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Anatomical Variation of Right Coronary Artery: A Retrospective Coronary Angiographic Study

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ABSTRACT

Background: The right coronary artery (RCA) plays a crucial role in cardiac perfusion, and its anatomical variations can have significant diagnostic and therapeutic implications, particularly in coronary interventions and cardiac surgeries. This study aimed to evaluate the prevalence and pattern of anatomical variations in the RCA based on coronary angiographic findings in a tertiary care center.

Material and Methods: A retrospective observational study was conducted over a 2-year period, involving 500 patients who underwent coronary angiography for various clinical indications. Demographic details, RCA origin, course, branching pattern, and dominance were recorded and analyzed using standard angiographic views. Data were expressed as frequencies and percentages.

Results: The majority of patients were male (65.6%), with most participants aged between 46 and 60 years (39.2%). A normal origin of the RCA from the right aortic sinus was observed in 93.6% of cases. Anatomical variations included high origin from the ascending aorta (2.8%), separate conus branch origin (2.0%), origin from the left coronary sinus (0.8%), and pulmonary artery origin (0.8%). Right coronary dominance was most common (82.4%), followed by left (10.4%) and co-dominance (7.2%). Normal RCA morphology was present in 87.6% of cases, with variations such as early branching (5.6%), duplication (2.4%), myocardial bridging (1.6%), and ectopic origin (2.8%) observed. The leading indications for angiography included chronic stable angina (39.6%), acute coronary syndrome (24.8%), ST-elevation myocardial infarction (21.2%), and preoperative evaluation (14.4%).

Conclusion: Anatomical variations of the RCA, though uncommon, are clinically relevant and must be recognized during diagnostic and interventional procedures. Awareness of these variations can aid in accurate diagnosis, procedural planning, and improved patient outcomes.

Keywords: *Right coronary artery, Coronary angiography, Anatomical variation, Coronary dominance, RCA morphology.*

1. INTRODUCTION

The right coronary artery (RCA) plays a fundamental role in myocardial perfusion, particularly supplying the right atrium, right ventricle, parts of the left ventricle, and the conduction system including the sinoatrial and atrioventricular nodes. A precise understanding of RCA anatomy is vital in the context of coronary artery disease, electrophysiological interventions, and cardiac surgeries. While the RCA typically arises from the right aortic sinus and follows a defined course, anatomical variations are not uncommon and may significantly influence both diagnostic and therapeutic strategies [1].

Coronary artery anomalies (CAAs) encompass a diverse range of deviations in origin, course, and distribution, with an estimated incidence of 0.3–1.3% in angiographic studies [2]. These variations can be benign or potentially life-threatening, depending on their anatomical course and relation to major vascular structures [3]. In particular, anomalies in the origin and course of the RCA may complicate coronary interventions, increase the risk of myocardial ischemia, or be associated with sudden cardiac death, especially when the anomalous vessel passes between the aorta and pulmonary artery [4].

Dominance patterns of coronary circulation—classified as right, left, or co-dominant—are determined by the artery supplying the posterior descending artery (PDA). Right dominance is the most prevalent pattern globally, observed in

approximately 80–85% of individuals [5]. Additionally, morphological variants such as myocardial bridging, duplication, and early branching are of clinical relevance in both diagnostic imaging and interventional cardiology [6].

Despite the importance of these variations, there remains a paucity of regional data from India, particularly from retrospective angiographic evaluations. This study was undertaken to assess the prevalence and patterns of anatomical variations of the RCA in patients undergoing coronary angiography at a tertiary care center.

2. MATERIAL AND METHODS

This retrospective observational study was conducted at a tertiary care teaching hospital. The study aimed to analyze the anatomical variations of the right coronary artery (RCA) using coronary angiographic data.

A total of 500 coronary angiograms performed during the study period were reviewed. Adult patients aged 18 years and above, who underwent diagnostic coronary angiography for suspected or known ischemic heart disease, were included. Patients with prior coronary artery bypass grafting (CABG), significant structural cardiac anomalies, or incomplete angiographic visualization of the RCA were excluded from the analysis.

All coronary angiograms were performed using standard Judkins technique [7] via femoral or radial access, following institutional protocol. The RCA anatomy was evaluated in multiple views (right anterior oblique, left anterior oblique, and cranial/caudal angulations) to ensure optimal visualization. Variations were documented based on origin, course, branching pattern, dominance, and termination. Coronary dominance was defined according to the vessel (RCA or left circumflex) that gives rise to the posterior descending artery.

