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ORIGINAL RESEARCH ARTICLE

Evaluation of the Spectrum of Imaging Findings in Patients Undergoing Coronary Computed Tomographic Angiography

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ABSTRACT

Introduction: Coronary artery disease (CAD) remains a leading global cause of morbidity and mortality. Coronary computed tomographic angiography (CCTA) is a non-invasive imaging modality that effectively visualizes coronary anatomy, detecting stenosis, plaques, and anomalies. Its high sensitivity and negative predictive value make it suitable for ruling out CAD in patients with low to intermediate risk. The aim of the study is to evaluate the spectrum of imaging findings in patients undergoing coronary computed tomographic angiography and to correlate the findings of coronary computed tomographic angiography with catheter coronary angiography in patients who are undergoing catheter angiography.

Material and Methods: This prospective study involved 100 patients undergoing CCTA at SRMSIMS, Bareilly. Findings were analyzed for coronary stenosis, plaque types, anomalies, and other abnormalities. CCTA results were compared with ICA to determine diagnostic accuracy.

Results: Coronary stenosis was the most frequent finding, with LAD most commonly affected. CCTA demonstrated 100% sensitivity for LM, LAD, LCX, and RCA. Specificity was 100% for LM, LAD, and RCA, but lower (66.6%) for LCX. Several anomalies, including ectopic origin and congenital absence of LCX, were noted.

Conclusion: CCTA is a highly sensitive, non-invasive tool for detecting CAD and coronary anomalies. However, its accuracy may be reduced in patients with high coronary calcium, highlighting the importance of patient selection.

Keywords: Coronary computed tomographic angiography, Coronary artery disease, Catheter angiography, Coronary artery calcium score, Left main coronary artery, Left anterior descending artery, Right coronary artery, Left circumflex artery.

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INTRODUCTION

Coronary artery disease (CAD) is a leading cause of death and illness in both developed and developing nations. In India, CAD is a significant contributor to mortality, and its impact is increasing: the number of deaths due to CAD in 1985 is anticipated to have doubled by 2015.[1] The typical age at which Indians experience their first acute myocardial infarction is 53 years.[2] Invasive coronary angiography (ICA) is the gold standard for evaluation of the coronary artery lumen, in view of its high spatial and temporal resolution.

Despite the importance of ICA, non-invasive imaging offers a less invasive means to assess CAD in a broader range of patients. Computed tomography coronary angiography (CTCA) is a robust non-invasive imaging modality that serves as an alternative to invasive coronary angiography, the reference standard for assessing coronary artery stenosis. With its high negative predictive value, CTCA is particularly useful for confidently ruling out significant CAD in patients at low to intermediate risk.[3]

CTCA plays a crucial role in evaluating the origin, course, calibre and dominance of the coronary arteries, as well as their relationship to key cardiac structures. It also allows for precise measurement of diameter stenosis and, optionally, area stenosis to assess the impact of luminal plaque on coronary blood flow.[4] CTCA also allows detection and quantification of coronary artery calcification, seen as high-density lesions (>130 HU), typically measured using the Agatston score.[5]

CCTA has certain limitations, including exposure to higher radiation doses and the need for iodinated contrast, which can lead to allergic reactions or kidney complications.[6] Image quality may be impacted by factors such as tachycardia, motion artifacts, and obesity. To overcome these, techniques like ECG-gating, beta-blockers for heart rate control, low-dose protocols to reduce radiation, and hydration or safer contrast agents to minimize kidney risk can be used.[7]

MATERIAL AND METHODS

This prospective observational study was conducted in the Department of Radiodiagnosis at SRMS Institute of Medical Sciences, Bareilly, from 1st May 2023 to 31st October 2024. Ethical clearance (Approval No.: SRMS IMS/ECC/2023/99, dated 29/08/2023) and written informed consent were obtained. All patients undergoing CCTA, regardless of age or sex, were included. Exclusion criteria were lack of consent, contraindications to iodinated contrast, poor image quality, and pregnancy.

A detailed history, clinical evaluation, and biochemical tests were done prior to imaging. CCTA was performed using a dual-source 256-slice Siemens Somatom CT scanner. β-blockers were administered for heart rate control. An initial non-contrast scan was done for calcium scoring, followed by a contrast-enhanced coronary angiogram. Images were acquired at 80–120 kV (based on body type) and up to 400 mAs per rotation.

