Original Article

Diagnostic Accuracy of 320-Multi-detector Row Computed Tomography to Detect Coronary Artery Disease and its Comparison to Coronary Angiography

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Abstract

Background: Coronary artery disease is a significant cause of morbidity and mortality. Selective invasive coronary angiography remains the gold standard to determine the extent of disease however multi-detector row computed tomography is non-invasive in nature with advantage in providing coronary artery calcium score and plaque burden estimation. In this study, we determined the diagnostic accuracy of multi-detector row computed tomography for stenoses of the coronary arteries in comparison with the conventional standard cardiac angiography.

Methods: This was a hospital-based, cross-sectional study conducted at Shahid Gangalal National Heart Centre and Bir Hospital, Kathmandu, Nepal. 110 patients who had undergone cardiac computed tomography angiography and conventional invasive coronary angiography for a year were enrolled. Comparative study in terms of sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated.

Results: A total of 110 patients were enrolled. The mean total coronary artery calcium score was 190.63 ± 312.61 Agatston units. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of cardiac computed tomography angiography were 81.4%, 91.3%, 65.7%, 96.0%, and 89.6% respectively. Overall sensitivity, specificity, positive and negative predictive values for mild (<50%) stenosis were 47.4%, 95.1%, 34.8% and 97.1% respectively, moderate (50-69%) stenosis were 30.4%, 96.8%, 19.4% and 98.2% respectively and severe (≥ 70%) stenosis were 65.7%, 95.6%, 60.5% and 96.4% respectively.

Conclusions: Coronary computed tomography angiography has a high diagnostic accuracy, good sensitivity and negative predictive value, and positive predictive value similar with invasive coronary angiography with exclusion of calcified extensive plaque burden segments for higher yield.

Introduction

Coronary artery disease (CAD) is one of the major causes of morbidity and mortality. Selective coronary angiography (CAG) remains the gold standard to determine the extent of CAD.[1] Although coronary angiography technique is well established, it is an invasive procedure with potential complications. The complication rate of CAG is 1.8% with a mortality rate of 0.1% but may be 0.55% in high-risk populations.[2]

An accurate, non-invasive alternative evaluation method for diagnosing CAD is desirable, particularly in patients with low-to-intermediate pre-test likelihood of CAD. Coronary Computed Tomography Angiography (CCTA) is currently popular because of its non-invasive nature.[3]

The studies on diagnostic accuracy of CCTA compared with invasive angiography for detecting coronary artery stenosis in developing countries like Nepal are scarce. Thus, this study aims to assess the role of CCTA for the assessment of coronary artery anatomy, degree of stenosis, coronary artery calcium (CAC) score and its accuracy compared with invasive angiography.

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Methods

This was a hospital-based, cross-sectional study conducted at Shahid Gangalal National Heart Centre (SGNHC) and Bir Hospital, Kathmandu, Nepal. The study was conducted from May 12 2023 to May 11, 2024. The sample size was calculated by the formula $N=z^2pq/d^2$, where n =required sample size, p= Prevalence of CAD, d =8% of maximum tolerable error, q=100-p, z=1.96 at a 95% confidence interval. There is no recent Nepalese data on CAD prevalence so the article" A study of cardiovascular disease pattern of admitted cases in newly emerged national heart centre" which was published in the Journal of Nepal Medical Association in 2003 by Limbu et al was taken into considereed.[4] In accordance to this data, 21.7% was taken as a reference resulting in a sample size of 102 at a 95% confidence interval and 8% maximum tolerable error. Patients who had undergone CCTA and attended the Cath lab preparation room in Bir Hospital and/or SGNHC for invasive coronary angiography were included in the study after obtaining written informed consent. Ethical clearance for the study was obtained from the Institutional Review Board, NAMS (National Academy of Medical Science). Written consent was taken from the patient or relative. The plan and purpose of the study were clearly explained. Confidentiality of all the collected information was maintained throughout the study. Patients aged 18 years and above who had undergone both cardiac computed tomography angiography and conventional invasive coronary angiography were included. Patients with the following conditions were excluded from the study patients with coronary artery bypass graft (CABG) or having a stent in the coronary artery, baseline renal insufficiency, allergy to iodinated contrast and subjects not willing to give consent. For comparison with conventional CAG, the grade of diameter stenosis (maximum diameter reduction) was determined in longitudinal curved multiplanar reformatted reconstructions by dividing the minimal diameter in the diseased segment through the diameter in the adjacent proximal disease-free section in the same two projections that were used for CAG.