The angiographic films were independently reviewed by two experienced interventional cardiologists to minimize observer bias. Discrepancies in interpretation were resolved by consensus. Data were recorded in a structured proforma and statistically analyzed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using mean and standard deviation. Chi-square test was applied for comparing proportions, and p-values less than 0.05 were considered statistically significant.

3. RESULTS

The study population comprised 500 patients who underwent coronary angiography over a 24-month period. As shown in Table 1, the majority of patients were males (65.6%) and belonged predominantly to the 46–60 years age group (39.2%), followed by those aged above 60 years (30.8%).

Analysis of the origin of the right coronary artery (RCA) revealed that in most cases, the RCA originated normally from the right aortic sinus (Table 2, Figure 1). However, anatomical variations were observed in a subset of cases, with 2.8% showing a high origin from the ascending aorta, and 2.0% having a separate origin of the conus branch. Anomalous origins from the left coronary sinus and pulmonary artery were each noted in 0.8% of cases.

With regard to coronary dominance patterns (Table 3), right dominance was the most frequently observed configuration, present in 82.4% of patients. Left dominance and co-dominance were identified in 10.4% and 7.2% of the angiograms, respectively.

Morphological assessment of the RCA course and branching patterns showed that a normal configuration was seen in 87.6% of patients (Table 4). Variations included early branching before the crux (5.6%), RCA duplication (2.4%), myocardial bridging (1.6%), and ectopic or aberrant courses (2.8%).

The most common clinical indication for coronary angiography was chronic stable angina, as detailed in Table 5, followed by acute coronary syndromes including non-ST elevation myocardial infarction and unstable angina (24.8%) and ST-elevation myocardial infarction (21.2%). Preoperative evaluation in patients undergoing non-cardiac surgery accounted for 14.4% of the angiographic referrals.

Table 1: Demographic Characteristics of Study Participants (N = 500)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
18–30	42	8.4%
31–45	108	21.6%
46–60	196	39.2%
>60	154	30.8%

Gender		
Male	328	65.6%
Female	172	34.4%

Table 2: Origin of Right Coronary Artery (RCA)

Origin Type	Frequency (n)	Percentage (%)
Normal origin from right aortic sinus	468	93.6%
High origin from ascending aorta	14	2.8%
Separate origin of conus branch	10	2.0%
Origin from left coronary sinus	4	0.8%
Anomalous origin from pulmonary artery	4	0.8%

