation and underlying pathology. The advances in coronary arterial bypass surgeries and modern methods of revascularisation make it necessary to have thorough knowledge of coronary artery and circulation.[4] "Anomaly" refers to the variation which happens in around 1% of the general population. Thorough Knowledge regarding normal anatomy of coronary arteries, its variations and anomalies is obligatory for good clinical outcome following therapeutic procedures, like coronary artery bypass grafting ,angioplasty, etc.[5] The present study was conducted to observe the origin, branching pattern, termination and variations of coronary arteries in human cadaveric hearts.

MATERIAL AND METHODS

The present observational descriptive study was conducted at Dept. of Anatomy; Government Medical College Yavatmal to observe the origin, course branching pattern and variations of the coronary arteries in human cadaveric hearts during August 2014 upto November 2016. Study includes hearts of adult cadavers from both genders (aged 25–70 years) that were fixed with 10% formaldehyde which were collected and used for the present study. Ethical clearance from college Institutional Ethical Committee was obtained. 50 human hearts were collected from the embalmed cadavers of both the sexes, from the department of Anatomy of our institution. They were preserved in 10% formalin. The specimens were serially numbered from 1 to 50.

The hearts were examined as per the general principles of anatomy. The coronary arteries were observed after removing visceral pericardium. The coronary arteries and their branches were dissected on the surface of the heart in the atrioventricular and interventricular grooves. By micro

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dissection the epicardium was removed, and coronary arteries were observed. The exit point of the LCA from the aorta, the courses and variations of the circumflex branch and anterior interventricular branch, and the presence of the median artery were investigated. The exit points of the RCA and conus branch, the courses of the posterior interventricular branch and the variations of the RCA branches were determined. The external diameters at the starting points of these branches were measured using 0.01 mm sensitive digital calipers. To determine the dominant circulation, the artery that supplies the posterior interventricular sulcus was investigated. The pericardial cavity was opened and explored. Anatomy of the great arteries before transecting them about 3 cm above the aortic and pulmonary valves was observed. The pulmonary veins were checked and transacted. The superior vena cava was transacted about 2 cm above the point where the crest of the right atrial appendage meets the superior vena cava. The inferior vena cava was transacted close to the diaphragm.

STATISTICAL ANALYSIS

Standard methods of descriptive statistics like mean and percentages were used to interpret the results.

results

In all 50 cases, the dissected (RCA) right coronary artery arose from the anterior aortic sinus. Left coronary artery was found to arise from left posterior coronary sinus in 49 hearts and in one heart from right posterior sinus of the ascending aorta. In anterior aortic and left posterior sinus one opening was present in 35 (70%) and 46 (84%) cases respectively. Out of total 50 cases 15 (30%) of the cases, multiple openings were found in the anterior aortic sinus. The extra openings were minute, of pinhead size. Only in three cases were multiple openings observed in the left posterior sinus.

It was observed that in 45 (90%) cases where the right ostia were situated just below the sinutubular ridge, the ridge was arched to accommodate the ostia within the sinus. Positions of left ostia were below of sinutubular ridge in 39 (78%) cases. Right and left ostia at level of sinutubular ridge were present in (6%) and 8 (16%) of cases respectively.

In most cases, the ostia were positioned but above the level of the cusps. It was observed that in 42 (84%) cases and 45 (90%) cases were above the level of cusps from the right and left Ostia respectively. Position of right ostia and left ostia were below cusps of aortic valve in Only 2 (4%) and 1 (2%) respectively.

Table-1 depicts that in 46 (92%) and 45 (90%) Posterior descending (PD) branch and branch to AV node was found to be a branch of RCA respectively. In all the cases the branch to SA node and acute marginal branch was found to be a branch from RCA.

In the present study in all 40 cases the obtuse marginal artery was found to be a branch of circumflex coronary artery. It was observed that in 4 (8%) and 5 (10%) cases Posterior descending or posterior interventricular artery and Branch to AV node were present. In all cases, Diagonal branch was present of left anterior descending branch.

