

ANATOMICAL STUDY OF VARIATIONS IN THE ORIGIN, COURSE AND TERMINATION OF RIGHT CORONARY ARTERY IN HUMAN ADULT HEART SPECIMENS

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ABSTRACT

Background: Coronary artery disease showed an alarming increase in incidence in the last few decades. Congenital coronary artery anomalies are a special entity that seem to play a role in acute coronary syndromes and sudden cardiac deaths. The increasing use of diagnostic and therapeutic interventional procedures demands a sound knowledge of normal and variant coronary artery anatomy. With this aim, anatomical variations in the origin, course and level of termination of the right coronary artery was studied. **Materials and Methods:** 50 formalin fixed heart specimens obtained from human adult cadavers at the Institute of Anatomy, Madras Medical College, Chennai were used for the study. Anatomy of Right Coronary Artery was studied using conventional dissection method. **Result:** Right Coronary artery ostium was located below the sinotubular junction in 88% of specimens, at the level of sinotubular junction in 8% of the specimens and above the level of sinotubular junction in 4% of the specimens. The course of the Right Coronary Artery was normal in all adult heart specimens except one (2%), in which it slightly deviated from its usual course from the right atrioventricular groove, lying over the anterior aspect of the right ventricle, splitting into two divisions. Among the 50 adult heart specimens, the Right Coronary Artery terminated at the level of inferior border in 14%, between the inferior border and crux in 10%, at the level of crux in 24%, between crux and left border in 44%, at the left border in 8%. **Conclusion:** The present study would be of great use to Radiologists, Cardiologists and Cardiothoracic Surgeons. Prior knowledge about the normal and variant anatomy helps to tackle the technical difficulties encountered during any interventional procedure and avoids inadvertent complications during cardiac surgeries. It also aids in better interpretation of angiographic images.

INTRODUCTION

The normal functioning capacity of the heart chiefly depends on the adequate blood flow through the coronary arteries. Cardio vascular disease is the most common cause of death worldwide. There is an alarming increase in heart diseases in south Asia in the last few decades. Acquired cardiovascular pathologies are more common than congenital, among which coronary artery disease gains utmost importance.

Early diagnosis of the disease and timely intervention within the golden period saves life and increases life expectancy. Recent advancement in the radiological diagnostic procedures, interventional procedures and upgraded surgical methods like myocardial revascularization are associated with excellent outcome. These demand a sound knowledge of both

the normal and variant anatomy of the coronary arteries.

Variations of coronary arteries are clinically significant, especially those involving the origin and proximal course like abnormal location of coronary ostium with retro aortic course, pre-pulmonary course, transeptal course, etc. When unnoticed it leads to intraoperative complications like compression by prosthetic valve ring during valve replacement, inadvertent hemorrhage or accidental ligation during corrective cardiac surgeries and coronary artery bypass grafting. When left undetected, it may lead to technical difficulties, prolongation of the procedures, errors in the interpretation of angiograms and unexpected complications during cardiac surgeries. Therefore, a sound knowledge of both normal and variant anatomy of coronary arteries becomes essential for successful outcome of any cardiovascular procedure.

The right coronary artery arises from the anterior aortic sinus (right coronary sinus), usually single. After its origin, it passes anteriorly and slightly to the right, traversing the groove between pulmonary trunk and right auricle. It reaches the atrioventricular groove, between right atrium and right ventricle, and traverses this groove towards the acute margin of the heart. It curves around the inferior border to reach the posterior part of the atrioventricular groove and traverses the groove for a variable extent. The artery usually terminates at the crux of heart or little left of it. It often terminates by anastomosing with the circumflex branch of the left coronary artery.^[1] The present study aims at studying the right coronary artery, with respect to the incidence of variations in its origin, course and level of termination.

MATERIALS AND METHODS

50 Human Adult heart specimens were obtained from the embalmed cadavers at the Institute of Anatomy, Madras Medical College, Chennai. Anatomy of the Right Coronary Artery was studied by Conventional Dissection Method as per the Cunningham's Practical Manual for Dissection.

