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Anatomical study of the branching pattern of the right coronary artery

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ABSTRACT

Background: The frequency of coronary artery disease is increasing nowadays. A detailed idea about the normal and variant anatomy of coronary arteries is essential in the management of various heart diseases, especially coronary bypass surgeries. **Aims and Objectives:** The aims and objectives of the study are to study the branching pattern of the right coronary artery (RCA). **Materials and Methods:** One hundred adult heart specimens were collected from the Department of Anatomy, Government Medical College, Kottayam. The specimens were fixed in formalin and the RCA was traced from origin to termination. Emphasis was given to the variations in branching patterns. **Results:** The incidence of a third coronary artery was 20%. The origin of the sinoatrial (SA) nodal artery from both the RCA and the left circumflex artery was 7%. The incidence of the double posterior descending artery was 9%. Short RCA terminating near the right margin was 4%. Long RCA reaching up to left margin was 4%. **Conclusion:** The SA nodal artery arose from RCA in the majority of cases. The posterior descending artery was single in most of the cases and its most common site of termination was up to three-quarters of the way down the posterior interventricular sulcus. In about half of the cases, the Atrioventricular nodal artery took origin from RCA. There was no statistically significant association between origin of the conus artery and gender. A statistically significant association was not observed between the origin of SA Nodal artery and gender.

Key words: Right coronary artery; Sinoatrial nodal artery; Atrioventricular nodal artery

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INTRODUCTION

The increasing frequency of coronary artery disease (CAD) forces us to pay more attention to the detailed study of coronary vasculature nowadays. Such knowledge is highly beneficial for the interventional cardiologist who does coronary arteriography and for the cardiac surgeon who does the bypass procedure. The advent of angiography followed by cardiac surgery was a major impetus for promoting the study of coronary arteries. With the introduction of non-invasive imaging techniques, the perception of cardiac anatomy and pathophysiology changed radically.[1]

Worldwide, epidemiological studies have shown that the frequency of deaths from CAD is increasing with each decade of life. Today with the widespread use of diagnostic imaging techniques it becomes easy to study the normal coronary anatomy and its variations. What was not possible 20 years back is now readily available at the common man's doorstep. The enormous number of interventional coronary care units in different parts of our country is a pointer to the fact that more and more people are suffering from CAD. Accurate angiographic diagnosis is vital before cardiac surgery.[1]

Aims and objectives

This study is an attempt to understand the normal branching pattern of the right coronary artery (RCA) and its variations.

MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Government Medical College, Kottayam. Approval was

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obtained from the Institutional Ethics Committee (IEC no: 08/2012). One hundred adult heart specimens were collected from the Department of Anatomy, Medical College Kottayam. The duration of the study was 4 years (August 2012–August 2016).

Specimens were fixed in 10% formalin for 3 days. After removing the epicardium and sub-epicardial fat, each coronary artery was traced from its origin from the corresponding coronary sinus to the point of termination. The origin, course, and termination of the main branches were studied. Emphasis was given to principal branches their termination and coronary artery dominance. Variations in branching patterns and anomalies, the difference in the origins of the conus artery, sinoatrial (SA) nodal artery, and dominance of RCA according to gender were also recorded. After dissecting the arteries acrylic paint was used for painting them for better visualization.

RCA was traced from its origin from the anterior aortic sinus to the point of termination. The Conus artery was seen as the first branch arising from RCA. Its origin from the anterior aortic sinus was recorded as the third coronary artery.

Acute marginal artery/right marginal artery

The right marginal artery was traced from its origin from the middle or distal portion of the first segment of RCA and ran downward and to the left toward the cardiac apex.

Posterior descending artery

The posterior descending artery was traced from its origin which is the right coronary (or from the left circumflex artery in left dominance) up to its termination, its level of termination whether up to 1/4th, 1/2, or 3/4th of the posterior interventricular groove or terminating at the apex was recorded. Variations such as a double posterior descending artery were noted as the level at which it supplied the posterior part of the interventricular septum.

