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Role of Computed Tomography Coronary Angiography Imaging in Assessment of Unstable Angina

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Abstract

Objectives: *We sought to evaluate the role of non-invasive Multidetector computed tomography angiography (CTA) in the assessment of the causes of unstable angina.*

Background: *Detection of coronary artery disease (CAD) using invasive coronary angiography needs extended time, contrast load, and high radiation exposure.*

Methods: *160 slices CTA was performed in 50 patients (38 men, mean age 55.48 ± 10.88years) symptomatic patients diagnosed as unstable angina. In this study, the mean coronary artery calcium score (CACS) was 204. Statistically higher CAC was found in patients ≥ 60 years old than those < 60 years. Female patients, hypertensives and diabetic patients show slightly higher (but not significant) level of CAC. Among 50 patients complaining of unstable angina we found 11 patients having normal CTA, four having dense coronary calcification, 21 having non-significant obstructive lesions, and 14 patients having significant CAD. We found significant relation between calcium score and the significance of CAD. We detected 70 plaques (29 of them caused significant stenosis) distributed in all coronary arteries. The most commonly affected artery was the LAD, followed by LCX then RCA and the small branches had only 14 plaques. According to the type of plaques, 45 plaques were mixed, five plaques were calcified and the last 20 were soft plaques. We found no significant difference in the significance of stenosis was detected in relation to the number of vessels affected.*

Patients were classified into Low, Intermediate, and High probability of CAD. We found significant relation between the pre-test probability and the significance of CAD.

Conclusions: *Multi-detector CTA allows accurate non-invasive assessment of patients presented with unstable angina.*

Introduction

Computed tomography angiography (CTA) is employed as non-invasive technique for detection of atherosclerosis and evaluation of obstructive CAD. This has led to its usage in awide range of patients suspected to have CAD with high diagnostic accuracy(1).

Conventional coronary angiography is the gold standard technique for identification of CAD, however, it carries risk of potentially risky complications, such as arrhythmia, coronary artery dissection, stroke, embolic events, and myocardial infarction(2).

Multi-detector CT including electrocardiogram-gated scanning and variable reconstruction techniques have made imaging of the coronary artery luminal patency and atherosclerotic plaque burden within the wall possible. In patients carrying high risk for CAD, the degree of coronary artery stenosis can be accurately assessed with CTA, as compared to the findings of conventional coronary angiography[3].

The literature continues to show the progression of the role of CT in the evaluation of CAD with advances in CT. However, cardiac CT did not gain confidence till the recent years. The old CT machines had limited ability to display cardiac morphology because of the effect of continuous cardiac motion and the low spatial resolution. The diameter of coronary arteries (ranging from 3 to 1.5 mm necessitates the spatial resolution to be at least 1 mm. Because of the cardiac motion, temporal resolution also was not adequate to display the heart. That is why, until the last few years, invasive coronary angiography was the only sensitive way for coronary vessels imaging[4].

In practice, CTA is usually used to detect the presence and extent of CAD as well as to exclude significant luminal stenosis. It shows high sensitivity and negative predictive value in evaluation of patient classified as having low-to-intermediate pretest probability for CAD. ECG-gated cardiac CT has the ability to get cine images to assess the left ventricular contractility and to detect regional wall motion abnormalities. Myocardial perfusion defects and delayed contract enhancement can also be assessed [5].

Materials and methods

Patients: This study was conducted on 50 patients who presented with unstable angina, referred to the radiology department at Al-Zahraa University hospital for imaging evaluation.

Inclusion criteria

* Patients with suspected coronary artery disease and recently showing one of the following:
  - Chest pain, dyspnea on exertion
  - Fatigue on mild effort
  - Typical ischemic chest pain.

Exclusion criteria

- Allergy to iodinated contrast media
- Absence of normal sinus rhythm
- Impaired renal functions
- Heart failure.

Patients with heart rate >60 beat/min received β-blocker; 100 mg atenolol orally 1 hour before the scan.

