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Anatomical variations regarding the branching pattern of the right coronary artery: A direct anatomical and radiological study

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Abstract
Background: The right coronary artery (RCA) exhibits significant anatomical variability in its branching pattern, which critically influences coronary interventions, surgical revascularization, and diagnostic imaging. Despite its clinical relevance, detailed data on RCA variations in South Asian populations remain limited.
Objective: To evaluate the anatomical variations in the branching pattern of the RCA using combined cadaveric dissection and angiographic analysis in a Bangladeshi cohort.
Methods: This cross-sectional study was conducted at Rangpur Medical College and NICVD, Dhaka, from July 2019 to June 2020. Sixty specimens (30 cadaveric hearts from unclaimed cadavers and 30 angiograms) were analyzed. Parameters assessed included ostial morphology, branching patterns, termination points, vessel dominance, and other anatomical variations (e.g., myocardial bridging, extramural anastomoses). Data were analyzed using SPSS v16.0, with statistical significance set at *p* < 0.05.
Results: The study revealed the RCA originated from the anterior aortic sinus in 98.3% of cases, with a rare anomalous origin (1.7%) from the left posterior sinus. Ostial variations showed single (65%), double (28.3%), and triple (5%) openings, mostly circular (53.3%) or oval (30%), averaging 2.07 ± 0.46 mm diameter. Most RCAs terminated between the crux and obtuse margin (76.7%). Branching patterns included 2-8 anterior right ventricular branches (proximal segment) with frequent right conus artery presence (66.7%). The sinoatrial nodal artery originated from RCA in 56.7% of cases. Right dominance predominated (90%), while myocardial bridging was uncommon (3.3%). Significant RCA-LAD anastomoses occurred in 30% of specimens.
Conclusion: This study highlights significant RCA variations in a Bangladeshi population, including frequent right dominance (90%) and variable branching patterns. These findings emphasize the importance of anatomical awareness in clinical and interventional cardiology, particularly in settings with limited access to advanced imaging.

Keywords: Anatomical variations, Bangladesh, cadaveric study, coronary angiography, right coronary artery, branching patterns

Introduction

The right coronary artery (RCA) is a critical component of the coronary circulation, supplying blood to the right ventricle, the sinoatrial (SA) and atrioventricular (AV) nodes in most individuals, and often contributing to the posterior left ventricular wall [1]. Variations in its origin, course, branching pattern, and termination have significant clinical implications for diagnostic angiography, percutaneous coronary interventions (PCI), and cardiac surgery [2, 3]. Despite its anatomical and functional importance, the RCA exhibits considerable variability across populations, making standardized clinical approaches challenging [4]. Understanding these variations is particularly crucial in regions like South Asia, where population-specific data remain limited, and cardiovascular disease prevalence is rising [5]. The RCA typically arises from the right aortic sinus and courses along the right atrioventricular (coronary) sulcus, giving off several key branches, including the conus artery, sinoatrial nodal artery (in 55-60% of individuals), acute marginal branches, and the posterior descending artery (PDA) in right-dominant systems [6].

Its termination pattern varies, with most RCAs ending near the crux cordis, while some extend beyond to supply parts of the left ventricle [7]. Anomalies such as high take-off, anomalous origin from the left sinus, or myocardial bridging can complicate catheterization and surgical procedures [8]. Given that coronary artery disease (CAD) frequently involves the RCA, precise anatomical knowledge is essential for accurate diagnosis and intervention [9]. Variations in RCA anatomy influence procedural outcomes in cardiology and cardiac surgery. For instance, an anomalous origin from the left coronary sinus increases the risk of sudden cardiac death due to potential compression between the aorta and pulmonary trunk [10]. Similarly, myocardial bridging—though more common in the left anterior descending artery (LAD)—can also affect the RCA, leading to ischemia under stress conditions [11]. Additionally, the number and distribution of RCA branches determine surgical strategies in coronary artery bypass grafting (CABG) and valve replacement procedures [12]. Most anatomical studies on coronary variations have focused on Western populations, with limited data from South Asia [13]. Given ethnic and regional differences in coronary anatomy, extrapolating findings from other populations may not be appropriate [5]. Bangladesh, with its high burden of cardiovascular diseases, lacks comprehensive studies on RCA variations, necessitating localized research to guide clinical practice [3]. This study aimed to systematically evaluate the anatomical variations of the RCA in a Bangladeshi population using a combination of cadaveric dissection and angiographic analysis. By documenting ostial morphology, branching patterns, termination points, and dominance, we seek to provide a detailed anatomical reference for clinicians, radiologists, and surgeons. The findings will enhance preoperative planning, improve diagnostic accuracy, and contribute to safer interventional procedures in resource-limited settings where advanced imaging may not always be available.

