Original Article

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An Anatomic Study of Branching Pattern of Right Coronary Artery (RCA)

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Abstract

Introduction: Malformations of position of ostia and origin of coronary arteries leads to potentially fatal significance unless diagnosed and treated surgically, because the coronary artery, and the myocardium it supplies, is fed with pulmonary rather than systemic blood. The present study aims to establish morphometry and pattern of right coronary artery with a special emphasis on its branching pattern, anastomoses and area of distribution. **Material and Methods:** The hearts of 25 adult human cadavers comprised the material for the study. The branching pattern of the Right Coronary Artery along with any variation were observed and noted down. Drawing of each artery was made and each specimen was photographed. The data was collected, finalized, analyzed & compared with the available data. **Results:** The observations from present study show that there is lot of variation in number, site of origin, and area supplied by the RCA. In 10 specimens a third coronary artery was seen arising from anterior aortic sinus just in front of the proper right coronary artery, 21 cases (84%) the posterior interventricular artery was a continuation of right coronary artery. In 21 specimens single conus artery was found out of which in 15 specimen conus artery was seen arising from RCA. In 18 specimens single marginal artery was found. **Conclusion:** The number of variations seen in branching pattern of RCA it becomes very difficult to assign the normal pattern.

Keywords: Coronary artery; Marginal artery; Conus artery; Variations; Branching pattern.

Introduction

Coronary arteries are the vasa vasorum of ascending aorta, right coronary artery arises from right coronary sinus (anterior aortic sinus) and left coronary artery arises from left posterior aortic sinus of ascending aorta.[1] Ostia of the coronary arteries are located in center of corresponding aortic sinuses. Malformations of position of ostia and origin of coronary arteries lead to high risk of sudden death.[2]

Clinically, the anomalies are arbitrarily divided into benign and malignant, based on their potential to cause myocardial ischaemia. The three most common benign anomalies are separate origins of left anterior descending and circumflex in left sinus of valsalva; origin of circumflex from right sinus of Valsalva or from right coronary artery; and ectopic origin of right coronary artery from aorta, a high origin being particularly prone to accidental cross clamping or side clamping, or transection during aortotomy. The most common malignant anomaly is the ectopic origin of right coronary artery from the left sinus of Valsalva.[3]

The right coronary artery, which in nine-tenths of individuals supplies most of diaphragmatic surface of ventricular mass, emerges from right coronary aortic sinus in upper part of right anterior surface of aortic

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root. In many instances, two arterial orifices are found in this sinus, with the second orifice most often giving rise to infundibular, or conal, artery, but sometimes giving rise to artery of sinus node.[4,5]

Having emerged from its aortic sinus, right coronary artery occupies right atrioventricular groove. Its first part extends to right, or acute, margin of ventricular mass, where it gives rise to acute marginal artery, with several atrial branches taking origin from its cranial surface. It also gives rise in this part of its course to infundibular artery, if this vessel has not taken origin directly from the aorta, and in just over half the population, to artery supplying sinus node. The right artery itself then continues to encircle the vestibule of tricuspid valve, extending to cardiac crux. Throughout this course, artery gives rise to right inferior ventricular branches, which supply diaphragmatic wall of right ventricle.[6]

In nine-tenths of population, having reached crux, right coronary artery gives rise to inferior interventricular artery and artery to atrioventricular node, then continuing to supply a variable portion of diaphragmatic wall of left ventricle. This arrangement is called right ventricular coronary arterial dominance.[4]

Of the named branches of right coronary artery, infundibular or conal branch is present in approximately half the population. Patients with well-developed infundibular arteries have more extensive distribution to the anterior wall of right ventricle through preventricular and ventricular branches of this artery. In some individuals, the artery anastomoses with an infundibular branch of anterior interventricular artery, forming so-called arterial circle of Vieussens. [7]

The anterior ventricular branches, usually two or three, ramify towards cardiac apex, which they rarely reach unless right marginal artery is included in this group of branches. Anastomoses are found at apex between this artery and anterior interventricular artery.[8]