Table 1: Study population characteristics

Parameter	
Age, years, Mean ± SD.	55.48 ± 10.88
Gender, Male	38 (76%)
Hypertension	35 (70 %)
Diabetes Mellitus	26 (52 %)
Current smoking	27 (54 %)
Dyslipidemia	29 (58 %)
Family history of CAD	35 (70 %)
Coronary artery calcium score, Mean ± SD.	204.80 ± 289.09

Data are means ± SD or n (%).

CT scan protocol: A non-enhanced examination is done first to detected coronary artery and cardiac structural calcifications. The non-contrast examination extended to include the whole cardiac field. The score for all vessels is calculated by the Agatstonscoring system[6, 7].

All patients were scanned using a 160-slice CT scanner (Toshiba Multi-Slice Aquilion PRIME, Toshiba Medical Systems, Tokyo, Japan). The system has two X-ray tubes along with 2 corresponding detector. The scan parameters were detector collimation: 32 × 0.6 mm; gantry rotation time: 400 ms; temporal resolution: 83 ms; slice acquisition: 64 × 0.5 mm; pitch: 0.2– 0.47 adapted to the heart rate; tube potential: 120 kV; tube current: 600mAs/rotation. Scanning was done in a single breath hold. ECG was used to reduce the radiation dose by modifying tube current. Synchronization of data reconstruction with ECG signal was done by retrospective gating technique. Best reconstructions (either systolic or diastolic) were made. The reconstruction had the least motion artifacts was used for further analysis [8].

A80-100 ml bolus of non-ionic contrast (Ultravist 370, Schering AG, Germany) was injected followed by a saline chaser. The flow rate ranged from 4.0 to 5.0 ml/saccording to the scan range and the required scan time[9].

CT image reconstruction and evaluation: Reconstruction of CT datasets was done using a single-segment algorithm: slice thickness 0.75 mm; increment 0.4 mm; with a spatial resolution of 0.6 to 0.7 mm in-plane and 0.5 mm through-plane [8]. Images reconstruction through a stepwise approach was done depending on the patient's heart rate during scanning [10,11].

The quality of acquired images was classified as good (no image-degrading artifacts due to motion or noise), moderate (moderate confidence in assessment despite presence of artifacts), or poor (low confidence of evaluation due to image-degrading artifacts). Continuous monitoring of the ECG was performed during the examinations, and all image acquisitions were acquired within single inspiratory breath-hold [12].

The medical ethics was considered. The patients had full knowledge of the examination. Patient's written consent was obtained and the patient had to get benefit from the examination.

Coronary artery interpretation: The interpretation depends on systematic review of each coronary segment from different planes, knowledge of relevant artifacts, assessment of plaque morphology and composition, and detection of degree stenosis severity using different images including MPR format[12].

Coronary segmentation: To improve description of findings, a standard approach for coronary segmentation is used according to Society of Cardiovascular Computed Tomography guidelines for the reporting of coronary CTA. Plaques have been considered in relationship to their segmental position. Assessment of the effect of the plaque relied on the maximum diameter stenosis and area stenosis. Coronary CTA also can detect presence of intramural plaques and their nature[13, 14].

Quantitative assessment of stenosis severity: Using digital tools, quantification of the diameter stenosis, area stenosis, and extent of plaque is available.

Recommended Quantitative Stenosis Grading

0 Normal: Absence of plaque or luminal stenosis

1 Minimal: Plaque exerting <25% stenosis

2 Mild: 25%–49% stenosis

3 Moderate: 50%–69% stenosis

4 Severe: 70%–99% stenosis

5 Total occlusion.

Results

In this study, four patients had high dense coronary calcification (> 1000) and their CT study ended at this step. Among the remaining 46 patients, 14 patients had zero calcium score, 10 patients had CACS ranged between 1-99, 19 patients had CACS ranging between 100-399 and only three patients had CACS ranging between 400-999. The mean CACS was 204.

In our study, 40 patients had right dominant circulation, eight patients had left dominant circulation and only two had co-dominant circulation.

In the present study, we found statistically higher CAC in patients ≥ 60 years old than those < 60 years. Female patients, hypertensives and diabetic patients show slightly higher (but not significant) level of CAC.

Among 50 patients complaining of unstable angina we found 11 patients having normal CTCA, four having dense coronary calcification, 21 having non-significant obstructive lesions, and 14 patients having significant CAD.