After procuring the heart specimen from the cadaver, the visceral pericardium was stripped off and the right coronary artery was traced from its origin from the ascending aorta. The main trunk of the right coronary artery, hidden within the atrioventricular groove was carefully dissected. The subepicardial fat surrounding the vessel was removed for better visualization. The aortic root was opened and the ostium of right coronary artery is visualised. Its location in relation to the sinotubular junction was noted. The course of the main trunk and level of termination of the artery were noted. The parameters studied were origin of Right Coronary artery, location of its ostium in relation to sinotubular junction, course whether normal or abnormal and level of its termination.

RESULTS

Origin of the Right Coronary Artery:

A. Location of Right Coronary Artery Ostium:

In all the 50 adult heart specimens, the Right Coronary Artery arose from the anterior aortic sinus.

B. Level of Right Coronary Artery Ostium in relation to Sinotubular Junction:

Among the 50 specimens, the ostium of Right Coronary Artery was located above the level of sinotubular junction [Figure 1] in 2 specimens (4%), at the level of sino tubular junction [Figure 2] in 4 specimens (8%) and below the level of sinotubular junction [Figure 3] in 44 specimens (88%).

Course of the Right Coronary Artery:

The course of the Right Coronary Artery was normal in all adult heart specimens except in one specimen, in which the Right Coronary Artery slightly deviated from its usual course. After its origin, it passed between right auricle and pulmonary trunk and

deviated towards left and descended over the anterior aspect of the right ventricle splitting into two divisions [Figure 4]. The first division closer to the atrio ventricular groove terminated at the inferior border. The second division had a much oblique, lengthier course over the right ventricle and terminated closer to the apex.



Figure 1: Level of Right Coronary Artery ostium above the sinotubular junction



Figure 2: Level of Right Coronary Artery ostium at the level of sinotubular junction



Figure 3: Level of Right Coronary Artery ostium below the level of sinotubular junction.



Figure 4: Abnormal course of Right Coronary Artery

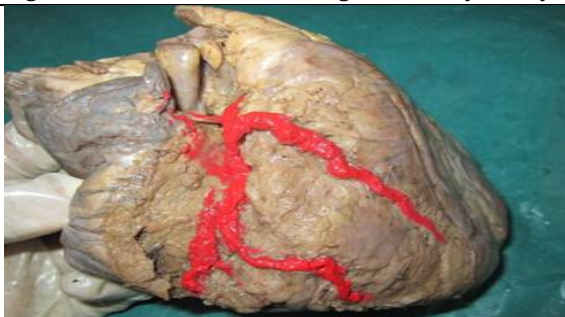


Figure 5: Level of Termination of Right Coronary Artery at the level of Inferior Border



Figure 6: Level of Termination of Right Coronary Artery between the crux and inferior border.

Level of Termination of the Right Coronary Artery: Among the 50 adult heart specimens, the Right Coronary Artery terminated at the level of

inferior border [Figure 5] in 7 specimens (14%), between the inferior border and crux [Figure 6] in 5 specimens (10%), at the level of crux [Figure 7] in 12 specimens (24%), between crux and left border [Figure 8] in 22 specimens (44%), at the left border [Figure 9] in 4 specimens (8%).

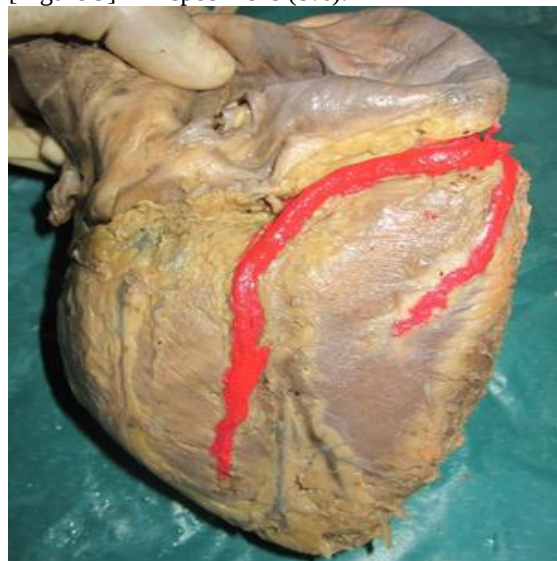


Figure 7: Level of Termination of Right Coronary Artery at crux



Figure 8: Level of Termination of Right Coronary Artery between the crux and left border

Table 1: Level of Ostium of Right Coronary artery in relation to sinotubular junction