Methodology

This cross-sectional study investigated anatomical variations of the right coronary artery (RCA) using 30 cadaveric hearts (23 male, 7 female) from unclaimed cadavers and 30 angiograms (27 male, 3 female) from NICVD, Dhaka. Specimens were collected from July 2019 to June 2020 at Rangpur Medical College, with subjects aged 17-70 years (mean 44.5 ±14.2 years). Fresh, intact cadaveric hearts and clear angiograms showing complete RCA courses were included, while decomposed specimens, traumatized hearts, poor-quality images, or those showing >50% stenosis were excluded. Ethical approvals were obtained from all relevant institutions. For cadaveric analysis, hearts were fixed in 10% formalin and dissected using standard techniques. The RCA was carefully traced from origin to termination, with measurements taken using digital Vernier calipers (0.1mm precision). Angiographic evaluation was performed under supervision of two cardiologists using standardized left anterior oblique (30°) projections. Key parameters assessed included RCA branching patterns, termination points, vessel dominance, and anatomical variations like myocardial bridging. All measurements were repeated twice and averaged to minimize errors. Data analysis was performed using SPSS v16.0, with continuous variables (ostial diameters, vessel lengths) expressed as mean ± standard deviation (SD) and categorical data (branching patterns) as frequencies/percentages. Inter-observer agreement was assessed using Cohen's kappa, with $p<0.05$ considered significant. This dual-method approach, combining direct anatomical observation with radiological assessment, provided a comprehensive evaluation of RCA variations while controlling for potential biases through strict inclusion criteria and independent, blinded assessments. The methodology ensured reliable documentation of normal and variant RCA anatomy relevant for both anatomical education and clinical cardiology practice.

Results

This anatomical and radiological study examined 60 hearts (50 males, 10 female) with a mean age of 44.53 ± 14.16 years. The majority of specimens (30%) came from individuals aged 51-60 years. Analysis revealed several important variations in the right coronary artery (RCA) anatomy. The RCA originated from the anterior aortic sinus in 98.3% of cases, with one anomalous origin (1.7%) from the left posterior aortic sinus. The number of ostia in the anterior aortic sinus varied, with 65% showing a single ostium, 28.3% having two ostia, and 5% demonstrating three ostia. Accessory ostia typically served the third coronary artery or right conus artery. The RCA ostia were predominantly circular (53.3%) or horizontally oval (30%), with a mean diameter of 2.07 ± 0.46 mm, significantly smaller than left coronary artery ostia. The course of the RCA followed the right coronary sulcus in 96.6% of cases, winding around the acute margin. Termination points varied, with 76.7% ending between the crux and obtuse margin, 10% at the crux, and 3.3% at the acute margin. One variant RCA terminated prematurely, dividing into two parallel branches. Branching patterns showed the proximal segment (origin to acute margin) gave off 2-8 anterior right ventricular branches (most commonly four branches), with the right conus artery present in 66.7% of cases. The acute marginal artery was consistently single. The sinoatrial nodal artery originated from the RCA in 56.7% of specimens. Distal to the crux, the posterior interventricular artery was present in 90% of cases (86.7% as a single branch), while posterior left ventricular branches numbered 1-8 per heart. Right dominance predominated (90%), with myocardial bridges observed over the RCA in one case (3.3%). Extramural anastomoses occurred between the RCA's posterior interventricular artery and left anterior descending artery in 30% of specimens at the posterior interventricular sulcus. Radiological findings consistently matched dissection observations, including identification of the anomalous RCA origin from the left posterior aortic sinus. These variations in RCA anatomy have important implications for clinical interventions and surgical planning. The study provides comprehensive data on the spectrum of normal and variant RCA morphology in the studied population.