In our study we found significant relation between calcium score and the significance of CAD with increasing percentage of significant stenosis with increasing CAC reaching 66.7 % in CAC ranging 400-999.

In our study, we detected 70 plaques (29 of them caused significant stenosis) distributed in all coronary arteries. The most commonly affected artery was the LAD, followed by LCX then RCA and finally the small branches. According to the type of plaques, 45 plaques were mixed, five plaques were calcified and the last 20 were soft plaques.

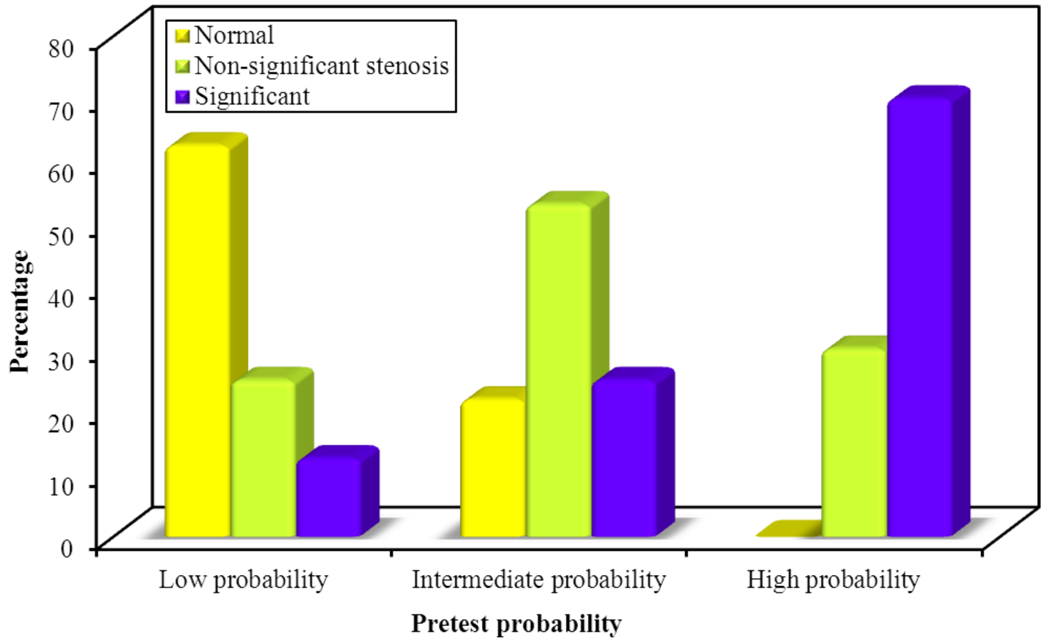
We found 15 patients having single vessel affection; only six of them had significant CAD. 20 patients had multi-vessel affection; eight of them had significant CAD. No significant difference in the significance of stenosis was detected in relation to the number of vessels affected.

According to pretest probability (depending on age, gender and character of chest pain), we classified patients into three groups; low, intermediate, and high probability of CAD. We found significant relation between the pre-test probability and the significance of CAD with all patients with high pretest probability had CAD, and 70% of them had significant CAD.

Table (2) Descriptive analysis of significance of CAD according to level of CACS

	CACS								MCp
	Zero (n = 14)		1 - < 100 (n = 10)		100 - < 400 (n = 19)		400 - < 1000 (n = 3)		
	No.	%	No.	%	No.	%	No.	%	
Normal	10	71.4	1	10.0	0	0.0	0	0.0	<0.001*
Non-significant CAD	2	14.3	6	60.0	12	63.2	1	33.3	
Significant CAD	2	14.3	3	30.0	7	36.8	2	66.7	