Location of Ostium of Right Coronary artery in relation to STJ	Frequency	Percentage
Above the level of STJ	2	4%
At the level of STJ	4	8%
Below the level of STJ	44	88%

Table 2: Course of the Right Coronary Artery

Course of RCA	Frequency	Percentage
Normal	49	98%
Abnormal	1	2%

Table 3: Level of Termination of the Right Coronary Artery

Level of termination of RCA	Frequency	Percentage
Inferior border of heart	7	14%
Between Inferior border and crux	5	10%
Crux	12	24%
Between crux and left border	22	44%
Left border	4	8%

Table 4: Comparison of the Level of Right Coronary Artery ostium in relation to Sinotubular Junction with other studies

Level of ostium	Kalpana	Pejkovic et al	Udhaya sankari et al	Prajapati et al	Manisha et al	Shamima et al	Present study
Below	90%	10%	73.3%	91%	10%	76.7%	88%
At	9%	71%	23.3%	-	67.33%	23.3%	8%
Above	1%	19%	3.3%	9%	22.67%	-	4%

Table 5: Comparison of the Level of Termination of Right Coronary Artery with other studies

Level of termination	Madiha Awad El Sayed et al	Luis Ernesto et al	Ashwini et al	Manisha et al	Shamima et al	Present study
Before inferior border	-	-	-	-	1.7%	-
At Inferior border	30%	-	-	8%	3.3%	14%
Between Inferior border and crux	-	8.6%	20%	8.67%	5%	10%
At crux	10%	13.6%	16%	10%	10%	24%
Between Crux and left border	60%	75.6%	60%	67.33%	76.7%	44%
At left border	-	2.2%	4%	6%	3.3%	8%

**Figure 9: Level of Termination of Right Coronary Artery at left border.**

DISCUSSION

Origin Of the Right Coronary Artery:

A. Location Of Right Coronary Artery Ostium:

Susan Standring,^[1] stated that the Right Coronary Artery arises from the Right Coronary aortic sinus. Shamima Islam et al,^[2] reported that the Right coronary artery originated from the anterior aortic sinus in 98.3% of cases, with one variant arising from the left posterior sinus in 1.7% of cases.

Isha Srivastava et al,^[3] reported anomalous origin of Right Coronary Artery from left coronary sinus in 0.8% and from pulmonary artery in 0.8%.

In the present study, in all the specimens, Right Coronary Artery had its ostium in the anterior aortic sinus.

B. Level of Ostium in relation to Sinotubular Junction:

Susan Standring,^[1] stated that the ostium of Right coronary artery is usually below the sinotubular junction.

Kalpana,^[4] reported that in 90% of the hearts, ostia of Right coronary artery were below the sinotubular junction, at the sinotubular junction in 9% of the hearts and above the level of sino tubular junction in 1%.

Pejkovic,^[5] reported that the ostia were at the level of sinotubular junction in 71%, below the sinotubular junction in 10%, above the level of sinotubular junction in 19%.

Udhaya sankari et al,^[6] reported that in 73.3% of the hearts, the ostia of Right Coronary Artery were below the sinotubular junction. In 23.3% of the hearts, ostia were at the level of sinotubular junction and in 3.3%, above the level of sinotubular junction.

Prajapati et al,^[7] reported that in 91% of the hearts, Right Coronary Artery ostia were below the sino tubular junction and in 9% of the hearts, above the sino tubular junction.

Shamima Islam et al,^[2] reported the level of ostia of Right coronary artery below Sinotubular Junction in 76.7% and at the level of Sinotubular junction in 23.3%.

Manisha et al,^[8] reported the level of ostia of Right coronary artery below the sinotubular junction in 10%, at sinotubular junction in 67.33%, above Sinotubular junction at 22.67%.

In the Present study, the Right Coronary Artery ostium was below the sinotubular junction in 88%, at the level of sinotubular junction in 8% and above the level in 4% of the hearts.

The location of the coronary ostium and its level in relation to sinotubular junction is very important for

performing any diagnostic and interventional procedure. Higher origin can lead to technical difficulties during catheterization. Coronary CT angiography is recommended in case of difficult coronary catheterization.

High take off of Right Coronary Artery, though benign clinically, becomes significant when associated with coronary occlusion and planned for any diagnostic and interventional procedure. Bypass grafting is the choice of revascularization in such cases.^[9]

Course Of Right Coronary Artery:

Kalpana,^[4] and Luis Ernesto et al,^[10] reported normal course in all the RCAs.

