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Coronary arteries distribution and variations: A study in the Nepalese cadavers

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Abstract
Background: Coronary diseases are more encountered in the clinic and clinical practices are being done regularly nowadays. Knowledge regarding the variations in coronary distribution has become a necessity especially for its implication in clinical and surgical procedures. Incidence of variations are most usually seen with the origin, length, branches, and area supplying. Some variations are of considerable clinical importance because misinterpretation of these variations may be disastrous.
Material and Methods: Thirty human hearts were taken for the study. They were dissected and analyzed.
Results: In 70% of the specimens, right coronary artery reached the crux of the heart, in 16.67% it crossed the crux, and in 13.33% it didn't reach the crux. No anomalies in the origin and course of left coronary artery was found. The average mean length of left coronary artery was 12.42 mm. In 46.67% the diagonal artery aroused from the circumflex artery and in 43.33% from left anterior descending artery. In 10%, left coronary artery trifurcated into left anterior descending, diagonal and circumflex branches. In 13.33% circumflex branch coursed to reach the crux of the heart, in 70% it reached between obtuse margin and crux, and in 16.67% it was short terminating at the obtuse margin. In 3.33% of the specimen, two parallel branches of right coronary artery were found to traverse in the posterior interventricular groove. In 40% the posterior interventricular artery didn't reach halfway the length of the posterior interventricular groove, in 33.33% it reached the halfway and in 26.67% it traversed about 3/4th length of the groove. Right coronary dominance was present in 86.67% of the specimens and 13.33% were left dominance. Co-dominance wasn't found.

Keywords: right coronary artery, left coronary artery, circumflex branch of left coronary artery, posterior interventricular artery, left anterior descending artery, coronary dominance

Introduction

Cardiac problems have become one of the major causes of death. The frequency of these problem have been increasing day-today due to increasing risk factors caused by changing fooding habits, changing nature of work from high physical labor to sedentary type, urbanization and so on [1]. Coronary artery disease is major cause of sudden cardiac deaths [2, 3]. In the young, the primary cause of death is non atherosclerotic coronary abnormalities [4]. Knowledge and understanding the anatomy of coronary distribution and variations is important in the management of cardiac diseases and related complications.

The heart is supplied mostly by right and left coronary artery. Each coronary artery is a vasa vasorum of the ascending aorta, because the heart is developed from the fusion of two primitive endothelial tubes which represent the ventral aorta [5, 6]. Right coronary artery (RCA) arises from anterior aortic sinus [7, 8]. There may be anomalies in the origin [7] causing important clinical manifestation including deaths during strenuous activity such as in the young competitive athletes [9]. It courses in the atrioventricular groove to reach the crux of the heart [7, 8]. There it gives a Posterior Interventricular (PIV) branch, which also supplies the atrio-ventricular (AV) node. Sometimes, the RCA is shorter and doesn't give PIV branch, in that instance the blood supply is compensated by PIV branch given by circumflex (CMX) branch of left coronary artery (LCA) and is termed as left coronary dominance. Here, the coronary dominance refers to the coronary artery which gives off the PIV branch [7] that ultimately supplies the AV node. The balanced or co-dominance is termed when the PIV branch is given by both arteries. The pattern of coronary distribution has important clinical significance. If it's right dominant, then higher risk of AV blocks will occur in case of RCA occlusion [10]. Mortality was found higher in the subjects with left dominance than in the right dominance or co-dominance [11] because the left ventricle and ventricular septum is entirely supplied by left coronary artery [8].

During the course, the RCA gives off several branches. The first branch is right conus artery which may arise independently from the ascending aorta. In that case it is called as third coronary artery. The second branch is the SA nodal artery which supplies the Sino-atrial node. It's one of the most important vessels as it supplies the SA node, the pacemaker of the heart for its conducting system [7, 8]. There are some few 3-4 ventricular rami during its course before it turns backward across the inferior border to supply the diaphragmatic surface. One of the large ventricular rami is the right marginal artery which traverses along the inferior border

towards the apex of the heart. Sometimes RCA crosses the crux of the heart and goes forward up to the left margin, whereas sometimes it doesn't reach the crux.

The LCA arises from the left posterior aortic sinus [7], with a short course it divides into left anterior descending (LAD) branch and a CMX branch. The length may be variable ranging from 6-15 mm (mean length 8.86±2.96 mm) [12].

The LAD branch courses in the anterior interventricular groove to reach the apex of the heart, wind round to pass on the inferior surface and anastomose with the PIV branch of RCA. The anomalous origin and course are associated with myocardial ischemia. According to its anatomic relationship to the aorta and pulmonary trunk, anomaly can be classified into 4 common courses: posterior, interarterial, anterior, and septal course [13]. Some other anomalies such as double LAD artery are also found [14]. Sometimes one of the ventricular rami is larger and may arise from the junction of the LAD artery and CMX branch; known as Diagonal artery.