When right coronary artery is dominant, it gives rise to artery supplying atrioventricular node, typically from a U-loop that extends in tissue plane forming floor of triangle of Koch. This, artery in conjunction with septal perforating branches of anterior interventricular artery, supplies proximal right and left branches of atrioventricular conduction axis in nine-tenths of individuals, with sole supply by the nodal artery reported in one-tenth of cases. The inferior interventricular artery, also known as posterior descending artery or posterior interventricular artery, arises from right coronary artery in all of those nine-tenths of individuals with right coronary arterial dominance, and from circumflex artery in remaining one-tenth, latter feature allegedly being more common in males. Branches of this artery can meet parallel branches of right marginal artery, and perpendicular branches of anterior interventricular artery, in inferior atrioventricular groove and at apex.[4]

Perforating branches from the artery supply myocardium of inferior part of muscular ventricular septum, adjacent ventricular walls, and infero-septal papillary muscle of the mitral valve in those individuals with right coronary arterial dominance.[9] In rare cases, anterior interventricular artery can extend into inferior interventricular groove, taking over territory usually supplied by inferior interventricular artery.[10]

In most individuals it is right coronary artery that supplies inferior wall of right ventricle and inferior diaphragmatic portion of muscular ventricular septum. The branches of left coronary artery supply majority of the sternocostal walls of heart and obtuse margin of left ventricle.[5] In up to half population, ominant right coronary artery, in addition to supplying inferior interventricular artery, also supplies a significant part of diaphragmatic wall of left ventricle.[6] In these individuals, it is branches of right coronary artery that typically supply infero-septal papillary muscle of mitral valve, and sometimes supero-lateral muscle.[9] In case of an extremely dominant right coronary artery, with hypoplasia of circumflex artery, the branches of right coronary artery can supply all inferior wall of

left ventricle.[11]

A solitary right coronary artery can take two forms. The right coronary artery itself can continue beyond crux, run through left atrioventricular groove, and terminate as anterior interventricular artery. Alternatively, right coronary artery can give rise to main stem of left coronary artery, which can then take a retroaortic, interarterial, or prepulmonary course before branching into anterior interventricular or circumflex arteries.[12]

Unlike the situation in which one of coronary arteries takes an anomalous origin from aortic root, ectopic origin is generally considered a congenital malformation in its own right. Very rarely a coronary artery can take an ectopic course from a brachiocephalic artery, or from a branch of subclavian artery. The most frequent ectopic origin, nonetheless, is from the pulmonary trunk, or one of its branches.[13]

This has potentially fatal significance unless diagnosed and treated surgically, because the coronary artery, and the myocardium it supplies, is fed with pulmonary rather than systemic blood. The condition is generally know as the Bland-White-Garland Syndrome, and is estimated to involve one in every 300,000 liveborn infants.[14]

This is a group of very infrequent anomalies, generally found during angiographic exploration. The right coronary artery originating from left coronary artery, a few millimeters from its beginning, has been described. This location is in fact similar to that of right coronary artery originating in left aortic sinus, and strictly speaking, is a case of a single coronary artery with a left-sided origin.[15]

Anomalous origin of coronary arteries from opposite sinus is potentially serious especially among young subjects and when a vessel runs between aorta and pulmonary artery.[16] Circumflex branch of coronary artery originating in right side, is most common "benign" coronary anomaly and is not considered cause of ischemia or myocardial infarction.[17]

Anomalous aortic origin of a coronary artery from an opposite sinus of Valsalva is a rare and sometimes lethal congenital anomaly. Anomalous coronary ostia are a recognized cause of sudden death, especially associated with high-intensity exercise in young adults. Traditional diagnostic techniques, such as coronary angiography and, to a lesser extent, transesophageal echocardiography, are invasive and ultimately underused. Improvements in noninvasive diagnostic techniques, such as transthoracic echocardiography and CT angiography, have increased ability to easily and safely screen for condition, leading to increased rates of diagnosis. Sudden death is thought to be associated with restriction of flow down anomalous artery, causing myocardial ischemia and ventricular arrhythmias, especially when anomalous coronary artery courses between great vessels (aorta and pulmonary artery). At present, mechanisms that lead to myocardial ischemia are unclear, but several potential mechanisms have been proposed.[18]