Atrioventricular (AV) nodal artery

It was traced from its origin where it formed the inverted loop which characterized the RCA at the crux. Variations in the origin whether from RCA/left coronary artery (LCA) or both were noted.

Termination of RCA

The termination of RCA was noted and it varied from the acute margin to the obtuse margin.

Inclusion criteria

The adult heart without congenital anomalies affects the morphology of the heart.

Exclusion criteria

Children below 18 years were excluded from the study. Specimens with distorted gross appearance were excluded.

RESULTS

The study was conducted on 100 adult specimens of which 53 were from males and 47 from females. Sixty-two percent of hearts were from individuals between 30 and 60 years. 17% belonged to the age group of more than 60 years.

The conus artery originated from RCA in 80% and from 20% from the anterior aortic sinus as the third coronary artery (Table 1).

Conus artery arose from the right coronary in 81.1% of males and 78.7% of females. On statistical analysis, the P-value was found to be 0.764. Hence there was no statistically significant association between the origin of conus artery and gender (Table 2).

Sinu-atrial nodal artery originated from RCA in 63% and from the left circumflex artery in 30%. The rest 7% showed dual origin from right coronary and circumflex arteries (Table 3).

In the majority of cases, the SA nodal artery was arising from RCA in both males and females. In 24.5% of males and 36.2% of females, it originated from the circumflex artery. Hence, a statistically significant association was not observed between the origin of SA nodal artery and gender (P=0.325) (Table 4).

Single posterior descending artery was seen in 91% of specimens. nine percent had a double posterior descending artery (Table 5).

Table 1: Origin of conus artery

Origin of conus artery	Frequency (%)
Right coronary artery	80
Anterior aortic sinus	20

Table 2: Relation between the origin of conus artery and gender

Sex	Origin of conus artery (%)	
	Right coronary artery	Anterior aortic sinus
Males	81.1	18.9
Females	78.7	21.3

Table 3: Origin of sinu atrial nodal artery

Origin of sinu atrial nodal artery	Frequency (%)
RCA first segment	63
Left circumflex proximal segment	30
Both RCA and left circumflex	7

RCA: Right coronary artery

Table 4: Relation between origin of sinoatrial nodal artery and gender

Gender	Right coronary (%)	Left circumflex (%)	Both (%)
Males	37 (69.8)	13 (24.5)	3 (5.7)
Females	26 (55.3)	17 (36.2)	4 (8.5)

Table 5: No. of posterior descending artery

Number of posterior descending artery	Frequency (%)
Single	91
Double	9

In the majority of cases (46%) posterior descending artery terminated ¾ way down the septum. In 32% the vessel reached ½ way down the septum. In 20% it reached up to the apex (Table 6).

AV nodal artery was observed to be arising from RCA in 88% of cases. In the rest 12%, it originated from the left circumflex artery (Table 7).

RCA terminated between the crux and left margin in 60% of cases. In 24% of specimens, it reached up to the crux. In eight percent, it terminated at the right or left margin. The remaining six percent terminated between the right margin and crux (Table 8).

Table 6: Level of termination of posterior descending artery

Termination of posterior descending artery	Frequency (%)
¼ way down the posterior interventricular septum	2
½ way down the posterior interventricular septum	32
¾ way down the posterior interventricular septum	46
Apex	20

Table 7: Origin of AV nodal artery

AV nodal artery origin	Frequency (%)
Right coronary artery	88
Left Circumflex Artery	12

AV: Atrioventricular

Table 8: Level of termination of right coronary artery

Termination of right coronary artery	Frequency (%)
Right margin	4 (4)
Between the right margin and crus	6 (6)
Crux	26 (26)
Between and left margin	60 (50)
Left margin	4 (4)

DISCUSSION

Conus branch/third coronary artery

The conus branch was seen arising from RCA in 80% of cases (Figure 1). In 20% of cases, the conus artery arose directly from the right coronary sinus. It was recorded as the third coronary artery (Figure 2). Third coronary artery was present in 18.9% of males and 21.3% of females. Dhobale et al.,[2] reported the incidence of the third coronary artery as 32%. Kalpana[3] reported the incidence of the third coronary artery as 24%. In the present study, the incidence of the third coronary artery was found to be 20%.