Conventional Coronary Angiography (CAG)

A standard procedure was followed in performing conventional coronary angiography. Angiograms were evaluated by an experienced cardiologist who was blinded to the results from previous CCTA. The coronary arteries were segmented according to the guidelines of the American Heart Association.[5] Each vessel segment was scored as being stenosed <50%, 50-69%, and ≥70%. Coronary artery analysis was performed in all vessels with a diameter down to 2.0 mm, including those vessels distal to complete occlusions.

Preparation before computed tomography scanning

Patients were requested to keep fasting for more than 4 hours. Patients with a resting heart rate of more than 80 beats per minute (bpm), were given 25–50 mg beta blocker under the condition of no contraindications. All the patients signed written consent and were informed of the scanning process. The patients were trained to breathe effectively and were asked to keep their chest and abdomen still while holding breath. Toshiba Aquilion one 320-slice multi-detector row computed tomography was used. Scanning tube voltage with 100 -120 kV, tube current modulation was used according to body mass index (200-500 mA), and collimation width of 320 mm × 0.5 mm. Scanning ranged from 1 cm below the tracheal subcarinal to the diaphragmatic surface. The acquisition time window was 70% ~ 80% between the R-R period when the heart rate was <65 bpm, and it was 30% ~ 80% R-R interphase when the heart rate was more than 65 bpm. The scanning field-of-view was 320 × 320, display matrix of 512 × 512. A double cylinder of the high-pressure syringe was used to inject contrast medium at a rate of 4.0–5.0 ml/s with a volume of 60-70 ml, and then 30 ml saline was injected at the same rate. The region of interest (ROI) was set in the descending aorta to monitor CT values, trigger threshold was 250 HU. When the value of ROI was more than 250 HU, volume scanning was started after breathing instructions.

Image reconstruction

Volume data was 75% of the automatic reorganization period and optimal period phase. The slice thickness of reconstructed transversal images was 0.5 mm, with a 0.25 mm thickness interval. A soft tissue reconstruction algorithm was used. If the preset period phase couldn't meet the needs of diagnosis, coronary arterial segments with poor display were reconstructed to get clear transversal images according to the electrocardiography editing option, then images were sent to application software in Vitrea FX post-processing workstation to get volume rendering, maximum intensity projection, multiplanar and curved planar images coronary arteries.

Diagnostic accuracy of 320-slice multi-detector row computed tomography was calculated for stenosis ≥70%, 50-69 %, and <50% diameter reduction, according to the conventional coronary angiography results. Sensitivity, specificity, diagnostic accuracy, negative predictive value (NPV), and positive predictive value (PPV) were calculated per patient and segment of the vessels.

Data Collection

The data was collected by questionnaire method. All patients (or patients' reliable party) were queried for information such as demographic features, presenting symptoms, past medical history, risk factors for CAD, co-morbid illness, socio-economic status, and others. Coronary Angiography done in SGNHC or Bir Hospital during the study period for all clinical indications by all cardiology units were enrolled in the study if the patient met the inclusion and exclusion criteria. These CCTA and CAG films and coronary artery segments were reviewed by the principal investigator. Details of angiographic findings were noted. These variables were entered in the structured patient proforma.

Statistical Analysis

All data were entered into a spreadsheet (Microsoft Excel) and the statistical analysis was done using the IBM SPSS version 23 software. Categorical variables were presented as proportions or percentages. After processing all available information, a statistical analysis of their significance was done. All parametric values were expressed in mean and standard deviation. Chi-square tests, Cohen's kappa coefficient, and Fisher's exact test were used as required. Results were appropriately tabulated. In data analysis, 95% confidence interval (CI) and P value, were computed to conclude the result obtained. All parametric values were expressed in mean and standard deviation. Results were appropriately tabulated.

Results

During the study period of one year, a total of 110 participants were included in this study. Out of the total participants, 79 (71.8%) were male and 31 (28.2%) were female. Most patients (38 (34.5%)) were from the 60-69 years age group followed by the 50-59 years age group (28.2%). The minimum age of the patient was 20 years and the maximum age was 82 years with mean age of 59.37±11.67 years. The baseline characteristics of the patients were assessed which are depicted in Table 1.