Image Reconstruction and Post-processing

Images were processed to reduce noise and enhance spatial resolution using the finest slice thickness. Curved multiplanar reformations, maximum intensity projections, and volume-rendered images were created for interpretation. CCTA findings were reviewed by the principal investigator and correlated with catheter angiography where applicable.

Data Analysis

Data was recorded in excel sheet and analysed using the IBM SPSS Statistics trial version 25. Data were expressed as mean, frequency and percentage. Descriptive statistics were applied to summarize demographic data, with categorical variables presented as frequencies and percentages. The diagnostic performance of CCTA was evaluated by calculating sensitivity, specificity, PPV, and NPV for the major diagnostic categories.

RESULTS

Table 1 shows the age distribution of 100 patients (24–78 years; mean 49.5 ± 12.36), with 30% in the 44 to 53 year group, 28% in the 54 to 63 years, 17% in the 34 to 43 years, and overall 58% between 44 to 63 years. Table 2 presents coronary artery calcium scores, with 62% of patients having a score of 0 and 38% showing mild to severe calcification; 7% with very high scores (>400) were excluded from CCTA.

Table 3 demonstrates that 74% of patients had abnormal CCTA findings, while 26% were normal. Table 4 shows coronary dominance in 93 evaluable patients, with right dominance in 76.3%, left dominance in 16.1%, and co-dominance in 7.5%. Table 5 indicates congenital coronary variations in 8.6% of patients, including ectopic coronary origins, congenital absence of LCX, and RCA duplication.

Table 6 shows that 90.3% had a normal left main coronary artery, with mild, minimal, and severe narrowing in 5.5, 1.4, and 1.4%, respectively, and congenital absence of LMCA in 3.2%. Table 7 presents the distribution of LAD narrowing, showing LAD as the most commonly involved vessel. Table 8 shows the presence of ramus intermedius in 13.9% of patients. Table 9 shows LCX involvement, with 60.2% normal, 17.2% mild stenosis, 12.8% moderate to severe stenosis, and about 1% congenital absence.

Table 10 depicts RCA narrowing with a pattern of mild to moderate atherosclerotic involvement. Table 11 shows myocardial bridging in 13.9% of patients. Table 12 summarizes invasive coronary angiography findings in 12 patients, of whom 8 underwent both CCTA and ICA. Table 13 compares 32 coronary arteries in 8 patients, showing 100% agreement for normal (15/15), moderate (3/3), and severe (10/10) stenosis, and 50% agreement for mild stenosis (2/4). Table 14 demonstrates the diagnostic performance of CCTA, with 100% sensitivity and NPV for LM, LAD, LCX, and RCA; specificity of 100% for LM, LAD, and RCA but 66.6% for LCX; and PPV of 100% for LM and LAD, 83.3% for LCX, and 75% for RCA.

REPRESENTATIVE CASES

Figures 1 to 5 shows the cases scenarioes encountered in daily practise.

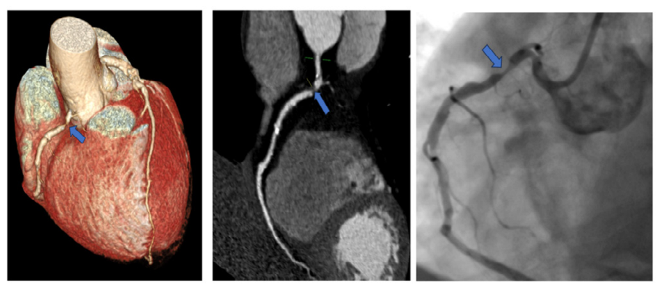

Figure 1: VRT, cMPR and catheter angiography images showing severe stenosis of RCA

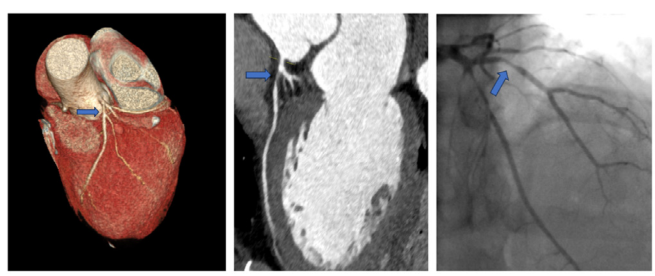

Figure 2: VRT, cMPR and catheter angiography images showing moderate stenosis of proximal LAD

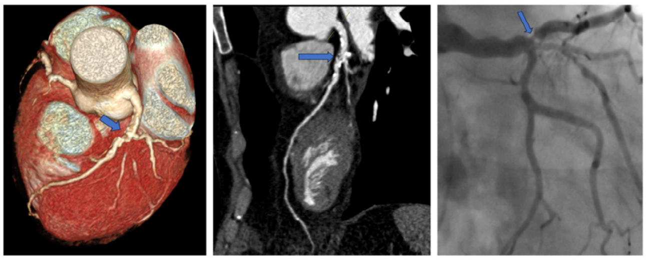

Figure 3: VRT and cMPR images showing severe narrowing of the proximal LAD near its origin.