The posterior interventricular septum is supplied by the right coronary artery in 46 (92%) of the cases thereby the diaphragmatic surface of the heart is supplied by the right coronary artery. Hence, in the present study, 46 (92%) of the hearts are right dominant. Only 4 (8%) cases posterior interventricular septum is supplied by left circumflex artery so heart is left dominant.

In the present study for right coronary artery branch the range of length of was depicted to be 6-8 cm in 6 (12%), 8-14 cm in 42 (84%), and 14-17 cm in 2 (4%) of cases. In 40 (80%) of the cases, the trunk of the left coronary artery was short measuring less than 5 mm and in 6 (12%) of the specimens, found more than 10 mm. The average length ranged from 2 mm to 17 mm. The length of left Circumflex artery was observed to be 3-5 cm in 20%, 5-9 cm in 70%, and 9-11 cm in 10% of all cases respectively. Average length for left circumflex artery 3 cm to 11 cm. Lengths of posterior descending branch of 3-5 cm were in 17 (34%) cases. Majority of cases have length between 5-7 cm i.e. 64%. Average length for posterior descending length i.e. 3 to 9 cm (table-2).

It was observed that right coronary artery concluded between crux and obtuse margin of heart in majority of cases 30 (60%) while in 10 (20%) cases it was terminated in between the acute margin of the heart and the crux (table-3).

In 2 (4%) of the cases, the right coronary artery concluded at the obtuse margin of the heart. In majority cases 35 (70%) bifurcation of left of coronary artery was found. Trifurcation and quadfurcation of trunk of the left coronary artery was depicted in 12 (24%) and 3 (6%) of the cases, respectively. In these specimens, trunk of the left coronary branched into left anterior descending artery, which continued as anterior interventricular artery, one or two median arteries and circumflex artery.

In majority cases 40 (80%) circumflex artery terminated

Coronary artery	No. of cases	%
Branch of RCA		
Posterior descending or posterior interventricular artery	46	92%
Branch to sinoatrial node	50	100%
Branch to AV node	45	90%
Acute marginal branch	50	100%
Branch of LCA		
Left anterior descending or left anterior interventricular artery	50	100%
Circumflex coronary artery	50	100%
Ramus intermedius branch	8	16%
Left conus artery	1	2%
Branch of Circumflex Artery		
Obtuse marginal branch	40	80%
Branch to AV node	5	10%
Posterior descending or posterior interventricular artery	4	8%
Branch of Left Anterior Descending		
Diagonals branch	50	100%

Table-1: Variation in the branching pattern of right coronary artery

Length of RCA (cm)	No. of cases	Percentage
6-8 cm	6	12%
8-14 cm	42	84%
14-17 cm	2	4%
Length of LCA (mm)		
< 5 mm	40	(80%)
5-7 mm	6	(12%)
7-10 mm	4	(08%)
Length of LCA (cm)		
3-5 cm	10	20%
5-9 cm	35	70%
9-11 cm	05	10%
Length of posterior descending (cm)		
3-5 cm	17	34%
5-7 cm	32	64%
7-9 cm	01	02%

Table-2: Length of the trunk of Right Coronary Artery

Termination of RCA	No. of cases	%
Between acute margin and crux of heart	10	20%
At Posterior interventricular septum	8	16%
Between crux and obtuse margin of heart	30	60%
At the obtuse margin of heart	02	04%
Termination of circumflex artery	**No. of cases**	**%**
At the posterior interventricular septum	07	14%
Between crux and obtuse margin of heart	40	80%
At the obtuse margin, of heart	03	06%

Table-3: Termination of Right Coronary Artery

between crux and obtuse margin of heart. In 03 (6%) of the cases, the circumflex artery concluded at the obtuse margin of the heart and in 7 (14%) of cases, the circumflex artery terminated by supplying the posterior interventricular septum as the posterior interventricular artery.