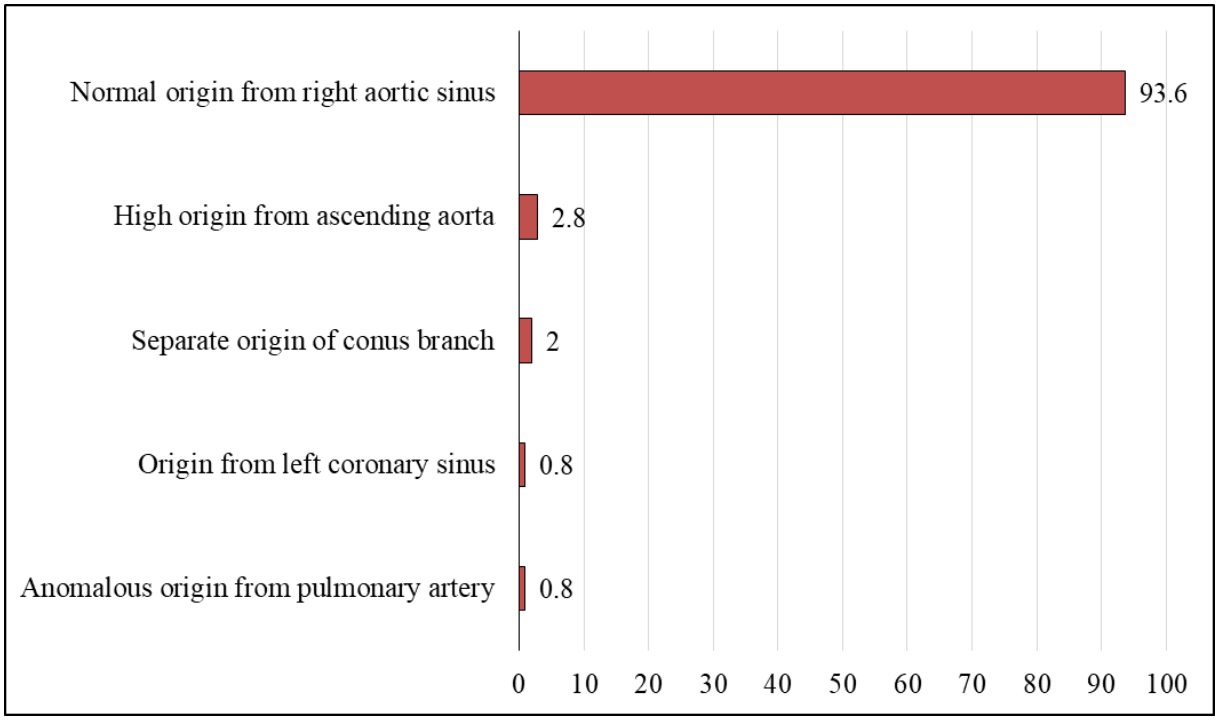

Figure 1: Origin of Right Coronary Artery (RCA) (%)

Table 3: RCA Dominance Pattern

Coronary Dominance	Frequency (n)	Percentage (%)
Right dominant	412	82.4%
Left dominant	52	10.4%
Co-dominant	36	7.2%

Table 4: Morphological Variations in RCA Course and Branching

Variation Type	Frequency (n)	Percentage (%)
Normal course and branching	438	87.6%
Early branching (before crux)	28	5.6%
Duplication of RCA	12	2.4%
Intramural course (myocardial bridging)	8	1.6%
Ectopic origin or aberrant course	14	2.8%

Table 5: Clinical Indications for Angiography

Indication	Frequency (n)	Percentage (%)
Chronic stable angina	198	39.6%
Acute coronary syndrome (NSTEMI/UA)	124	24.8%
ST-elevation myocardial infarction	106	21.2%
Preoperative cardiac evaluation	72	14.4%

4. DISCUSSION

This retrospective coronary angiographic study of 500 individuals confirms that right coronary artery (RCA) variations, while infrequent, are clinically significant and mirror findings from recent Indian cohorts. Kashyap et al. assessed 6,258 patients at a Northern India tertiary center and reported an overall congenital coronary anomaly prevalence of 2.06%, with anomalous RCA origin from the left sinus seen in approximately 0.22% of cases—closely aligning with our observed rates of RCA variation from the left sinus and pulmonary artery [8]. Another large South Indian CT-angiography study by Sirasapalli et al., covering over 8,000 patients, reported a higher overall anomaly rate (~10%), with myocardial bridging being the most common and anomalous RCA origin second-most frequent—consistent with our identification of myocardial bridging and aberrant courses [9].

The predominance of right dominance (82.4%) in our cohort is similar to earlier anatomical studies describing right-dominant circulation in the majority of individuals (~80%) [10-13]. Morphological anomalies such as early branching, duplication, and intramural (myocardial bridging) occurrence corroborate anatomical findings from a cadaveric series in Kerala, which noted unusual RCA branching variations in up to 20% of specimens [14].

These variations have important clinical and procedural implications. For instance, anomalous RCA origin may complicate catheter engagement during angiography or percutaneous interventions, while myocardial bridges can alter flow dynamics or serve as foci for ischemia in exertional settings. Awareness of such anatomical deviations is critical for risk stratification, personalized procedural planning, and prevention of potential complications.

Limitations of this study include its retrospective design and reliance on angiographic morphology without surgical or CT-correlative confirmation. Despite these constraints, the results emphasize that while normal RCA anatomy predominates, a noteworthy minority exhibits anatomical variants that demand recognition for safe and effective management.

5. CONCLUSION

This study highlights that while the majority of right coronary arteries originate normally and follow typical courses, a significant number exhibit anatomical variations. Right coronary dominance was the most prevalent pattern, with a smaller proportion showing left or co-dominance. Variations in origin and branching, though infrequent, can have important clinical and procedural implications during coronary angiography and interventions. Accurate recognition of these anomalies is essential for optimal management and avoiding potential complications. Incorporating knowledge of RCA variations into routine practice can enhance diagnostic precision and procedural safety.

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