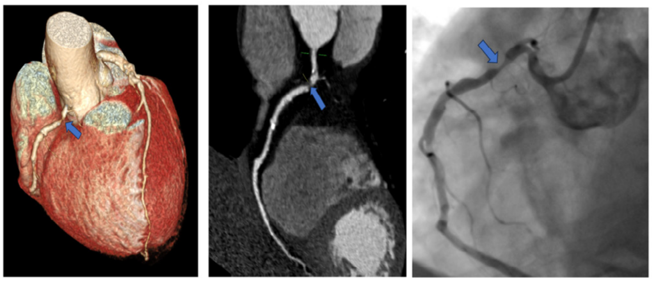

Figure 4: VRT and cMPR images showing the anomalous origin of RCA out of left coronary cusp

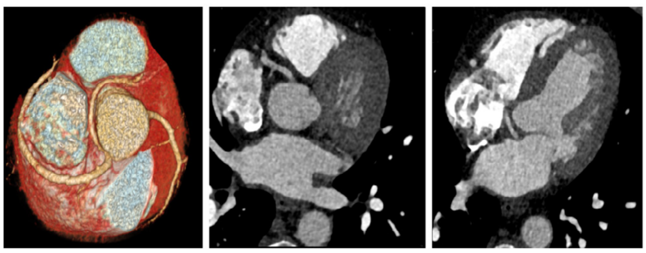

Figure 5: VRT and cMPR images showing anomalous origin of the LCX having a common ostium with RCA in the right coronary sinus

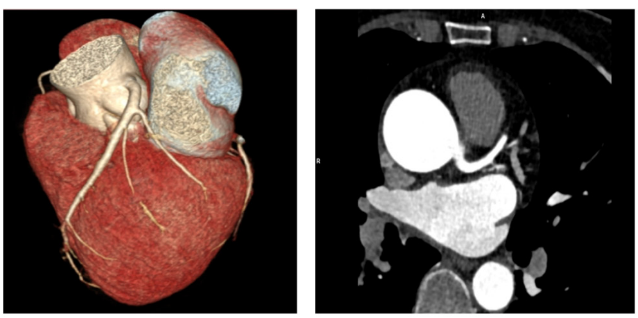

Figure 6: VRT and cMPR images showing congenital absence of LCX

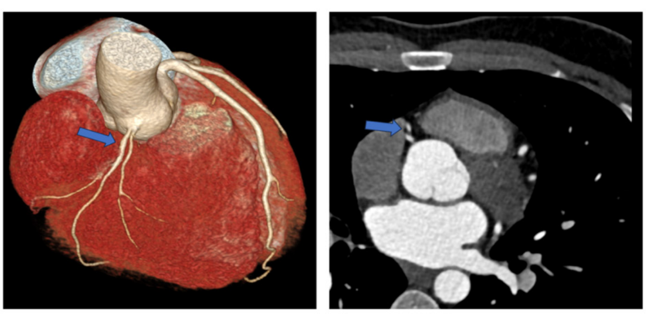

Figure 7: VRT and cMPR images showing duplication of RCA with two RCA arising from aorta

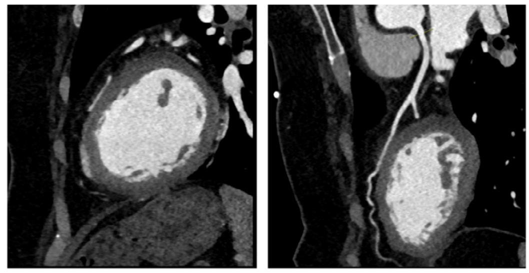

Figure 8: cMPR images showing myocardial bridging

Table 1: Distribution of cases according to age

Age Group (In Years)	Frequency	Percentage
24 - 33	13	13%
34 - 43	17	17 %
44 - 53	30	30%
54 - 63	28	28%
64 - 73	9	9%
74 - 83	3	3%
Total	100	100%
Mean Age (In Years)	49.5 ± 12.6	

