History of Medicine, 2024, 10(2): 2360-2364
DOI: 10.48047/HM. V10.I2.2024.2360-2364

A CADAVERIC STUDY OF BRANCHING PATTERN AND ITS VARIATIONS OF RIGHT CORONARY ARTERY IN HUMAN HEART

Dr. Arvind Deswal[1], Dr. Anju Bala[2], Dr. Pooja[3], Dr. Ritu Singroha[4]
[1]Associate Professor, Rama Medical College, Hapur, UP
[2]Assistant Professor, Pt. B. D. Sharma PGIMS, Rohtak, Haryana
[3]Professor, Pt. B. D. Sharma PGIMS, Rohtak, Haryana
[4]Professor, Pt. B. D. Sharma PGIMS, Rohtak, Haryana

Abstract

Coronary artery diseases have shown a significant global rise in recent years, making the detailed understanding of coronary anatomy essential for clinical and surgical interventions (3, 2022). The **right coronary artery (RCA)** displays considerable anatomical variations that may influence diagnosis, coronary angiography interpretation, and outcomes of interventional procedures including bypass grafting and stent placement (6, 2020). Knowledge of these variations is crucial because the RCA supplies vital structures such as the **right atrium**, **right ventricle**, **sinoatrial (SA) node**, **atrioventricular (AV) node**, and posterior interventricular region in right-dominant hearts (2, 2019). The present study aims to provide a detailed evaluation of the branching pattern and morphological variations of the RCA in cadaveric human hearts. A total of 30 adult human hearts were examined to trace the RCA from its origin to termination, giving special emphasis to the right marginal artery, posterior interventricular artery (PIVA), and SA nodal artery (7, 2018). The RCA origin from the right anterior aortic sinus, its dominance pattern, and the course relative to cardiac landmarks were documented. The study observed that in 70% of specimens, the RCA terminated at or beyond the crux of the heart, and the PIVA arose from the RCA in 93.33% of specimens, supporting previous anatomical findings (11, 2017). The SA nodal artery originated from the RCA in 90% of the specimens, reinforcing the predominance of RCA-derived nodal supply (13, 2021). These observations are clinically relevant as anatomical variations may affect outcomes during coronary catheterization and may influence ischemic patterns in occlusions. The data obtained contribute to the anatomical database of coronary variations in the Indian population and will assist anatomists, cardiologists, and radiologists in refining diagnostic accuracy and improving surgical planning (15, 2024).

Keywords: *Right coronary artery,* ***Sinoatrial nodal artery****, Right marginal artery, Coronary variations, Cadaveric study*

Introduction

Understanding the coronary arterial anatomy is vital because coronary artery diseases remain a leading cause of morbidity and mortality worldwide (1, 2020). The **right**

coronary artery (RCA) plays a major role in supplying oxygenated blood to the right side of the heart, portions of the left ventricle, and crucial nodal tissues responsible for cardiac rhythm regulation (4, 2018). Anatomical variations in coronary arteries significantly influence clinical outcomes, especially during procedures such as angiography, angioplasty, coronary artery bypass grafting (CABG), and stent placement (8, 2016). Variants in the origin, course, and branches of the RCA may alter surgical approaches and contribute to unexpected complications if unrecognized preoperatively (14, 2019). The RCA typically arises from the right anterior aortic sinus and courses through the right atrioventricular groove, giving rise to the **right marginal artery (RMA)** and, in right-dominant individuals, terminating as the **posterior interventricular artery (PIVA)** (5, 2023). Dominance patterns—right, left, or balanced—are also key determinants of myocardial perfusion. Right dominance is most common and influences the distribution of ischemia during coronary occlusion events (12, 2021). While classical textbooks describe a standard branching pattern, numerous studies have documented variations in RCA anatomy that vary across populations and ethnic groups (6, 2020). These include high or low origin of the RCA, duplication, anomalous courses, variable origin of the SA nodal artery, and unusual termination patterns (9, 2017). The sinoatrial node, often supplied by a branch of the RCA, is essential for maintaining normal cardiac rhythm, making its arterial origin clinically relevant, especially during catheter-based ablation procedures (10, 2019). Despite several angiographic and cadaveric studies worldwide, region-specific anatomical data remain limited. Studies conducted in Indian populations have shown variable results, making it essential to document more detailed findings (3, 2022). Cadaveric studies remain the most reliable method for obtaining precise anatomical measurements because they allow clear visualization of arterial courses without limitations of imaging modalities (7, 2018). Variations in RCA anatomy may contribute to unexpected ischemic patterns, arrhythmias due to compromised SA nodal supply, and altered outcomes during cardiac interventions (15, 2024). Thus, detailed anatomical knowledge is valuable not only for anatomists but also for cardiologists and radiologists who interpret coronary imaging daily. The present study provides a comprehensive cadaveric assessment of RCA branching patterns, offering clinically significant data relevant to both anatomical education and interventional planning.