Wherever it originated from the conus branch had a relatively constant distribution. The conus artery passed between the branches of the left anterior descending artery and RCA and was a potential path of the anastomosis with either of these vessels.

The relation between the origin of the conus artery and gender was noted. Conus artery arising from the RCA as its first branch was observed in 81% of males and 78.7% of females. The third coronary artery arising directly from the anterior aortic sinus was seen in 21.3% of females and 18.96 of males. Miyazaki and Kota reported that there is no clear difference in the sex in the incidence of the third coronary artery.[4] The present study also did not show a statistically significant association between origin of conus artery and gender (P=0.764).

SA nodal artery

In the present study, the SA nodal artery originated from the first segment of RCA in 63% of hearts, from the proximal part of the left circumflex artery in 30% and dual origin from RCA and left circumflex in 7% (Figure 3). In most of the cases, SA nodal artery was arising from the first 1 or 2 cm of RCA, then passed between the right auricular appendage and the aorta and got terminated by encircling the base of the superior vena cava.

Sinha et al.,[5] reported the origin of the SA nodal artery from RCA in 78% and from RCA in 22%.

DiDio et al., 1995 reported the origin of SA nodal artery from RCA in 58% and from RCA in 42%.[6] Kalpana (2003) reported the origin of the SA nodal artery from the right coronary in 56% and from RCA in 35% of specimens. In the rest, 8% of SA nodal was from both RCA and LCA.[3]

The association between variation in the origin of the sinu-atrial nodal artery and sex was also analyzed. Sinu-atrial node was supplied by RCA in 69.8% of males and 55.3% of females. Sinu-atrial nodal artery took origin from left circumflex artery in 36.2% of females and 24.5% of males. In 8.5% of females and 5.7% of males, the sinu-artial nodal

Figure 1: Origin of conus artery from right coronary artery

Figure 2: Third coronary artery

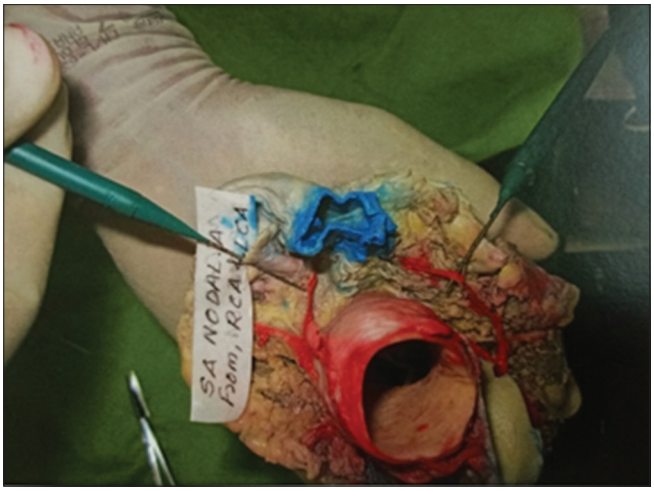

Figure 3: Sinoatrial nodal artery from right coronary and left circumflex arteries