Figure (1) Relation between the pretest probability and findings in CTCA



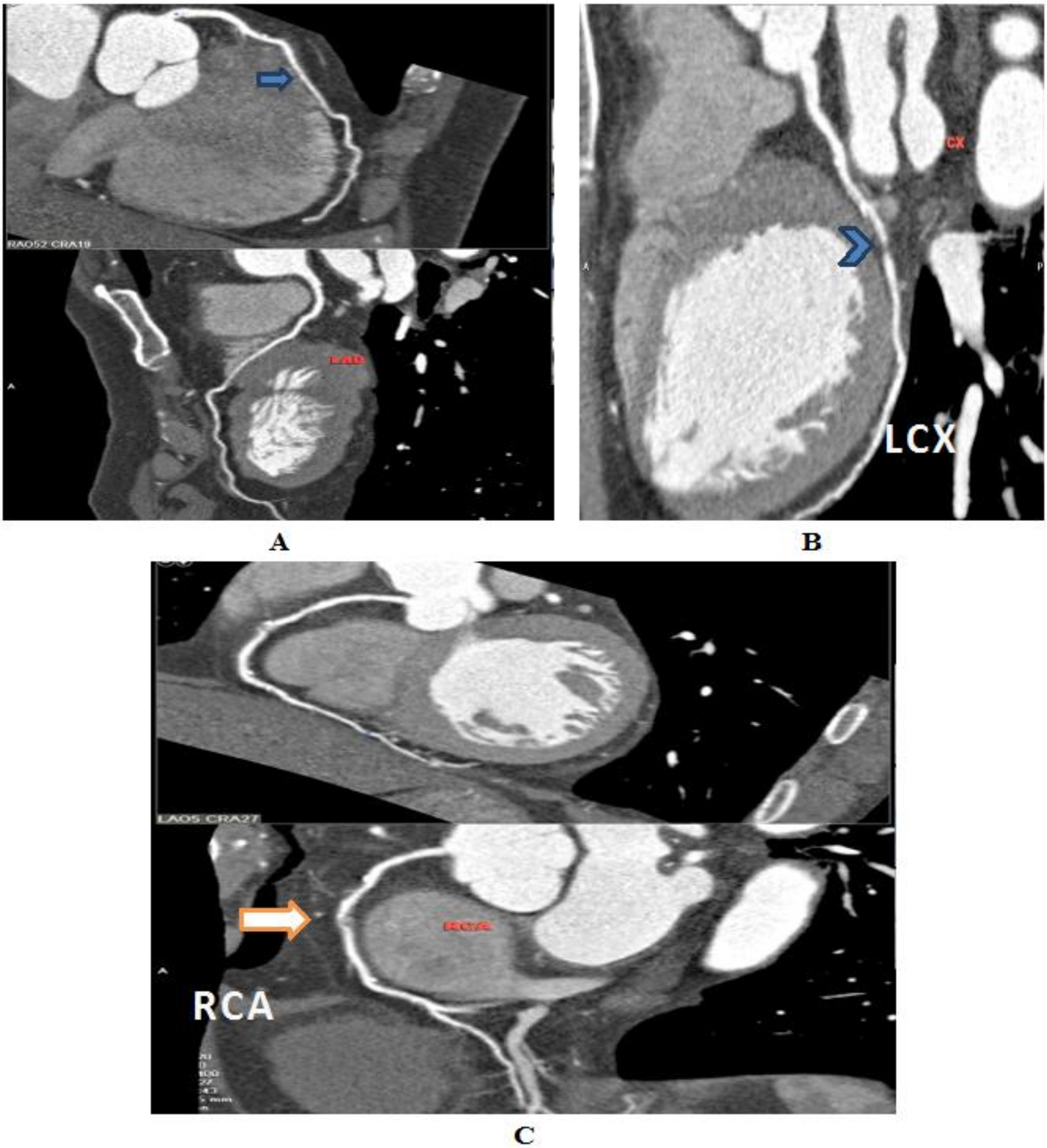


Figure (2) A sixty year old male patient diabetic and hypertensive presented with dyspnea on exertion. (A) Curved MPR shows normal course and opacification of the LAD (Blue arrow). (B) Curved MPR shows tight stenosis proximal LCX (Arrow head). (C) Curved MPR shows moderate lumen encroachment segment 2 RCA (White arrow).