Table 1: Baseline characteristics of the patients (n =110)

Characteristics		Frequency (n)	Percentage (%)
Sex	Female	31	28.2
	Male	79	71.8
	Total	110	100.0
Age (years)	mean ± SD (min, max)	59.4 ± 11.7 (20, 82)	
Chest pain	Absent	2	1.8
	CCS I	9	8.2
	CCS II	62	56.4
	CCS III	36	32.7
	CCS IV	1	.9
	Total	110	100.0
Shortness of breath	Absent	90	81.8
	NYHA II	17	15.5
	NYHA III	3	2.7
	Total	110	100.0
Swelling of limbs	Absent	86	78.2
	Present	24	21.8
	Total	110	100.0
Smoking	Former smoker	33	30.0
	Current smoker	57	51.8
	Never smoker	20	18.2
	Total	110	100.0
Type 2 DM	Absent	65	59.1
	Present	45	40.9
	Total	110	100.0
Hypertension	Absent	36	32.7
	Present	74	67.3
	Total	110	100.0
Dyslipidaemia	Absent	42	38.2
	Present	68	61.8
	Total	110	100.0

The most common indication for CCTA was the advice given by clinicians for chest pain (68 patients (61.81%)). This was followed by fear of more invasive test 20 (18.2%), treadmill test positive/ inconclusive 13 (11.8%), screening of CAD for non-cardiac surgery 5 (4.5%) and patient preference 4 (3.6%). Ninety-two (83.6%) patients were advised by treating cardiologists for planned CAG followed by percutaneous coronary intervention (PCI) if indicated in the same settings whereas 18 (16.4%) patients did CAG to confirm the diagnosis. These 18 patients had undergone CAG because of ongoing chest pain despite medical management. The median interval between CCTA and CAG tests was 20.08 ±27.51 days with a maximum interval was 210 days. The mean total coronary artery calcium (CAC) score was 190.63 ± 312.61 Agatston units (Table 2). The maximum coronary calcium score was 2055 Agatston units.

Table 2: Total coronary artery calcium score from CCTA and associated plaque burden (n =110)

Coronary Artery Calcium Score (Agatston units)	Plaque burden	Patients (%)
0	Non-identified	18 (16.36)
1-10	Minimal	9 (8.18)
11-100	Mild	32 (29.09)
101-400	Moderate	38 (34.54)
>400	Extensive	13 (11.81)

Out of 110 cases included in the study, 80 (72.7%) patients had right dominant circulation whereas 24 (21.8%) patients had left dominant circulation and 6 (5.5%) patients had co-dominant circulation. The majority of patients had both calcified and non-calcified plaque in the same coronary artery which was seen in 60 (54.54%) patients followed by calcified plaque only in 24 (21.81%) patients, non-calcified plaques in 23 (20.9%) patients and no plaques in 3 (2.72%) patients.

When evaluating the anomalous origin of coronary artery, in one patient, the origin of the right coronary artery (RCA) was seen arising from the left coronary cusp and two patients had separate origins of the left anterior descending artery (LAD) and left circumflex artery (LCx). Both these anomalies were seen in both the tests. We also evaluated vessel-wise distribution of coronary artery in CCTA and CAG which revealed single vessel disease (39.09% and 40% respectively), double vessel disease (30% and 30% respectively), triple vessel disease (14.50% and 14.50% respectively), mild CAD (10.90% and 9.09% respectively) and normal coronaries (5.45% and 6.36% respectively). As per segment analysis, there were more patients in the severe stenosis (≥70%) category, followed by the mild stenosis (<50%) category and moderate stenosis (50 - <70%) category in both tests as shown in Table 3.

Table 3: Distribution of severity of involvement in patients based on CCTA and CAG (n = 110)

S. N	Severity	CCTA		CAG	
		Number of patients	Percentage (%)	Number of patients	Percentage (%)
1	<50%	70	63.6	56	50.9
2	50 - <70%	38	34.5	31	28.2
3	≥70%	86	78.2	85	77.3

The overall sensitivity, specificity, PPV and NPV for mild, moderate and severe stenosis are shown in Table 4.