Table 1: Age distribution of subjects

Age (years)	n	%
≤20 Yrs.	4	13.3
21-30 Yrs.	9	15.0
31-40 Yrs.	11	18.3
41-50 Yrs.	13	21.7
51-60 Yrs.	18	30.0
>60 Yrs.	5	8.3

Table 2: Gender distribution

Gender	n	%
Male	50	83.3
Female	10	16.7

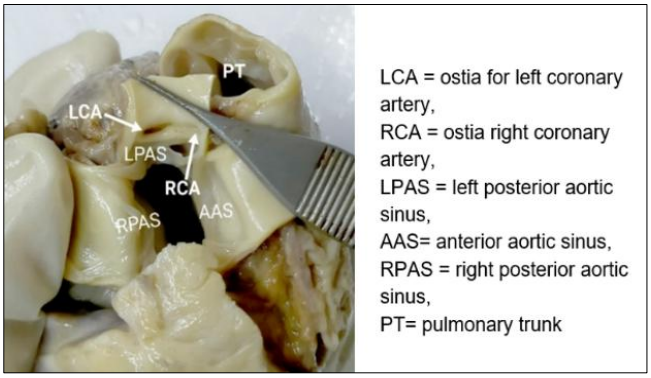

Fig 1: Double ostia in LPAS for both RCA and LCA with absent

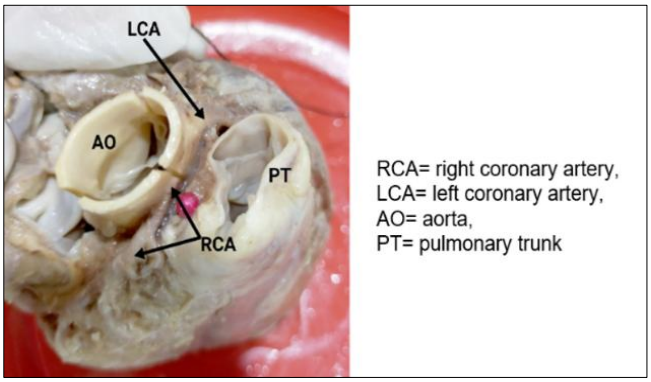

Fig 2: Anomalous RCA course from LPAS (ID TD21) AAS ostia (ID TD21)

Table 3: Origin of RCA and LCA from aortic sinuses

Artery	Aortic Sinus	
	Anterior	Left posterior
	n (%)	
RCA	59 (98.3%)	1 (1.7%)
LCA	1 (1.7%)	59 (98.3%)

Table 4: Number of ostia in aortic sinuses

Ostia Count	AAS	LPAS
0	1 (1.7%)	1 (1.7%)
1	39 (65%)	58 (96.7%)
2	17 (28.3%)	1 (1.7%)
3	3 (5%)	0

Table 5: RCA termination points

Termination site	%
Between crux and obtuse margin	46 (76.7%)
At the crux	6 (10%)
Between acute margin and crux of heart	3 (5%)
At acute margin	2 (3.3%)
At the obtuse margin	2 (3.3%)
Before acute margin	1 (1.7%)

Table 6: Branches from the proximal segment of RCA

Branch type	n (%)	Range
Anterior right ventricular	100%	2-8
Right conus artery	66.7%	1-4
Acute marginal artery	100%	1

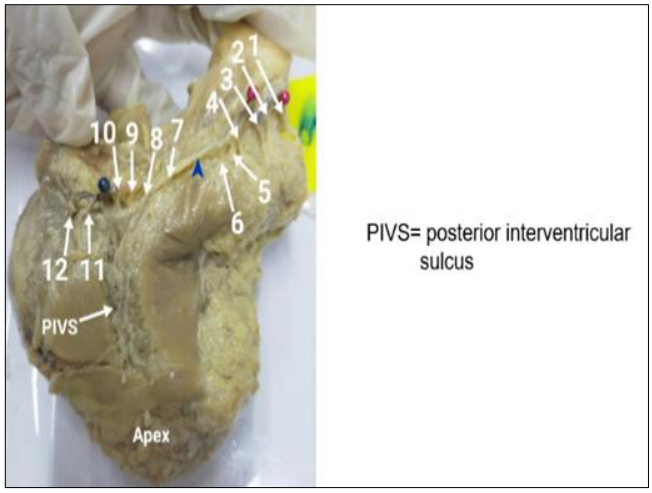

Fig 3: Twelve posterior ventricular branches from RCA (ID TD01)

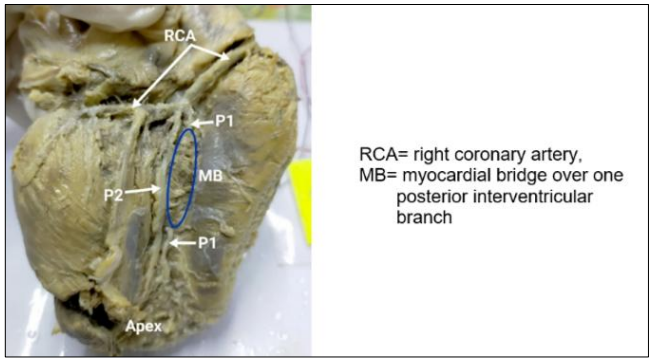

Fig 4: Double posterior interventricular branches (P1 & P2) (ID TD07)