Manisha et al,^[8] reported in 1.33%, the aberrant origin of right coronary artery from the left posterior aortic sinus which followed the inter-arterial course between pulmonary trunk and ascending aorta before reaching the Atrioventricular groove.

Bulent Eren et al,^[11] reported a case in which Right Coronary Artery had high origin and abnormal proximal course between aorta and pulmonary trunk with an acute oblique downward angulation.

Cengiz Erol et al,^[12] described split Right Coronary Artery with two divisions, which is an extremely rare benign variant.

Isha Srivastava et al,^[3] described duplication of Right coronary artery in 2.4%.

Karaosmanoglu et al,^[13] reported a patient with duplicated right coronary artery as a CT angiographic finding in their case report

In the present study, course was normal in 49 specimens (98%) but in one specimen, the Right Coronary Artery after its origin from anterior aortic sinus, continued as a small trunk and split into two divisions. This specimen showed abnormal course where the Right Coronary Artery deviated to the left away from the atrioventricular groove, dividing into two major vessels running over the anterior aspect of the right ventricle.

This variant course could be hemodynamically stable but during cardiac surgeries utmost care is needed to prevent accidental injury to these vessels.

Level of Termination of the Right Coronary Artery: Susan Standring,^[1] stated that the artery ends a little to the left of the crux, often by anastomosing with the circumflex artery of the heart. The Right Coronary artery may end near the right cardiac border, between this and the crux, or more often it reaches the left border, replacing the more distal part of the circumflex artery.

Madiha Awad El Sayed,^[14] reported the level of termination at inferior border in 30%, at the level of crux in 10% and between crux and left margin in 60%.

Luis Ernesto et al,^[10] reported the level of termination between inferior border and crux in 8.6%, at crux in 13.6%, between crux and left margin in 75.6% and till left margin in 2.2%.

Ashwini Vijay et al,^[15] reported the level of termination between inferior border and crux in 20%,

at crux in 16%, between crux and left border in 60%, till left border in 4%.

Manisha et al,^[8] reported the level of termination at inferior border in 8%, between inferior border and crux in 8.67%, crux in 10%, between crux and left border in 67.33%, till left border in 6%.

Shamima et al,^[2] reported the level of termination before acute margin in 1.7%, at acute margin in 3.3%, between acute margin and crux in 5 %, at crux in 10%, between the crux & obtuse margin in 76.7%, at obtuse margin in 3.3%.

Majid et al,^[16] reported Right Coronary Artery which terminated at the left border as Superdominant Right Coronary artery which was associated with absent left circumflex artery in their case report.

In the Present study, the level of termination of Right Coronary Artery was at inferior border in 14%, between inferior border and crux in 10%, at crux in 24%, between crux and left border in 44% and till left margin in 8%.

The level of termination depends on the dominance of the coronary system. In case of left coronary dominance, the Right Coronary Artery mostly terminates at the level of inferior border and less frequently between inferior border and crux. Other levels of termination are mostly associated with right dominance.

Hypoplastic Right Coronary Artery are non dominant arteries that are of shorter length with decreased calibre, terminating earlier. It is associated with greater incidence of coronary artery anomalies than normal. Absent left main trunk of Left Coronary Artery is the most common anomaly associated with it. Hypoplastic Right Coronary Artery was first described by Whiting in 1937. This variant can lead to technical difficulty during catheterisation due to decreased size of the ostium. Usage of a thinner catheter and taking a non- selective film initially leads to a successful procedure in such cases.^[17]

CONCLUSION

Right coronary artery arose from the anterior aortic sinus in 100% of the hearts. Its ostium was located below the level of sinotubular junction in majority of the specimens (88%). The Right Coronary Artery had a normal course in all the hearts except in one specimen where the artery deviated from its usual course and split into two divisions over the right ventricle. The most common level of termination was found to be between crux and left border of heart, in about 44% of specimens.

These findings will be highly useful for cardiologists, radiologists and cardiothoracic surgeons for better outcome of their procedures. Prior knowledge about these variations helps to tackle the technical difficulties during any interventional procedure and to avoid inadvertent complications during cardiac surgeries. It also aids in better interpretation of angiographic images.

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