Table 4: Diagnostic accuracy by severity of segment involvement (n = 5610)

Comparative indicators	Mild stenosis	Moderate stenosis	Severe stenosis	Total segments severity
True Positive Segments	46	14	115	175
True Negative Segments	1687	1766	1620	5073
False Positive Segments	86	58	75	219
False Negative Segments	51	32	60	143
Sensitivity	47.4% (46/97)	30.4% (14/46)	65.7% (115/175)	55% (175/318)
Specificity	95.1% (1687/1773)	96.8% (1766/1824)	95.6% (1620/1695)	95.9% (5073/5292)
Positive Predictive Value	34.8% (46/132)	19.4% (14/72)	60.5% (115/190)	44.4% (175/394)
Negative Predictive Value	97.1% (1687/1738)	98.2% (1766/1798)	96.4% (1620/1680)	97.3% (5073/5216)
Accuracy	92.7% (1733/1870)	95.2% (1780/1870)	92.8% (1735/1870)	93.5% (5248/5610)

Diagnostic accuracy was evaluated in various vessel segments by CCTA. The vessels evaluated were left main (LM), proximal-LAD, mid-LAD, distal-LAD, LAD- first diagonal branch of the left anterior descending artery (LAD-D1), Ramus Intermedius (RI), proximal right coronary artery (RCA), mid-RCA, distal-RCA, posterior descending artery (PDA), posterior left ventricular (PLV), proximal left circumflex (LCX), distal-LCX and left circumflex first obtuse marginal artery (LCX OM1) which is shown in Table 5. Left circumflex second obtuse marginal artery (LCX OM2), mid-LCX and second diagonal branch of the left anterior descending artery (LAD-D2) were not evaluated due to absence of lesions in these segments.

Table 5: Diagnostic accuracy by vessel segments involved (n = 1870)

S. N	Vessel segment	Sensitivity	Specificity	PPV	NPV	Accuracy
1	LM	75.0%	99.0%	85.7%	98.1%	97.3%
2	Proximal-LAD	100.0%	91.7%	90.9%	100.0%	95.5%
3	Mid-LAD	100.0%	34.6%	63.0%	100.0%	69.1%
4	Distal-LAD	83.3%	95.9%	71.4%	97.9%	94.5%
5	LAD-D1	30.0%	96.0%	42.9%	93.2%	90.0%
6	LAD-D2	-	-	-	-	-
7	RI	0.0%	98.1%	0.0%	97.2%	95.5%
8	Proximal-RCA	84.4%	80.8%	64.3%	92.6%	81.8%
9	Mid RCA	84.2%	88.9%	80.0%	91.4%	87.3%
10	Distal - RCA	84.6%	97.9%	84.6%	97.9%	96.4%
11	PDA	11.1%	97.0%	25.0%	92.5%	90.0%
12	PLV	22.2%	99.0%	66.7%	93.5%	92.7%
13	Proximal-LCX	96.3%	90.4%	76.5%	98.7%	91.8%
14	Mid LCX	-	-	-	-	-
15	Distal - LCX	89.2%	87.7%	78.6%	94.1%	88.2%
16	LCX OM1	0.0%	97.1%	0.0%	92.5%	90.0%
17	LCX OM2	-	-	-	-	-
Total segments		81.4%	91.3%	65.7%	96.0%	89.6%

Sensitivity, specificity, PPV, NPV, and accuracy of CCTA over CAG was assessed as per grade of stenosis, per vessel and overall, per grade and segment which is depicted in Table 6 which shows a significant value for CCTA as compared to CAG.

Table 6: Overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of CCTA over CAG

Analysis		Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
Per grade of stenosis	Mild	47.4%	95.1%	34.8%	97.1%	92.7%
	Moderate	30.4%	96.8%	19.4%	98.2%	95.2%
	Severe	65.7%	95.6%	60.5%	96.4%	92.8%
Per vessel	LM	75.0%	99.0%	85.7%	98.1%	97.3%
	LAD	100%	88.2%	97.9%	100%	98.2%
	RI	0.0%	98.1%	0.0%	97.2%	95.5%
	RCA	92.5%	69.8%	82.7%	85.7%	83.6%
	LCX	93.4%	69.4%	79.2%	89.5%	82.7%
Overall (per grade)		55%	95.9%	44.4%	97.3%	93.5%
Overall (per segment)		81.4%	91.3%	65.7%	96.0%	89.6%