Table 2: Distribution of calcium score

Calcium Score	Frequency	Percentage
None	62	62%
Mild	18	18%
Moderate	13	13%
Severe	7	7.0%

Table 3: Distribution frequencies of CCTA

CCTA	Frequency	Percentage
Abnormal	74	74%
Not Done	7	7%
Normal	19	19%

Table 4: Distribution of dominance (n = 93)

Dominance	Frequency	Percentage
Right	71	76.3%
Left	15	16.1%
Co Dominance	7	7.5%

Table 5: Distribution of congenital variation (n = 93)

Congenital Variation	Frequency	Percentage
Not Present	85	91.4%
Present	8	8.6%

Table 6: Distribution of severity of left main narrowing (n= 93)

Left Main	Frequency	Percentage
Normal	84	90.3 %
Not Present	3	3.2 %
Minimal Narrowing	1	1.4%
Mild Narrowing	4	5.5%
Severe Narrowing	1	1.4%

Table 7: Distribution of severity of LAD narrowing (n = 93)

LAD	Frequency	Percentage
Normal	32	34.4 %
Minimal Narrowing (1-24 %)	9	12.2%
Mild Narrowing (25-49%)	30	40.5%
Moderate Narrowing (50-69%)	14	18.9%
Severe Narrowing (70-99%)	8	10.8%

Table 8: Distribution of RAMUS INTERMEDIUS (n = 93)

Ramus Intermedius	Frequency	Percentage
Seen	13	13.9 %
Not Seen	80	86.1%

Table 9: Distribution of severity of LCX narrowing (n = 93)

LCX	Frequency	Percentage
Normal	56	60.2 %
Minimal Narrowing (1-24 %)	8	8.6%
Mild Narrowing (25-49%)	16	17.2 %
Moderate Narrowing (50-69%)	6	6.4 %
Severe Narrowing (70-99%)	6	6.4 %
Absent	1	0.01%

Table 10: Distribution of severity of RCA narrowing (n = 93)

RCA	Frequency	Percentage
Normal	59	63.4 %
Minimal Narrowing (1-24 %)	8	8.6%
Mild Narrowing (25-49%)	18	19.3 %
Moderate Narrowing (50-69%)	5	5.4 %
Severe Narrowing (70-99%)	3	3.2%

Table 11: Distribution of myocardial bridging (n = 93)

Myocardial Bridging	Frequency	Percentage
Present	13	13.9 %
Absent	80	86.1 %

Table 12: Distribution of catheter angiography

Catheter Angiography	Frequency	Percentage
Done	12	12 %
Not Done	88	88%

Table 13: Comparison of CCTA and catheter angiography findings among 32 arteries of 8 patients

CCTA	CATHETER ANGIOGRAPHY				
	Normal	Mild	Moderate	Severe	Total
Normal	15 (100%)	0	0	0	15 (100%)
Mild	2 (50%)	2 (50%)	0	0	4 (100%)
Moderate	0	0	3 (100%)	0	3 (100%)
Severe	0	0	0	10 (100%)	10 (100%)
Total	17(53.1%)	2 (6.3%)	3 (9.3%)	10 (31.3%)	32

Table 14: Diagnostic accuracy of CCTA in comparison with catheter angiography

CCTA	CATHETER ANGIOGRAPHY			
	LEFT MAIN	LAD	LCX	RCA
Sensitivity	100%	100%	100%	100%
Specificity	100%	100%	66.6%	80%
PPV	100%	100%	83.3%	75%
NPV	100%	100%	100%	100%

DISCUSSION

In our study, patient ages ranged from 24 to 78 years, with the average age at presentation being 49.5 ± 12.6 years. Notably, 58% of the patients were in the 44 to 63 age group. A similar study by Villines *et al.* (2011)[8] found the mean age of presentation to be 57 ± 12 years, with 56% of the patients being male.

The study involved 100 patients, with a greater proportion of males (69%) than females (31%). This aligns with previous studies done by Park *et al.* (2015)[9] where CAD and other cardiovascular conditions have a higher prevalence in males (72.8).

The calcium score is vital in CAD assessment. In this study, Agatston scores ranged from 0 to 1951.6, with 62% showing no coronary calcium, indicating a low likelihood of obstructive CAD. However, 38% had mild to severe calcifications, suggesting atherosclerotic plaque and possible coronary narrowing seen on CCTA. Yamamoto *et al.* (2014)[10] demonstrated that patients with a CAC score of ≥ 100 had significantly higher cardiovascular disease mortality compared to those with a CAC score of < 100. A CAC score ≥ 400 is recommended for invasive coronary angiography, while a score between 1 and 399 suggests that CCTA is appropriate. However, the diagnostic accuracy of CCTA diminishes in patients with extremely elevated CAC scores, particularly those above 400. Consequently, 7 out of 100 patients in our study were excluded from undergoing CCTA due to excessively high calcium scores.