The present study aims to establish morphometry and pattern of right coronary artery with a special emphasis on its branching pattern, anastomoses and area of distribution. This information is definitely useful for clinicians as anomalous patterns of artery are related with ischaemia, myocardial infarction, ventricular arrhythmias and sudden death.

Material and Methods

The study was conducted in the department of Anatomy Government Medical College, Patiala. The hearts of 25 adult human cadavers comprised the material for the study. The hearts were labeled from 1-25. Mediastinum was dissected. Hearts were taken out from the cadaver & Right Coronary Artery was located in the Coronary sulcus. The fat from the coronary sulcus was carefully removed to avoid damage to small branches. Right Coronary Artery was followed from its origin to termination by careful dissection. The branching pattern of the artery along with any

variation were observed and noted down. Drawing of each artery was made and each specimen was photographed. The data was collected, finalized, analyzed & compared with the available data. The diameter of artery was taken at its origin & at the right border of the heart and at the point where it enters in posterior interventricular sulcus and after giving right marginal branch.

Observations

The observations from present study show that there is lot of variation in number, site of origin, and area supplied by the RCA. In no case particular text book description was found. Therefore it is very difficult to assign the normal course, site of origin, girth, branches and area supplied

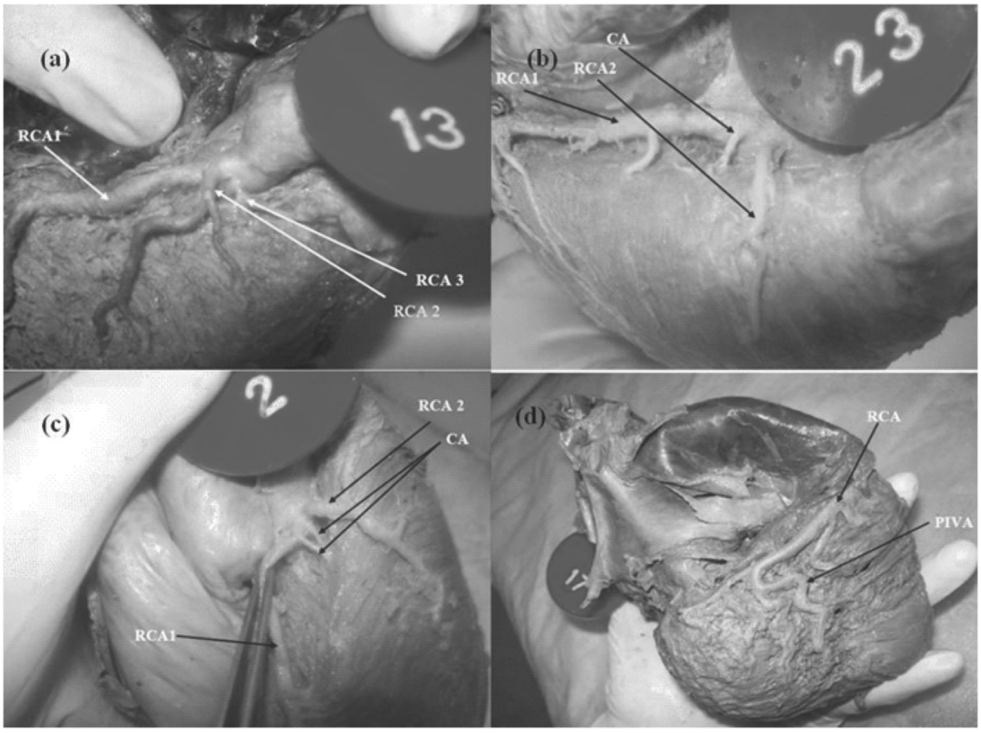
The branching pattern of the artery along with any variation was observed in all twenty five specimens. In all the specimens right coronary artery was seen arising from anterior aortic sinus.