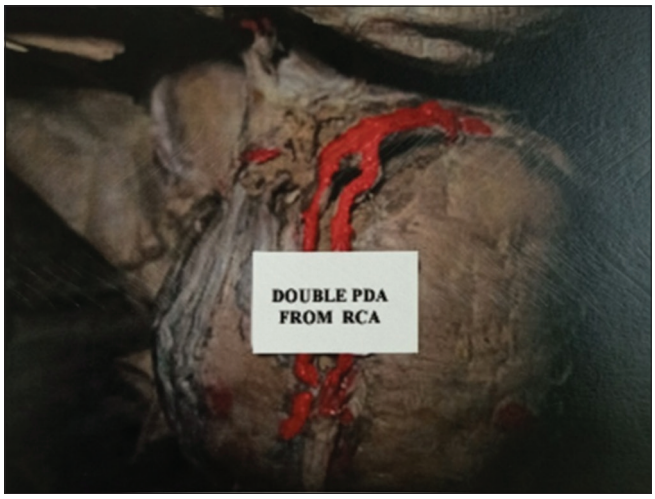

Figure 4: Double posterior descending artery from right coronary artery

Figure 5: Atrioventricular nodal artery from posterior descending artery (branch of right coronary artery)

Figure 6: Atrioventricular nodal artery from circumflex artery

artery had dual origin from both the right coronary and left circumflex artery. A statistically significant association between the variation in the origin of the sinu-atrial nodal artery and gender was not observed (P=0.325).[4]

Acute marginal artery

The acute marginal artery was present in all the cases. All were single and it passed downward and to the left toward the apex of the heart.

Figure 7: Right coronary artery supplying up to left margin

Posterior descending artery (PDA)

In the present study, the posterior descending artery was single in 91%. The double posterior descending artery was seen in 9% of hearts (Figure 4). Levin and Baltaxe reported the incidence of the double posterior descending artery in 6% of cases.[7]

In 46% of specimens, PDA supplied three-fourths of the way down the posterior part of the interventricular septum. The posterior interventricular artery supplied up to half of the posterior interventricular septum (PIVS) in 32% of cases. In 20% of cases, it reached up to the apex, and in 2% of cases it reached up to one-quarter way down PIVS.

The level of termination of the posterior descending artery in relation to the PIVS was previously studied by James (1961). In his study, the most frequent (46%) site of termination was three-quarters way down the posterior interventricular septum. According to Bhimalli et al., the level of termination PDA three-quarter way down PIVS was 50%, half-way down PIVS was 33.3%, at the apex 10%, and one-quarter way down PIVS at 6.6%.[8]

The posterior descending artery irrespective of its origin and number is the chief source of blood supply to the posterior part of the interventricular septum.

AV nodal artery

In the present study, the atrioventricular nodal artery originated from RCA in 88% of cases (Figure 5). In 12% of cases, it originated from the left circumflex artery (Figure 6). According to Reig and Petit[9] (1995), the atrioventricular nodal artery was from the RCA in 86%, from the circumflex artery in 12%, and from both in 2% of cases.[7] Kuniewicz et al., reported origin from RCA in 82% and from RCA alone in 16%.[10]

Termination of the RCA

The most frequent site of termination of the RCA in the present study was between the crux and the obtuse margin (60%). The second most frequent site was the crux (26%) followed by the region between the right margin and the crux (16%). In 4% of specimens, RCA terminated at the right margin, and in the remaining 4% it terminated at the left margin (Figure 7).

According to James most frequent site of termination of RCA was between the crux and the obtuse margin (64%).[11]

Barold and Scomazzoni also reported the termination of RCA between the crux and the obtuse margin in 64% of cases.[12]

CONCLUSION

The present study was a morphological study of the human coronary arteries with special emphasis on RCA and its branches. One hundred adult heart specimens were studied and the main parameters were the incidence of third coronary artery (20%) and its relation to gender, variation in the origin of SA nodal artery, the incidence of double PDA (9%), and its level of termination and variations in the level of termination of the RCA. SA nodal artery had a dual origin in 7% of specimens. In the majority of cases, the RCA terminated between the crux and left margin. The variations in the branching pattern obtained in this study were comparable with the available literature.

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Authors Contribution:
RA – content and design of study, literature survey, data collection, preparation of manuscript, submission of article, **DB –** manuscript editing, statistical analysis **NAG –** co ordination, manuscript revision.

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