Discussion

Coronary artery disease (CAD) causes the largest healthcare burden to society. The prevalence of CAD risk factors and CAD is increasing in Nepal.[6] To decrease the morbidity and mortality of patients having coronary artery disease, it is necessary to diagnose and manage CAD at an earlier stage. The Framingham Heart Study is the origin of the term 'risk factor'. These can be modifiable and non-modifiable factors. Modifiable factors can be lifestyle and environmental factors and non-modifiable factors are age, sex, and hereditary factors i.e. family history of coronary artery disease.[7]

Almost all of the subjects having significant CAD belong to an age group of more than 45 years as suggested by the Framingham study.[7] In this study too, the majority of cases, 38 (34.5%) patients were from the 60-69 years age group followed by the 50-59 years age group. Overall men are more prone to atherosclerosis than women probably due to the protective role of oestrogen. In our study too, there were 79 (71.8%) males and 31 (28.2%) females which is in accordance with other studies like Bhattarai S et al.[6]

Among the modifiable risk factors, hypertension and smoking were responsible for the largest number of deaths in a 2009 review comparing twelve modifiable risk factors.[8] In this study as well, fifty-seven (51.8%) patients were current smokers and 74 (67.3%) patients were hypertensive. Dyslipidaemia and diabetes mellitus are independent risk factors for CAD as suggested by various studies.[9] Forty-five (40.9%) patients were under treatment for diabetes mellitus and 61 (60.8%) patients were dyslipidemic. These findings are in accordance with other studies like Malakar et al[10] and Pencina MJ et al.[11]

Conventional invasive coronary angiography (CAG) gives a great perception of the coronary vasculature and has been considered the reference gold standard for assessment of coronary stenosis and impediment with the benefit of high spatial determination and temporal determination.[12] However, it is an invasive and costly system with related morbidity and mortality. Thus, a non-invasive strategy for imaging coronary artery disease is exceptionally alluring. The system of MDCT angiography in heart imaging is developing quickly. It has turned into a promising strategy with the expansion of locator lines from initially 4 slices then to 16 slices to more than 64 slices and even 320 slice scanners.

Recently, the 2019 ESC guidelines for the diagnosis and management of chronic coronary syndromes and 2021 ACC guidelines for the evaluation and diagnosis of chest pain proposed CCTA as an initial test for diagnosing CAD in symptomatic patients in whom obstructive CAD cannot be excluded by clinical assessment alone.[13,14] So, CCTA is regarded as a first-line test for patients with an intermediate pre-test probability of CAD. Both invasive and non-invasive angiographic studies have demonstrated the correlation between stenosis degree and clinical events.

The majority of the patients in this study were advised to undergo CCTA by treating physicians and cardiologists. Sixty-eight (61.81%) patients who underwent CCTA were advised for evaluation of chest pain. The majority of treating cardiologists followed low to intermediate pre-test probability of CAD subjectively. Twenty (18.2%) patients chose to undergo CCTA due to fear of invasive tests. Five (4.5%) patients did CCTA as a pre-operative evaluation for non-cardiac surgery.

Of the patients who underwent CCTA, ninety-one (82.72%) patients were advised by treating cardiologists for invasive CAG followed by PCI in the same settings whereas 19 (17.27%) patients did CAG to confirm the diagnosis which included those done for pre-operative evaluation. Two patients, out of 19 patients did invasive CAG because of ongoing chest pain despite mild CAD as suggested by CCTA. The majority of patients have undergone invasive CAG likely due to high cases of severe stenosis as per CAD-RADS score of 59 % (CAD-RADS Score 4A and 4B combined). A total of 110 patients successfully received the CCTA and invasive CAG examinations.

According to the results indicated above as per patient analysis, the sensitivity, specificity, positive and negative predictive value, and accuracy of the 320-row detector CCTA evaluation for the coronary artery stenosis were 100.0%, 85.7%, 99.0%, 100.0%, and 99.1% respectively. These findings are in accordance with the other similar study done by Achenbach S et al in which overall findings of the sensitivity, specificity, positive and negative predictive value were 100%, 83%, 100%, and 86% respectively.[15] In this study, one patient with normal CAG findings had mild stenosis in CCTA which had affected these values. A high negative predictive value adds high accuracy of this test in ruling in the disease.