Variations

There are two coronary arteries i.e. right and left in 15 specimens and in the other 10 specimens a third coronary artery was seen arising from anterior aortic sinus just in front of the proper right coronary artery. In these 10 cases 2 ostia were clearly defined in right aortic sinus. Out of 25 hearts studied RCA was seen arising from right anterior aortic sinus. In one case there were 3 independent arteries arising from aorta and in 9 cases there were two independent RCA arising from anterior aortic sinus where as in rest of cases there was single artery arising from anterior aortic sinus (Figure 1).

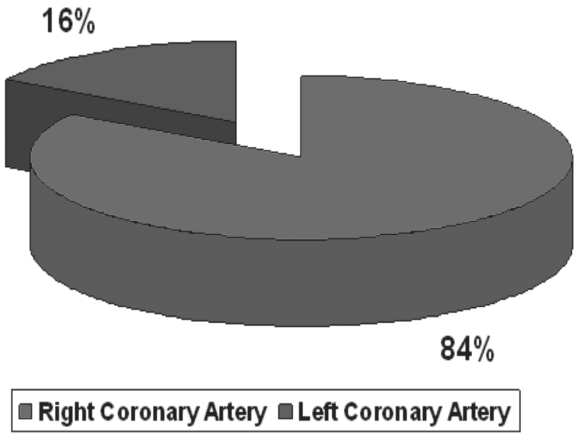
From the total 25 specimens studied SA nodal artery was arising from RCA in all 24 specimen and in specimen no. 1 this artery was found absent and could not be traced from

Figure 1: Variations in Heart (a): Heart showing 3 right coronary arteries (b): Heart showing 2 right coronary arteries with conus artery arising from right coronary artery (c): Heart showing 2 right coronary arteries and 2 conus arteries arising from anterior aortic sinus (d): Heart showing right coronary artery and posterior interventricular artery



Abbreviations used: RCA-Right coronary artery, CA-Conus artery, PIVA –Posterior interventricular artery

Figure 2: Dominant Circulation



LCA.

From the total 25 specimen in 21 cases (84%) the posterior interventricular artery was a continuation of right coronary artery and in 4 specimens (16%) it is a branch of left coronary artery (Figure 2). In 4 cases the RCA did not terminate as PIV artery. Out of these cases in one case the artery was seen running in posterior sulcus but finished before the crux branches to whole of the sternocoastal surface. In 21 cases right dominance was present (Figure 1).

Mean diameter (Mean ±SD) (in mm) of right coronary artery at origin is 4.49+0.94, just before origin of right marginal artery is 4.11+0.93, just after giving right marginal artery is 3.55+1.06 and right marginal is 2.87+0.53.

Conus Artery

In 21 specimens single conus artery was found out of which in 15 specimen conus artery was seen arising from RCA and in 6 specimen conus artery was seen arising from anterior aortic sinus (referred as third coronary artery). Conus branches varied from 1-3 in numbers (Figure 1 and 3).

In 3 specimens, 2 conus arteries were seen and out of these one specimen two conus arteries were seen arising directly from anterior aortic sinus. In the other two specimen's one conus branch was seen arising from anterior aortic sinus and second conus branch was seen arising from RCA (Figure 1).

In 1 specimen there were 3 conus arteries. One conus artery was seen arising from anterior aortic sinus (referred as third coronary artery) and 2 more conus arteries were seen arising from RCA.