DISCUSSION

Nowadays, with the extensive use of advanced image diagnostic techniques and the development of non-aggressive treatments, a in-depth knowledge of anatomy of the normal coronary and its variations and anomalies is important. Branches of coronary arteries may vary in origin, distribution, number and size. The name and nature of a coronary artery or a branch is defined by that vessel's distal vascularisation pattern or territory, rather than by its origin. As per the observations of Loukas et al. (2009), it is necessary to determine the incidence of the variations, which are possibly capable of inducing sudden cardiac death, in order to evaluate the value of screening.[6]

In the present study, the dissected right coronary artery (RCA) was found to originate from the anterior aortic sinus in all 50 cases while Left coronary artery arose from left posterior coronary sinus in 49 hearts and in one heart from right posterior sinus of the ascending aorta in all the specimens studied and there were no variations in the location of the ostia. Same observations were also found by the Kalpana R (2003) i.e. the Right and left coronary ostia were present at the anterior aortic and left posterior aortic sinus respectively in all the 100 specimens studied and there were no variations in the location of the ostia.[7] Study done by Subhash D Joshi et al on 105 embalmed heart specimens found that neither openings were detected in the pulmonary sinuses nor in the right posterior aortic sinus.[4] Study conducted by Jyoti P kulkarni et al revealed that in all 60 cases, the dissected right coronary artery (RCA) and left coronary artery (LCA) were found to originate from anterior aortic sinus and the left posterior aortic sinus, respectively.[8] In a dissection study on heart specimens received from medico legal autopsies and performed by Sahni and Jit et al[9], revealed that anomalous origin of any coronary artery was not found in any case. Baroldi and Scomazzoni In 1967, described 36% prevalence of independent origin of right conus.[10] Similar findings also noted by Bhimalli *et al*.[11] However, ectopic origin may have for RCA from left posterior aortic sinus. On angiographic studies 0.0008% prevalence of this ectopic origin was observed, as mentioned by Yarnanaka and Hobbs[12] and 0.043-0.46%, as revealed by Solanki et al.[13] Grag and Tiwari et al[14] observed anomalous coronaries in 0.95% of individuals. Of these cases, about 90% were anomalies of origin. Harikrishnan et al.[15] reported an incidence of 0.45% of anomalies of origin of coronary artery.

Present study revealed that in the anterior aortic sinus multiple openings were seen. The extra openings of pinhead size were seen. Multiple openings were detected only in three cases in the left posterior aortic sinus . The presence of multiple orifices in the right aortic sinus is the most frequent variation while second most is the presence of an accessory orifice for the conal artery. Study done by Joshi et al[4] found that in approximately 8% of hearts, in right coronary sinus three or more openings were present. Standring et al. (2005) have reported that in 36% of individuals the incidence of extra openings in the right aortic sinus. Sahni and Jit et al[9] reported extra openings in 34.8% of male hearts and 27.8% of female hearts. Wolloscheck et al. (2001)[16] reported extra ostia in 65% of cases in an anatomic and transthoracic echocardiographic study.

In our study, most cases, the ostia were positioned below the level of the sinutubular ridge. It was observed that in 45 (90%) cases where the right ostia and 39 (78%) cases where left ostia were situated just below the sinutubular ridge, the ridge was arched to accommodate the ostia within the sinus. Right and left ostia at level of sinutubular ridge were present in (6%) and 8 (16%) of cases respectively. A study conducted by Shinde VS et al reported that the majority of the coronary ostia were present below the sinutubular ridge this may be functionally more efficient than the ostia above the sinutubular ridge.[17] Study done by Patil R et al[18] reported that the coronary ostia were below the sinutubular ridge in 34 specimens (89.47% of cases) while coronary ostia were opening above the sinutubular ridge in 4 specimens (10.52% of cases). Turner and Navratnam et al[19] found that 62 of the 74 main coronary ostia lay either at or immediately below the

sinutubular ridge. Joshi SD et al[4] reported that the majority of ostia lay below the sinutubular ridge. An accessory origin or an abnormal location of the coronary orifices may be disturbed by performing an aortotomy incision for aortic exposure. Precise knowledge of coronary ostia related to the aortic root is vital for various interventional and surgical cardiovascular procedures.[18]

In present study; Posterior descending (PD) and branch to AV node was observed to be a branch of RCA in 46 (92%) and 45 (90%)cases respectively. In all the cases the branch to SA node and acute marginal branch was found to be a branch from RCA. Similar observation were observed in the study conducted by Kulkarni J, in all 60 cases the branch to SA node was seen to originate from the RCA. However in 35% of cases Hutchison found a variable origin of the branch to SA node from circumflex coronary artery, which is a significant finding.