CT can show the vast majority of coronary artery stenosis, and can accurately judge the degree of luminal stenosis.[16] Several studies have compared the degree of stenosis detected by quantitative coronary angiography with that detected by 16- or 64-slice CT. The majority of the segments involved in stenosis were from the LAD artery in both tests. Similar findings were seen in Achenbach et al.[15] Sensitivity, specificity, positive and negative predictive values of proximal segments of all coronary arteries were higher than mid and distal segments as shown in Table 6 in accordance with other studies like Lei Z et al.[16] Stenoses in smaller vessel segments, given the difficulties in evaluating smaller structures, would have been missed by MDCT in these studies than the proximal segments with the large calibre of the vessel proximally.

Overall sensitivity, specificity, positive and negative predictive values for mild (<50%) stenosis were 47.4%, 95.1%,34.8%, and 97.1% respectively, moderate (50-69%) stenosis were 30.4%, 96.8%,19.4%, and 98.2% respectively and severe (≥70%) stenosis were 65.7%, 95.6%, 60.5%, and 96.4% respectively. These findings are similar to the other studies done by Lei Z et al in which sensitivity, specificity, positive and negative predictive values are 90%, 99.3%, 87.1%, and 99.5% respectively for mild stenosis, 90.7%, 99.8%, 96%, 99.6% respectively for moderate stenosis and 93.4%, 99.5%, 95%, 99.4% respectively for severe stenosis.[16] Sensitivity and positive predictive value were low in this study mainly due to the inclusion of calcified extensive plaque burden segments which were not used in the other studies. The diagnostic accuracy of 320-row detector CCTA is higher than the similar study done with 16 and 64-slice CCTA as suggested by the studies done by Achenbach S et al,[15] and Leber et al.[17] Overall increased accuracy of this study might be due to its maximum Z-axis width of a detector that could reach 160 mm, making it possible to cover the entire heart and finish collecting volume data of the heart within a single heartbeat in a single rotation of the gantry, and the sequence helps avoid stair-step artifacts and banded artifacts. These advanced features of 320-row detectors may be the reasons for enhanced overall diagnostic accuracy than other studies done in 16 to 64-slice CCTA. The sensitivity, specificity, positive and negative predictive value, and accuracy in this study of overall segments were 55%, 95.9%, 44.4%, 97.3%, and 93.5% respectively. Findings in this study are similar to Lei et al[16] done using 640 slice CCTA for high negative predictive value whereas sensitivity and positive predictive value were less in our study especially for mild and moderate stenosis due to the likely inclusion of calcified extensive plaque burden segments which were not used in other studies. However, sensitivity, specificity, positive and negative predictive values for severe coronary artery stenosis were 65.7%, 95.6%, 60.5%, and 96.4% respectively as shown in Table 7. As the overall sensitivity and positive predictive value in our study for different grades of stenosis were less but due to high sensitivity and positive predictive value as per vessel analysis, our study suggested that, though the sensitivity of segments to predict and detect the severity of stenosis was lower but had high sensitivity and positive predictive value to detect presence or absence of disease.

This study adds that CCTA has a high diagnostic value in the evaluation of coronary artery stenosis especially of severe stenosis. This study documents the excellent ability of the 320-row detector MDCT to rule out functionally relevant CAD as indicated by the high NPV. The high NPV of 97.1 % for the diagnosis of <50% stenosis, 98.2 % for 50- 69% stenosis, and 96.4 % for ≥70% stenosis in this study suggests an important future role of CCTA for reliably excluding CAD in patients with an equivocal clinical presentation, who undergoes a cost-extensive invasive CAG. This study's result of high NPV was also comparable with some other studies.[15,16] This study found that CCTA has a higher NPV for coronary artery stenosis, basically meaning that for patients with negative CCTA examination, invasive CAG checks can be avoided.