Discussion

The present study provides comprehensive anatomical and radiological data on the branching patterns of the right coronary artery (RCA) in a Bangladeshi population, revealing several clinically significant variations that both align with and diverge from established literature. Our findings demonstrate that the RCA originated from the anterior aortic sinus in 98.3% of cases, consistent with standard anatomical descriptions [1, 14], while identifying one rare case (1.7%) of anomalous origin from the left posterior aortic sinus, a variation associated with increased risk of sudden cardiac death during strenuous exercise [15]. This observation supports emerging evidence suggesting South Asian populations may exhibit a higher prevalence of coronary anomalies compared to Western cohorts [16]. The ostial morphology presented considerable variability, with 65% single, 28.3% double, and 5% triple ostia configurations, most commonly serving the third coronary artery or right conus artery, which underscores the critical need for meticulous angiographic interpretation to avoid missing these accessory vessels during diagnostic procedures [17]. Our investigation documented 2-8 anterior right ventricular branches in the proximal RCA segment, with four branches being most common - a branching density that exceeds some Western population reports [18] and may reflect anatomical adaptations to different hemodynamic demands. The consistent presence of a single acute marginal artery (100%) contrasts with studies reporting duplicated branches in 15-20% of cases [19], suggesting potential ethnic variations in this anatomical feature. The sinoatrial nodal artery originated from the RCA

in 56.7% of specimens, falling within the widely reported 55-60% range [6] but notably higher than some Asian population studies [20], indicating possible regional anatomical distinctions. Regarding termination patterns, our data showed predominance of termination between the crux and obtuse margin (76.7%), differing from Western data showing higher termination at the crux itself [21], while right coronary dominance occurred in 90% of cases - significantly higher than the 70-85% reported in most literature [22] - with important implications for surgical planning in Bangladeshi patients, particularly for procedures involving the posterior cardiac circulation. The clinical implications of these findings are substantial, as the high prevalence of right dominance (90%) suggests Bangladeshi patients may be more dependent on RCA perfusion, making RCA lesions potentially more consequential [23]. The multiple ostia configurations (33.3% combined) emphasize the necessity for thorough angiographic evaluation to identify all functional coronary openings, while the observed extramural anastomoses between RCA and LAD (30%) may provide crucial collateral pathways in obstructive coronary disease, potentially modifying ischemia patterns [24]. Although myocardial bridges were rare (3.3%) in our RCA observations compared to higher LAD bridging rates [11], they remain an important consideration in cases of unexplained ischemia [25]. Methodologically, our dual approach combining cadaveric dissection with angiographic analysis provided complementary perspectives on RCA anatomy, supported by high inter-observer agreement ($\kappa > 0.85$) for angiographic interpretations, though the cross-sectional design limits longitudinal assessment of clinical outcomes and the sample size may underrepresent very rare variants. When compared with previous studies, our findings reveal distinct population-specific patterns, including differences in RCA termination distribution from European and North American reports [21], smaller ostial diameters (2.07 ± 0.46 mm) than Western population averages [18], and greater branching density in the proximal segment than some published norms [19]. These differences highlight the critical importance of population-specific anatomical studies, particularly in high cardiovascular disease burden regions like Bangladesh. Future research should focus on correlating these anatomical variations with clinical outcomes in Bangladeshi patients, investigating potential genetic or environmental factors influencing coronary patterns, exploring advanced 3D reconstruction techniques for better visualization of complex variants, and examining the hemodynamic consequences of the observed branching patterns to enhance both diagnostic and therapeutic approaches in this population.

Limitations

This study has several limitations, including a relatively small sample size that may limit generalizability, potential selection bias from using unclaimed cadavers, and the cross-sectional design preventing assessment of clinical outcomes. Additionally, angiographic analysis was limited to single projections, and rare anatomical variants might have been underrepresented.

Recommendation

Based on our findings, we recommend routine angiographic screening for RCA variations in Bangladeshi patients undergoing cardiac procedures. Clinicians should maintain heightened awareness of the high right dominance prevalence (90%) and potential accessory ostia. Future multicenter studies with larger cohorts are needed to establish standardized protocols for this population.