The results of this study showed that the majority of the participants (76.3%) exhibited RCA dominance, followed by LCA dominance (16.1%) and co-dominance (7.5%), which is consistent with previous studies examining coronary artery dominance patterns. In a study done by Bovey *et al.* (2024)[11] approximately 85% of the population exhibited right coronary dominance, 8% had left coronary dominance, and 7% showed co-dominance variations.

In this study 74% of patients had abnormal CCTA findings, indicating a high prevalence of CAD within the studied population. The most common abnormalities observed in CCTA were coronary artery narrowing and the presence of coronary plaques.

A small portion (8.6%) of patients showed congenital coronary artery variations, which can impact imaging accuracy and require careful interpretation of CCTA results. In our study, six cases had ectopic coronary origins: three with aberrant RCA origin, two with LCX originating anomalously from the right coronary sinus, and one with separate origins of LAD and LCX directly from the aorta.

Among three cases of anomalous RCA origin, two arose from the left coronary cusp, and one from the proximal ascending aorta. Additionally, there was one case of congenital absence of the LCX and another with RCA duplication. Our results were in accordance with a study done by Charan *et al.* (2021)[12]. In their study of 8,500 patients, the most frequent anomaly was the anomalous origin of the right coronary artery from the left coronary sinus (51 patients - 68.9%), followed by the origin of the left circumflex artery from the right coronary sinus (21 patients - 28.4%).

The LAD artery showed mild to moderate narrowing in many patients, with similar narrowing seen in the RCA and LCX. These results indicate that atherosclerotic plaque and coronary artery narrowing are common in the study population, explaining the high rate of abnormal CCTA findings. The LM artery was mostly normal, with only a few cases of mild to severe narrowing, consistent with other studies reporting less frequent LM involvement. Our findings are consistent with the study by Bergstrom *et al.* (2021)[13], which concluded that atherosclerosis was more common in older individuals and primarily affected the proximal LAD artery.

Ramus Intermedius and myocardial bridging were each present in 13.9% of patients, highlighting common anatomical variations in coronary arteries. For comparison, Mathai *et al.* (2017)[14] reported myocardial bridging in 9.26% and the ramus intermedius branch in 19% of patients. Out of 100 patients, 12 underwent invasive coronary angiography (ICA) after CCTA. Among these, both CCTA and ICA were completed in 8 patients, while 4 patients could not complete CCTA due to high coronary artery calcium (CAC) scores. Additionally, CCTA identified 13 patients with significant coronary stenosis who did not undergo ICA and received alternative treatments, making further comparison unavailable. The results highlight CCTA's high diagnostic accuracy, with 100% sensitivity and negative predictive value (NPV) across all arteries (LM, LAD, LCX, RCA). Specificity was 100% for LM, LAD, and RCA but lower for LCX (66.6%), reflecting more false positives likely due to anatomical and imaging challenges. Positive predictive value (PPV) was excellent for LM and LAD (100%), but slightly lower for LCX (83.3%) and RCA (75%), indicating occasional overestimation of stenosis. In a study done by Z Sun *et al.* (2012)[15], the authors found that CT angiography demonstrated mean sensitivities ranging from 85 to 99% in detecting coronary artery stenosis. Another study conducted by Muhammed *et al.* (2024)[16] examined 214 patients (67.3% male, median age 56) and found that CCTA demonstrated a sensitivity of 80.8% and a negative predictive value (NPV) of 90.3% for detecting stenosis greater than 70%. For stenosis of 50%, the sensitivity increased to 93.5%, while the NPV was 92.1%. These results emphasize the strong diagnostic potential of CCTA as a non-invasive imaging tool, which is consistent with the findings of our study.

CONCLUSION

This study highlights CCTA as a reliable, non-invasive tool for assessing coronary stenosis, plaque, and anomalies. Its high accuracy and patient comfort make it valuable for diagnosing CAD while reducing the need for invasive procedures. However, diagnostic accuracy decreases with high CAC scores due to blooming artifacts, as seen in 7 excluded patients. Technological advancements may enhance CCTA performance, but ICA remains essential for complex cases and precise assessment.

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