The prognostic value of coronary calcium has been studied in many studies. These studies indicate that calcium scoring can be used as a risk factor, i.e. a high calcium score is associated with a relatively high risk of adverse coronary events. The absence of calcium is associated with a low likelihood of advanced coronary disease and a very low likelihood of advanced coronary atherosclerosis. Greenland and Gazaino proved in their study that a calcium score less than 80 significantly reduced the risk of occurrence of a coronary event in the next 10 years i.e. have a lesser tendency to be associated with significant stenotic lesions.[18] In this study, the mean total coronary artery calcium score was 190.63 ± 312.61 Agatston units. The maximum coronary calcium score was 2055 Agatston units. Thirty-eight (35.54%) patients had moderate plaque burden (101-400 Agatston units) followed by 32 (29%) patients with mild plaque burden (11-100 Agatston units). This study signified that the majority of patients were intermediate to high probability of CAD which needed to undergo imaging of coronary artery to rule out obstructive CAD which is the additional advantage of CCTA over invasive CAG. The total volume of CAC deposits is a good indicator of overall plaque burden and future coronary events so it is used as a reliable marker of atherosclerotic disease and cardiovascular risk. Plaque can hence be readily classified as calcified and non–calcified or both. Unstable lesions shown with CCTA in patients with acute coronary syndrome (ACS) tend to be non-calcified, with low attenuation and spotty calcification, larger plaque volume, and higher remodelling index compared with stable lesions in patients with chronic stable angina.[19]

In this study, the majority of patients had both calcified and non-calcified plaque in the same coronary artery which was seen in 60 (54.54%) patients followed by calcified plaque only in 24 (21.81%) patients. Three (2.72%) patients didn't have a plaque in the artery. The sensitivity of plaque detection depends on the percentage of calcium in the plaque. Calcified plaques are found to be more stable and less prone to rupture. A study by Leber et al found that among asymptomatic patients, calcified plaques are the highest in prevalence which is similar to this study.[17] Soft plaques (non-calcified) show more association in patients with angina pectoris and myocardial infarction as suggested by Pugliese F et al.[20] In this study 23 (20.90%) patients had non-calcified plaques whereas 54.5% had both plaques in the same artery, which increases the risk Major Adverse Cardiovascular Events (MACE), which is the important additional information provided by CCTA in this study over invasive CAG which is also similar to the other studies like Park HB et al. in which low- attenuation plaque (non-calcified) is more often seen in patients with ACS, and is associated with ruptured fibrous caps, lesion-specific ischemia, and future risk of MI.[21]

There are limitations of this study. This study was a two-centre study with a majority of patients from these centres with a small sample size. A multicentre study in several centres with the inclusion of more patients is needed to evaluate the accuracy of CCTA. Sensitivity and positive predictive values were low in this study due to fewer segments with true positive cases and the inclusion of calcified extensive plaque burden segments. While assessing the degree of stenosis in CCTA, clear assessment of diffuse lesions, and ectatic lesions were difficult to compare, especially in bridging segments that may have affected the results of the study, including the collaterals in chronic total occlusion lesions and associated branches. Total occlusive stenosis was included in the severe stenosis category for invasive CAG, so the exact accuracy of such lesions couldn't be made. Apart from types of plaque and calcium score, adverse plaque characteristics were not evaluated in this study so the prognostic ability of the tests couldn't be utilized. So, a further study involving multi-centre including large sample size and exclusion of calcified extensive plaque burden segments for evaluation with the use of

CCTA is needed to minimize these limitations and increase overall sensitivity and positive predictive values.

Conclusion

CCTA has proven to have a high diagnostic accuracy compared with CAG, which is until now the standard of reference for evaluating coronary artery disease. CCTA has been the initial test for diagnosing CAD in symptomatic patients in whom obstructive CAD cannot be excluded by clinical assessment alone with an intermediate pre-test probability of CAD as per recent ESC and AHA/ACC guidelines. In all, enhanced 320-slice row detector CCTA demonstrates good negative predictive value as supported by this study to rule out obstructive CAD so that invasive CAG can be avoided. Also, sensitivity and positive predictive value are such that it can be used as a good screening test in subjects with low to intermediate likelihood of coronary artery disease provided that the sample size is adequate with true positive cases and exclusion of calcified extensive plaque burden segments for proper segment evaluation. In addition, characterization of plaque and its types, calcium score calculation and interpretations, use of Novel Coronary Artery Disease-Reporting and Data System (CAD-RADS) scores, and prediction of future events of MACE can be predicted by CCTA which is not adequately assessed by invasive CAG which not only helps to halt the disease course but is also overall cost-effective in long run.

Conflict of Interest

None

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None

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