In the present study for right coronary artery branch the range of length was depicted to be 6-8 cm in 6 (12%), 8-14 cm in 42 (84%), and 14-17 cm in 2 (4%) of cases. Findingsof study done by Kulkarni J[8] showed analogous findings with present study. Study done by Bhimalli S et al.[11] revealed average length of the RCA around 7 cm and length of RCA was11 cm in the case reported by Vathsala V et al.[21]

It was observed that right coronary artery concluded between crux and obtuse margin of heart in majority of cases 30 (60%) while in 10 (20%) cases it was terminated in between the acute margin of the heart and the crux.The inverse relationship between the RCA and left circumflex branch is most simply expressed as right or left dominance, depending on which artery gives rise to the PIVA. right coronary artery giving origin to posterior inter ventricular artery is the commonest anatomy in man, and referred to as right dominance, which occurred in 92% of the hearts in our study and a left dominance, was observed in 8%. Ortale et al examined dominant circulation in 40 cadaver hearts, and accepted the posterior interventricular branch arising from the RCA and its branches supplying at least the middle medial part of the left ventricular posterior face as right dominance (62.5%).[22]

When the common trunk of left coronary artery is less than 5 mm then it is considered to be short and when it is more than 15mm its considered as long common trunk. In present it was revealed that the trunk of the left coronary artery study in 40 (80%) of the cases, was short measuring less than 5 mm while in 6 (12%) cases, the trunk of the left coronary artery measured more than 10 mm. The average length ranged from 2 mm to 17 mm. Results were consistent with other studies like Reig and Petit et al[23] with an average of 10.8 mm. Kalpana R. (2003)[7] observed length of the main trunk of LCA ranges between 6 mm to 15 mm. Study conducted by Kulkarni et al,[8] revealed the length of LCA to be 5 mm in 76.7% of specimens, while it was observed to be 10 mm in 5% of specimens. Waller et al.,[24] observed the length of Left Coronary Artery to be 6 mm in 76% of all specimens and 10 mm in 3% of specimens. Fox et al., found the length of Left Coronary Artery to be <6 mm in 36% of all specimens while >20 mm in 5% of all specimens on cine angiofilms.[25] In present study in all 50 cases, the Left anterior descending and Circumflex coronary artery were observed to be the branches of Left Coronary Artery. Ramus intermedius branch present in 8 (16%) cases. Left conus artery branch was present in one case only. Cavalcanti (1995) described that the circumflex and the anterior descending branches originate directly from the aorta in about 1.82% of the specimens.[26]

In present study; bifurcation of left of coronary artery (LCA) was revealed in majority cases 35 (70%) whileTrifurcation and quadrifurcation was found in 12 (24%) and 3 (6%) of the cases, respectively. In these cases, the left coronary trunk branched into left anterior descending artery, which continued as anterior interventricular artery, one or two median arteries and circumflex artery. Other Researchers viz. Fazliogullari Z, et al (2010) (Fazliogullari et al., 2010); Surucu et al (2006) (Sürücü et al., 2006); Reig and Petit M et al (2004) (Reig and Petit, 2004) and Kalpana, R (2003) (Kalpana, 2003) have reported similar results regarding the LCA branching frequency mentioned in table below

In present study circumflex artery concluded between crux and obtuse margin of heart in majority cases 40 (80%). The circumflex artery terminated at the obtuse margin of the heart In 03 (6%) of the cases while in 7 (14%) of specimens, the circumflex artery terminated by supplying the posterior interventricular septum as the posterior interventricular artery. Study done by Anbumani T L et al[27] showed similar result that is 16%; 80% and 04% specimens terminates at Posterior interventricular septum (%); Between crux and obtuse margin of heart (%) and Between crux and obtuse margin of heart (%) respectively.

CONCLUSION

A proper knowledge of anatomy of coronary arteries and its variations are needed for a successful clinical outcome following treatment of coronary artery diseases. Knowledge about the variations of coronary arteries is helpful for cardiologists and radiologists in performing various procedures like coronary angiogram, coronary angioplasty, and bypass grafting surgeries etc.

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