Circumflex branch courses in the atrioventricular groove giving off one marginal branch and several small branches. The CMX branch sometimes gives off the PIV branch [7, 8].

The present study was designed to study the distributing pattern of coronary arteries and to find any variations present in the Nepalese cadavers comparing with other study.

Materials and Methods

Thirty hearts were dissected out from the cadavers during the routine laboratory exercises conducted for the undergraduate students of Nobel Medical College Teaching Hospital and Research Centre, Biratnagar, Nepal during the period from October 2013 to September 2017. The hearts were thoroughly dissected and the coronary arteries were exposed out. Various parameters were used for the study such as origin, length, caliber, branching pattern, dominance.

Inclusion Criteria

Fresh undissected hearts were used whereas damaged and dissected heart were excluded.

Results

The right coronary artery originated from right anterior aortic sinus in all the specimens. No anomalies in the origin of the RCA was found. The RCA displayed normal course following the atrio-ventricular groove but the termination of the artery differed in different cases. In 21 (70%) of the specimens, it reached the crux of the heart giving a PIV branch and a terminating branch which supplied a portion of left diaphragmatic surface and anastomosed with CMX branch of LCA whereas in 5 (16.67%), it crossed the crux and supplied almost the entire left diaphragmatic surface. In 4 (13.33%) of the specimens, it didn't reach the crux of the heart. In 1 (3.33%) of the case, it was seen that the right marginal branch was larger in caliber than its continuation in the groove. In another 1 (3.33%) of the case it was found to give a small twig in the posterior interventricular groove than its continuation to supply on the left diaphragmatic surface. In that case the PIV branch was largely compensated by the LAD artery winding around the apex and coursing in the posterior interventricular groove.

Left coronary artery originated from the left posterior aortic sinus in all the specimens. It coursed behind the pulmonary trunk and left auricle. No anomalies in the origin and course was found. In all cases the LCA was seen to have larger caliber than the RCA. The mean length was found to be 12.42 mm ranging from 6 mm to 18 mm. In 14 (46.67%) of the specimens, the diagonal artery was found to arise from the CMX whereas in 13 it was found to arise from the LAD artery. In 3 (10%) of the cases the LCA was found to trifurcate into LAD, diagonal and CMX branches.

LAD artery originated from the LCA and had the normal course following the anterior interventricular groove in all the cases. In one (3.33%) of the case it was found to wind around the apex of the heart to course about half the way of PIV groove, the PIV artery from RCA was too short in that case.

Circumflex branch originated from the LCA in all of the cases. It coursed in the atrioventricular groove supplying the left surface of the heart and left diaphragmatic surface. In 21 (70%) of the specimens it terminated near the crux anastomosing with the branches of RCA, in 4 (13.33%) of the cases it coursed to reach the crux of the heart and gave a PIV branch. In 5 (16.67%) of the cases, the CMX was short supplying the left surface of the heart and terminated by giving a large left marginal branch and other small branches.

Posterior interventricular branch originated from the RCA in most of the specimens (26/30= 86.67%) but in 4 (13.33%) of the specimens it originated from CMX branch whereas in one of the specimen a very small twig appeared from RCA which was largely compensated by the LAD curving around the apex and coursing in the posterior interventricular groove. In another 1 (3.33%) of the specimen, two parallel branches of RCA were found to traverse in the PIV groove. In 12 (40%) of the specimens, the PIV artery was small which didn't reach halfway the length of the PIV groove before going deep in the myocardium. In 10 (33.33%) of the specimens, the PIV artery reached the halfway and in 8 (26.67%) of the specimens it traversed about 3/4th length of the PIV groove.

According to the PIV artery given by a particular coronary artery, it was found to be right coronary dominance in 86.67% of the specimens whereas in 13.33% it was found to be left dominance. Co-dominance wasn't found.

Discussion

Coronary diseases are more encountered in the clinic and clinical practices are being done regularly nowadays. Knowledge regarding the variations in coronary distribution has become a necessity specially for its implication in clinical and surgical procedures. Incidence of variations are most usually seen with the origin, length, branches, and area supplying. Some variations are of considerable clinical importance because misinterpretation of these variations may be disastrous.

Regarding the origin various anomalies are found in literature. Altin C et al found the absence of left main coronary artery in 0.9% [15]. By Kulkarni JP, it was found in 100% of the cases that RCA aroused from right anterior aortic sinus and LCA from left posterior aortic sinus [16]. In the present study no anomalies regarding the origin of RCA and LCA were found.