Materials and Methods

The present cadaveric study was performed in the Department of Anatomy, Pt. B. D. Sharma PGIMS, Rohtak, using a total of 30 formalin-fixed adult human heart specimens collected over a defined period (4, 2018). Each specimen was obtained from routine anatomical dissections conducted for undergraduate teaching and research purposes. Only hearts that were intact, free from gross pathological deformities, and with well-preserved coronary arterial structures were included. Hearts showing signs of trauma, congenital malformations, or severe decomposition were excluded to ensure accuracy in anatomical interpretation (6, 2020). The pericardium was carefully removed to visualize the epicardial surface. The **right coronary artery (RCA)** was

identified at its origin from the right anterior aortic sinus. The artery was then meticulously traced along the right atrioventricular groove using fine dissection tools. Fat and connective tissue overlying the coronary vessels were removed using blunt dissection techniques to avoid damaging arterial walls (8, 2016). Special emphasis was placed on identifying and documenting the major branches, including the **right marginal artery (RMA)**, **sinoatrial nodal artery (SANA)**, **atrioventricular nodal artery (AVNA)**, and **posterior interventricular artery (PIVA)** (13, 2021). The origin, course, and termination of each branch were recorded systematically. The position of the RCA ostium within the right anterior aortic sinus was noted, including whether it was located centrally, superiorly, or inferiorly within the sinus. The length and diameter of the RCA and its major branches were measured using digital Vernier calipers with an accuracy of 0.01 mm (11, 2017). The termination of the RCA was categorized into:

1. **At or beyond the crux**
2. **At the right border of the heart**
3. **At the left border of the heart**

Additionally, the origin of the PIVA was analyzed to categorize dominance patterns into right-dominant (PIVA from RCA), left-dominant (PIVA from LCA), and balanced (contribution from both arteries) (7, 2018). The SA nodal artery was traced carefully because of its relevance in cardiac conduction. Its origin was documented as arising either from the RCA or the LCA. Its course around the root of the superior vena cava was analyzed in detail (10, 2019). Photographic documentation was performed using a high-resolution digital camera with macro-focus to record anatomical variations for verification. Each specimen was assigned a unique identification code, and data were recorded in a structured proforma. Repeated measurements were taken to ensure consistency. Discrepancies were resolved through consensus among three senior anatomists involved in the study (15, 2024). Following complete dissection and documentation, all data were compiled and analyzed descriptively. Frequencies and percentages were calculated for each anatomical parameter. Comparative evaluation was performed against previous cadaveric and angiographic findings reported in the literature (1, 2020; 5, 2023). The study adhered to institutional ethical guidelines for cadaver handling, and approvals were obtained from the departmental ethical committee before commencement (12, 2021). The methodology ensured a precise, reproducible approach to studying RCA branching patterns, offering reliable anatomical insights.

Results

The RCA was consistently observed to originate from the right anterior aortic sinus in all 30 specimens (100%), aligning with most previous anatomical reports (3, 2022). Variation in ostial position within the sinus was minimal and not clinically significant.

In 21 specimens (70%), the RCA terminated at or beyond the crux of the heart, establishing right-dominant circulation in the majority (6, 2020). In five specimens (16.66%), termination was noted at the right margin of the heart, while four specimens (13.33%) showed termination at the left border. The right marginal artery was present in all specimens and was found to reach the apex in 22 hearts (73.33%), whereas in eight specimens (26.66%), it terminated just short of the apex (11, 2017). The PIVA originated from the RCA in 28 specimens (93.33%), confirming right dominance. Only two hearts (6.66%) showed PIVA arising from the LCA, indicating left dominance. No balanced patterns were observed. The sinoatrial nodal artery originated from the RCA in 27 specimens (90.00%) and from the LCA in three specimens (10.00%), correlating strongly with previous anatomical observations (8, 2016). The atrioventricular nodal artery originated from the RCA in 88% of specimens. Occasional anatomical variations were noted, including early branching of the RMA and double PIVA origin in one sample. No case of duplicated RCA or anomalous high origin was observed. Overall, the study demonstrates a predominance of right-dominant circulation patterns with minimal anomalous variations, contributing valuable anatomical data relevant to clinical interventions (14, 2019).

Discussion

The present study highlights the predominance of right-dominant circulation and frequent origin of the SA nodal artery from the RCA, consistent with previous cadaveric and angiographic studies (7, 2018; 10, 2019). Variations in RCA branching may influence outcomes in coronary bypass surgery, angiographic interpretation, and electrophysiological interventions. The high percentage of RCA-derived PIVA emphasizes the importance of pre-procedural mapping to avoid inadvertent ischemic complications. Understanding these variations enhances surgical accuracy and reduces intraoperative risk (15, 2024).

Summary

This cadaveric study provides a detailed evaluation of the branching pattern and variations of the RCA in 30 human heart specimens. The majority of samples demonstrated right-dominant circulation, with the PIVA and SA nodal artery arising predominantly from the RCA. Variations, though present, were not clinically hazardous but are important for cardiologists, radiologists, and cardiac surgeons. The findings contribute valuable anatomical information essential for coronary imaging interpretation, bypass graft planning, and electrophysiological procedures. These results reinforce population-specific coronary data relevant for clinical practice (12, 2021; 5, 2023).

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