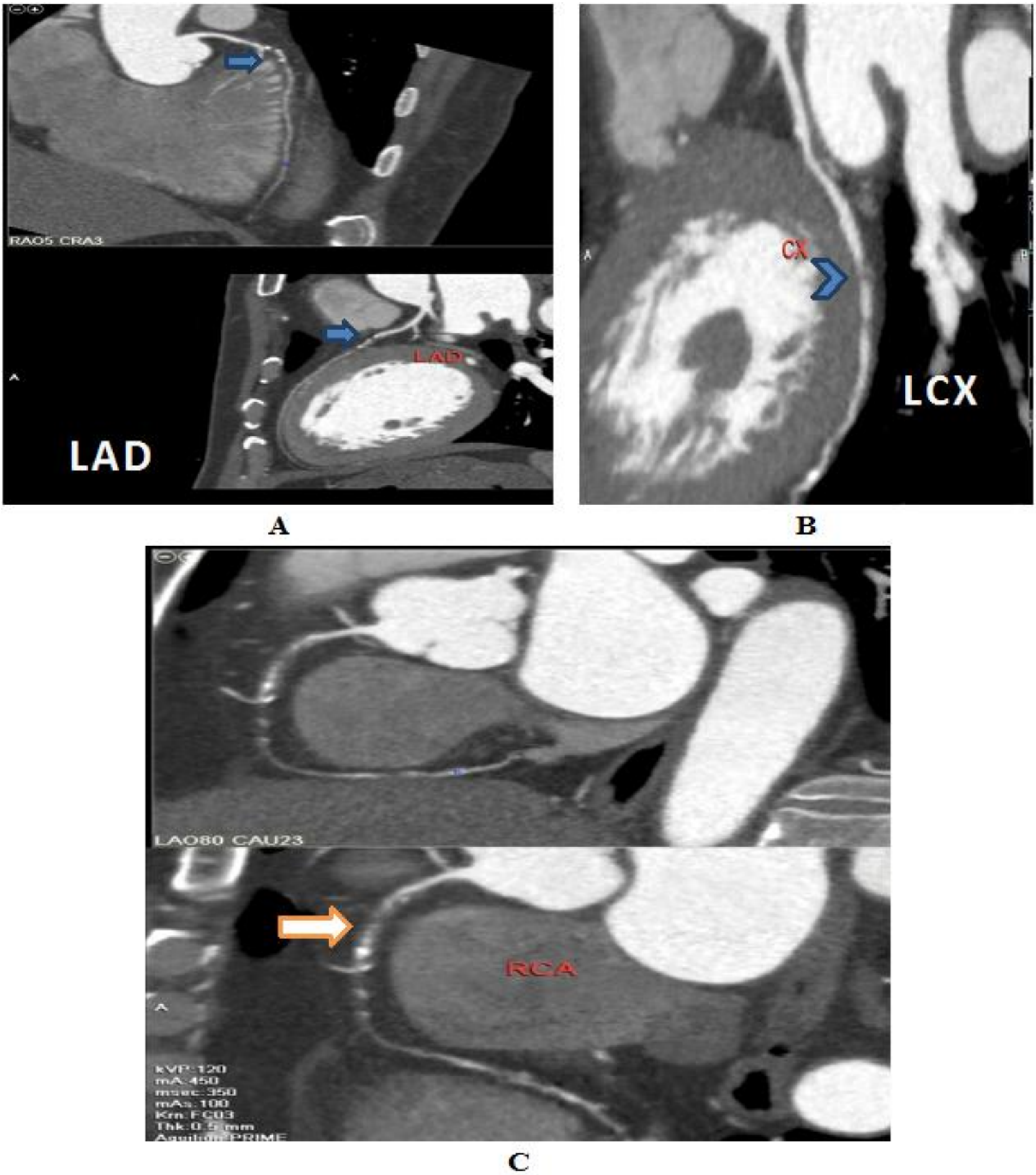


Figure (3) A 63-year old male patient had hypertensive and heavy smoker presented with unstable angina. (A) Curved MPR shows near total occlusion proximal LAD (Blue arrows) with distally diffusely diseased artery. (B) Curved MPR shows proximal Om moderate to tight stenosis (Arrow head). (C) Curved MPR shows near total occlusion of the RCA (White arrow) with distally diffusely diseased artery.