The course of RCA was found to be normal but its caliber differed. In 70% of the specimens, it reached the crux of the heart; in 16.67% it crossed the crux, reached the left margin of

the heart and supplied almost the entire left diaphragmatic surface. In 13.33% of the specimens, it didn't reach the crux of the heart. In the study done by Ballesteros LE et al, RCA ended between crux cordis and the obtuse (left) margin in 75.6% of specimens [17]. In 3.33% of the specimens it was seen that the right marginal branch was larger in caliber than its continuation in the groove. In another 3.33% of the specimens, it was found to give a small twig in the posterior interventricular groove than its continuation to supply on the left diaphragmatic surface. In that case the PIV branch was largely compensated by the LAD artery winding around the apex and coursing in the posterior interventricular groove.

Ballesteros LE et al reported that PIV artery reached the inferior third, or the apex, or the anterior interventricular sulcus in 67.4% cases [17]. In the present study, in 40% of the specimens, the PIV artery didn't reach halfway the length of the groove, in 33.33% it reached halfway the length and in 26.67% the PIV artery traversed about 3/4th length of the PIV groove. PIV branch was very small in 3.33% of the specimens which appeared from RCA and was largely compensated by the LAD curving around the apex and coursing in the posterior interventricular groove. In another 3.33% of the specimen, two parallel branches of RCA (two PIV arteries) were found to traverse in the PIV groove.

In the present study the average mean length of LCA was found to be 12.42 mm ranging from 6mm-18mm which is seen higher in comparison to the data found in other literature. In the study done by Kulkarni JP it is 7mm [16] and in the study by Hosapatna M et al is 8.86±2.96mm ranging from 6-15mm [12]. In the same study done by Hosapatna M et al, trifurcation is reported in 6.7% of the specimens and remaining had bifurcation [12]. Reig and Petit reported bifurcation in 62% of the specimens and more than three branches in 38% of the specimens [18]. In the present study LCA was found to bifurcate in 90% of the specimens whereas in 10% it trifurcated. In 46.67% of the specimens, the diagonal artery was found to arise from the CMX whereas in 43.33% it was found to arise from the LAD artery.

Table 1: Length and branching pattern of LCA

Authors	Average Length of LCA (Range)	Bifurcation	Trifurcation
Hosapatna M *et al*.	8.86±2.96mm (6-15mm)		6.7%
Reig and Petit	-	62%	38% with trifurcation and more
Kulkarni JP	7 mm		10%
Present study	12.42mm (6-18mm)	90%	10%

The termination of CMX branch of LCA is also found variable in literature. In the study done by James TN it is reported to terminate at obtuse margin in 22%, between obtuse margin and crux in 60%, at the crux in 9% and between crux & acute margin in 9% of the cases [19]. In another study done by Baroldi and Scomazzoni, CMX branch terminated at obtuse margin in 25% of the cases, between obtuse margin and crux in 63%, at the crux in 5% and between crux & acute margin in 7% of the cases [20]. Table 2 shows the comparison between the different study. In the present study CMX branch reached the crux of the heart in 13.33% of the specimens and gave a PIV branch. In 16.67% of the cases, the CMX was short supplying the left surface of the heart and terminated by giving a large left marginal branch and other small branches. In 70% of the specimens it terminated near the crus of the heart anastomosing with RCA.

Table 2: Termination of Circumflex branch of LCA

Authors	Obtuse margin	Between obtuse margin and crux	Crux	Between Crux and Acute margin
James TN	22%	60%	9%	9%
Baroldi and Scomazzoni	25%	63%	5%	7%
Present study	16.67%	70%	13.33%	-

The dominance pattern is found quite variable in literature. As explained by the literatures about dominancy i.e. the coronary artery which gives the PIV branch; in the study by Altin C et al it is 81.6% right coronary dominance, 12.2% left coronary dominance, 6.2% co-dominant15; Kulkarni JP found 90% right dominance, and 10% left dominance16; by Dakhane PS et al it was 82.4% right, 13.3% left and 4.3% balanced21 and in study done by Ghaffari S et al, it is 78.6% right, 8.9% left and 12.5 % balanced22. However, in the present study it was found to be 86.67% right dominance and 13.33% left dominance. Co-dominance wasn't seen.