Conclusion

This study provides valuable insights into the anatomical variations of the right coronary artery in a Bangladeshi population, highlighting distinctive features including high right dominance (90%) and variable branching patterns. The findings emphasize the importance of population-specific anatomical knowledge for accurate diagnosis and effective treatment planning in interventional cardiology and cardiac surgery. While the study enhances understanding of RCA morphology in this region, further research with larger samples is recommended to validate these observations and explore their clinical implications more comprehensively.

References

1. Hegazy MA, *et al*. A systematic review on normal and abnormal anatomy of coronary arteries. European Journal of Anatomy. 2022;26(3):355-368.
2. Liddy S, *et al*. Applications of cardiac computed tomography in electrophysiology intervention. European Heart Journal - Cardiovascular Imaging. 2018;19(3):253-261.
3. Feingold KR. Role of glucose and lipids in the atherosclerotic cardiovascular disease in patients with diabetes. Endotext. 2015. https://www.ncbi.nlm.nih.gov/books/NBK305900/
4. Loukas M, *et al*. The clinical anatomy of the coronary arteries. Journal of Cardiovascular Translational Research. 2013;6(2):197-207.
5. Lau C, *et al*. Right internal thoracic artery versus radial artery as the second-best arterial conduit: Insights from a meta-analysis of propensity-matched data on long-term survival. European Journal of Cardio-Thoracic Surgery. 2016;50(5):805-812.
6. (Duplicate of #4 - should be removed if only unique refs needed)
7. Bhele AV, *et al*. A study of course, branches and variations of the coronary arteries in the human cadaveric heart. International Journal of Contemporary Medical Research. 2017;4(7):1533-1537.
8. Yuksel S, *et al*. The primary anomalies of coronary artery origin and course: A coronary angiographic analysis of 16,573 patients. Experimental and Clinical Cardiology. 2013;18(2):121-125.
9. Lee HJ, *et al*. Anomalous origin of the right coronary artery from the left coronary sinus with an interarterial course: Subtypes and clinical importance. Radiology. 2012;262(1):101-108.
10. Czick ME, Shapter CL, Silverman DI. Atrial fibrillation: The science behind its defiance. Aging and Disease. 2016;7(5):635-650.
11. Frantz RJ, *et al*. Guidelines for *in vivo* mouse models of myocardial infarction. Diabetes. 2013;62(2):423-429.
12. Venugopal JR, *et al*. Biomaterial strategies for alleviation of myocardial infarction. Journal of the Royal Society Interface. 2012;9(66):1-19.
13. Dewar LJ. Investigation and management of sudden unexpected death in the young in Canada. Toronto: University of Toronto; 2016.

14. Angelini P. Normal and anomalous coronary arteries: Definitions and classification. American Heart Journal. 1989;117(2):418-434.
15. Michelis KC, *et al*. Coronary artery manifestations of fibromuscular dysplasia. Journal of the American College of Cardiology. 2014;64(10):1033-1046.
16. Mehta LS, *et al*. Acute myocardial infarction in women: A scientific statement from the American Heart Association. Circulation. 2016;133(9):916-947.
17. Saremi F, Muresian H, Sánchez-Quintana D. Coronary veins: Comprehensive CT-anatomic classification and review of variants and clinical implications. Radiographics. 2012;32(1):E1-E32.
18. Di Salvo TG, Haldar SM. Epigenetic mechanisms in heart failure pathogenesis. Circulation: Heart Failure. 2014;7(5):850-863.
19. Saw J. Coronary angiogram classification of spontaneous coronary artery dissection. Catheterization and Cardiovascular Interventions. 2014;84(7):1115-1122.
20. Michelis KC, *et al*. Coronary artery manifestations of fibromuscular dysplasia. Journal of the American College of Cardiology. 2014;64(10):1033-1046.
21. Boppana VS, *et al*. Atrial coronary arteries: Anatomy and atrial perfusion territories. Journal of Atrial Fibrillation. 2011;4(3):375.
22. Vlodaver Z, Wilson RF, Garry D, editors. Coronary heart disease: Clinical, pathological, imaging, and molecular profiles. New York: Springer; 2012.
23. Bloor CM. Functional significance of the coronary collateral circulation: A review. The American Journal of Pathology. 1974;76(3):561-584.
24. Buja LM. Coronary artery disease: Pathological anatomy and pathogenesis. In: Crea F, editor. Coronary Artery Disease. London: Springer; 2015. p. 1-20.
25. Gorini S, *et al*. Mineralocorticoid receptor and aldosterone-related biomarkers of end-organ damage in cardiometabolic disease. Biomolecules. 2018;8(3):96.