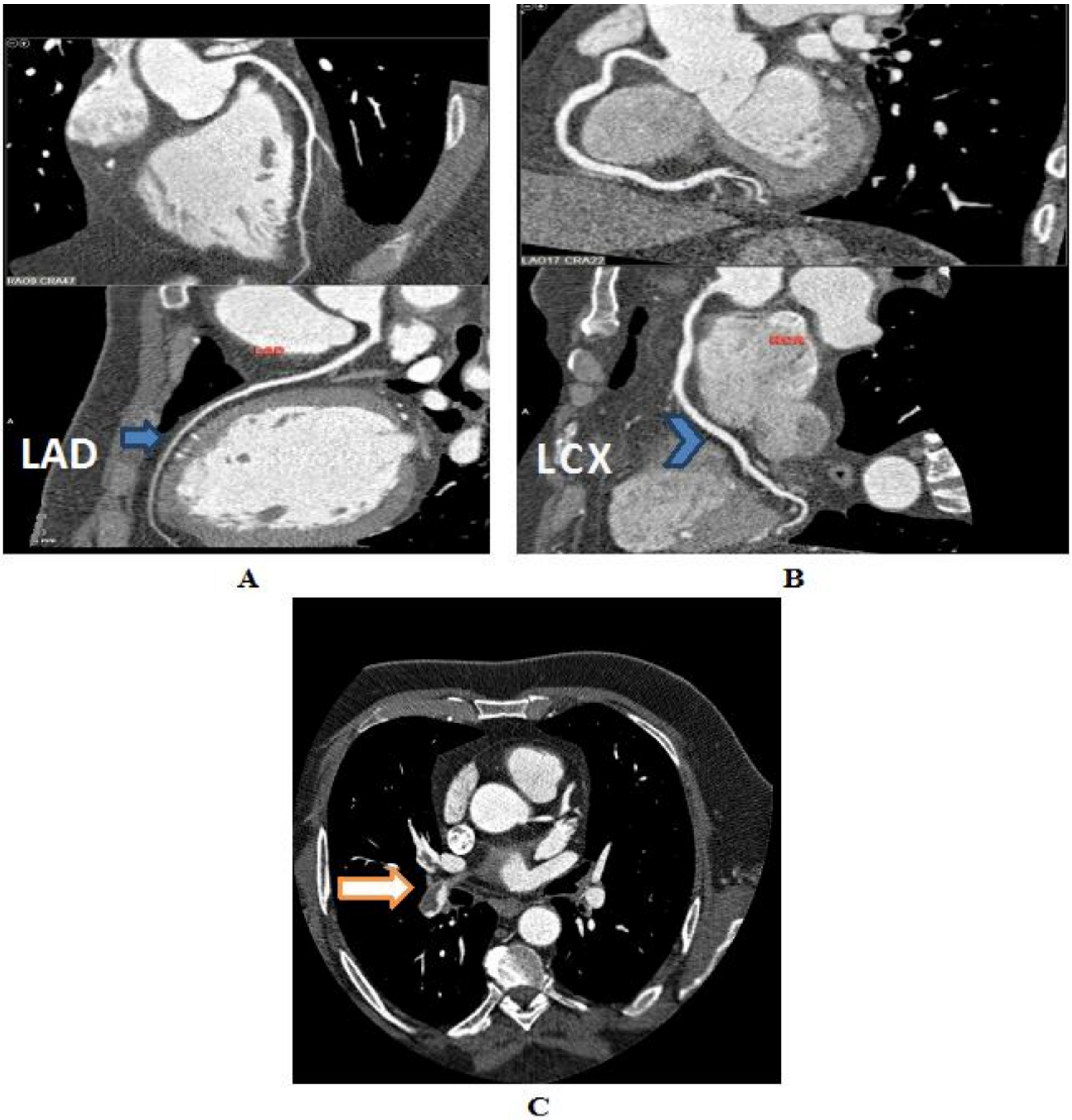


Figure (4) A sixty-three year old male diabetic patient presented with chest pain. (A) Curved MPR shows normal and good opacification of the LAD (Blue arrow). (B) Curved MPR shows normal course and good opacification of the LCX (Arrow head). (C) Axial CT image shows extensive bilateral pulmonary embolism (White Arrows).