Table 3: Dominance pattern

Authors	Right dominance	Left dominance	Balanced
Altin C et al	81.6%	12.2%	6.2%
Kulkarni JP	90%	10%	-
Dakhane PS et al	82.4%	13.3%	4.3%
Present study	86.67%	13.33%	-

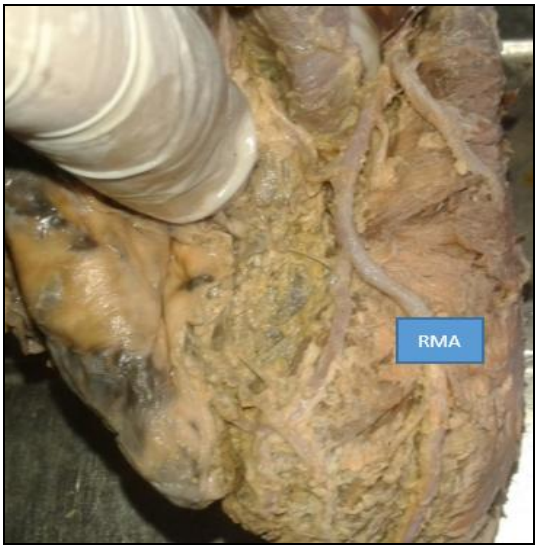

Fig 1: RCA, RMA is larger than its continuation.

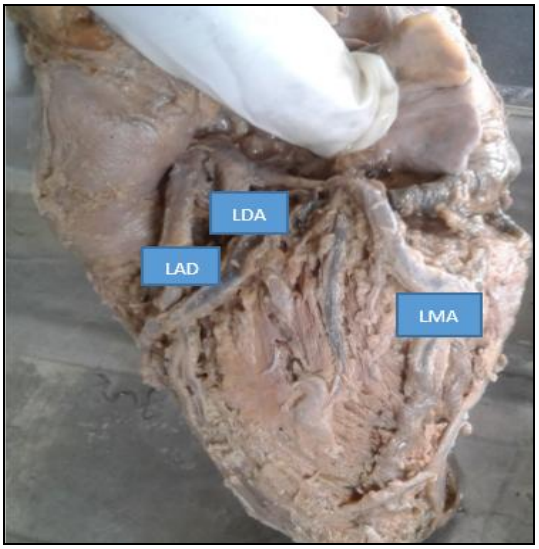

Fig 2: Left surface showing LCA and its branches. The left diagonal artery arising from CMX branch

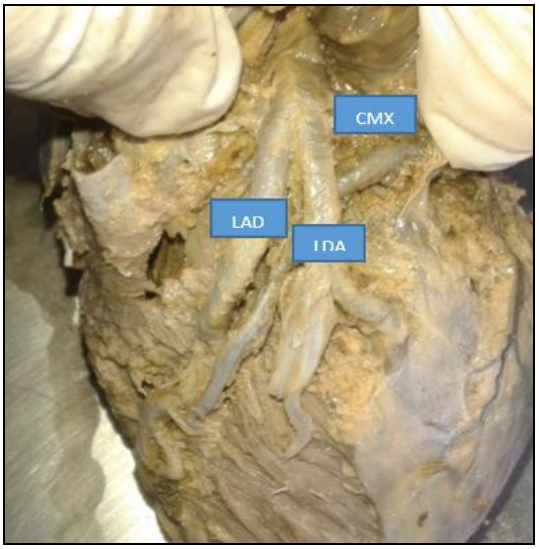

Fig 3: LCA trifurcating

Fig 4: Diaphragmatic surface, PIV artery coming from CMX branch of LCA

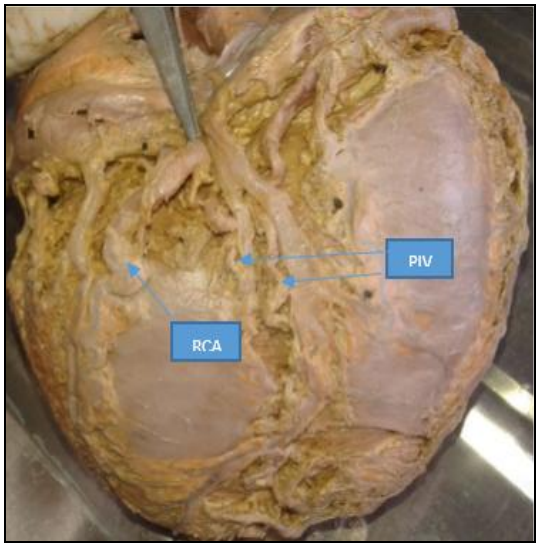

Fig 5: Diaphragmatic surface; RCA supplying the left part. Two parallel (PIV) arteries are seen in the PIV groove.

Fig 6: Diaphragmatic surface, LAD artery winding around the apex and traversing in the posterior interventricular groove.

Conclusion

The variations in the coronary distribution is seen a lot. The common and uncommon variations seen in different study and present study helps the clinicians in their clinical practices. Ignorance of the anomalies and variations can be disastrous.

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