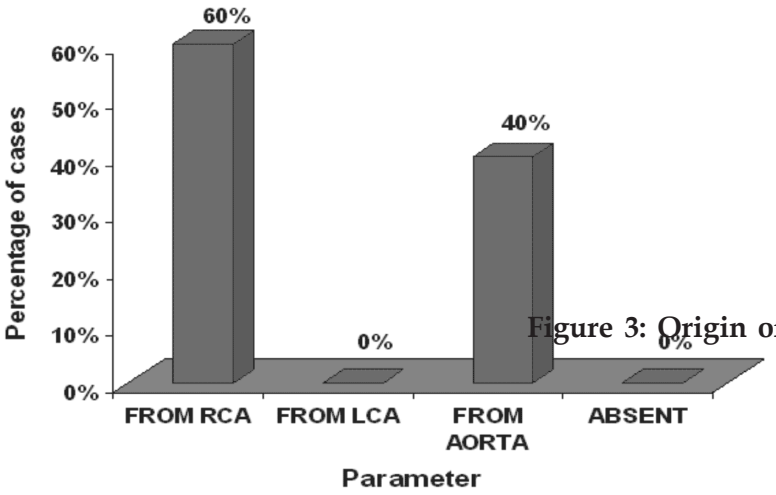


Figure 3: Origin of Conus Arteries

Right Marginal Artery

Right marginal artery was present in all the specimens arising from the right coronary artery and the number varied from 1-3. In 18 specimens single marginal artery was found. Morphologically in one specimen marginal artery did not reached the proper right margin. In 6 specimens 2 marginal arteries were found. In 1 specimen 3 marginal arteries were present

Discussion

Knowledge of the normal and variant anatomy and anomalies of coronary circulation is an increasingly vital component in management of congenital and acquired heart disease. Several studies have been conducted by various authors on origin of coronary artery and found many variations.

In the present study the right coronary ostium was present in all the specimens in the right anterior aortic sinus in other study by Vlodaver *et al* (1972) the author observed that in most of cases (56%) the orifice of coronary arteries were situated in aortic sinus below supravalvular ridge and in 8% of cases the origin of right coronary artery occurred above supravalular ridge.[19]

In the present study, third coronary artery was present in 10 cases (40%) of the specimens studied where as in rest of cases conus artery was almost first branch. The results are quite similar to a study were the first and highest branch of the proximal segment of right coronary artery, the conus artery arose in 36% of the cases from a separate ostium (third coronary artery), in right aortic sinus of valsalva.[20] In another study by Kalpana R. the author dissected 100 hearts and observed the third coronary artery presents in 24% of the specimens.[21]

In the present study, 96% of specimens the sinuatrial node artery is a branch of right coronary artery is in contrast to a study were second branch of first segment of right coronary artery was sinuatrial node artery. The sinuatrial node artery arose from right coronary artery in more than 60% and from left coronary artery in less than 44% of the specimens.[22]

In other study the author observed in 51% of the specimen sinuatrial node artery arose from right coronary artery and 41% from left coronary artery. In 8% of the specimens the vessel arose from both right and left coronary artery.[23] Similarly, another study observed that in 54% of the cases the sinuatrial artery was a branch of right coronary artery and in 42% of the specimens the artery arose from left coronary artery and in 4% of the cases the sinuatrial node artery was seen arousing directly from aorta.[24]

The dominance of artery is determined by the posterior interventricular artery. It is termed right dominance if the posterior interventricular artery is a branch of right coronary artery and if the posterior interventricular artery is a branch of left coronary artery it is termed left dominance. In present study in 21 cases (84%) the posterior interventricular artery is a branch of right coronary artery hence it was right dominance. The results are similar to a study were the author observed posterior interventricular artery as a terminal branch of right coronary artery in 90% of the cases.[24] Similarly another study observed that 80% of the specimens showed right dominance and 11% of the cases showed left dominance.[25]

In the present study in 6 cases posterior descending artery was found to arise before the crux and contributed to the supply of left ventricle. Similar results have been found by James and he observed a vessel arising before the crux contributed to the supply of the left ventricle in 7 cases.[26]

It is concluded with the remark that from the number of variations seen in branching pattern of RCA it becomes very difficult to assign the normal pattern. The variations are very important for cardiologists and radiologists.

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