Discussion

Cardiac CTA is a demanding task. Imaging of coronary arteries needs high spatial resolution as well as high temporal resolution to get motion-free imaging of the heart. Submillimeter spatial resolution is mandatory to be able to view the small branches of the coronary arteries. This is associated with the use of ECG-synchronized techniques, segmentation, and detailed reconstruction algorithms. Elimination of respiratory motion is a must, so scanning is ideally done during a single breath-hold.

The current study was conducted on 50 patients who presented with unstable angina and scheduled for elective coronary CTA between October 2016 and January 2018. All patients came complaining of dyspnea or fatigue on exertion or ischemic chest pain.

In this study, four patients had high dense coronary calcification (> 1000) and their CT study ended at this step.

Among the remaining 46 patients, 14 patients had zero calcium score, 10 patients had CTCS ranged between 1-99, 19 patients had CACS ranging between 100-399 and only three patients had CACS ranging between 400-999. The mean CACS was 204.

The mean of CACS was close to Meijs et al,[15] who examined 127 patients with mean CACS averaging 216. This differs from Miller et al,[16]who examined 291 patients with mean CACS averaging 140.

Female patients show slightly higher level of CAC (average is 217.17 in females and 200.89 in males, P value > 0.05).

This differs from Niazi et al,[17]who found that male patients show higher level of CAC (469.3) compared to female patients (232.3) with P value< 0.05. In 2010, Chu et al,[18] found that men had more calcified plaques.

Hypertensive patients show higher (but not significant) level of CAC compared to normotensive patients (average is 239.49 in hypertensives vs. 123.87 in normotensives, P value > 0.05). Also diabetic patients show higher (but not significant) level of CAC compared to non-diabetic patients (average is 235.42 in diabetics vs. 171.63 in normotensives, P value > 0.05)

In the present study we found that the frequency of CAD among all patients complaining from recent chest pain was 78%. Among 50 patients complaining of unstable angina we found 11 (22 %) having normal CTCA, four (8 %) having dense coronary calcification, 21 (42%) having no significant obstructive lesions, and 14 patients (28%) having significant CAD.

This is close to Dedic et al,[19]who examined 392 patients, 114 (30 %) of them show no plaques at all, 155 (41%) show non-significant plaques and 110 (29%) show significant plaques.

This slightly differs from Newby et al,[20] who found that 654 patients (37%) show normal CTA, 672 (38 %) of patients show non-significant CAD and 452 (25%) show significant CAD.

In our study, 28 patient (71.8 %) with CAD were hypertensive, 14 (50%) of them had significant CAD, while 11 (28.2 %) patients were normotensive, 4 (36.4 %) of them had significant CAD.

This is close to Zeina et al,[21]where the percentage of their hypertensive patients having CAD reached 28%. Obstructive CAD was as twice as common in hypertensive patients

In our study, 19 patient (48.7 %) with CAD were diabetics, 10 (52.6%) of them had significant CAD, while 20 (51.3 %) patients were non-diabetics, 8 (40 %) of them had significant CAD.

This is similar to Chu et al,[18]who examined 480 plaques, 242 (50.4 %) of them were non-significant and 238 (49.6 %) of them were significant.

In our study, 22 patient (56.4 %) with CAD had hyperlipidemia, 10 (45.5%) of them had significant CAD, while 17 (43.6 %) patients had no hyperlipidemia, 8 (47.1 %) of them had significant CAD.

In our study, we found no relation between positive family history of IHD and CAD; 13 patient (33.33 %) with CAD had positive family history of CAD, 6 (46.2%) of them had significant CAD, while 26 (66.66 %) patients had no positive family history, 12 (46.2 %) of them had significant CAD.

This differs from Otaki et al,[22] who found that young patients having positive family history have higher extentand severity of CAD.

In our study we found significant relation between calcium score and the significance of CAD. Zero calcium score was detected in 14 cases (28%) of all examined patients, two of them (14.3%) had significant CAD and two had non-significant CAD.

Villines et al,[23]studied the severity of CAD in patients with zero CAC score and found that 13% of the patients had non-obstructive stenosis, only 3% hd ≥ 50% stenosis, and 84% had normal CTCA.

Three patients (6%) had calcium score ranged 400-999, two of them (66.7%) had significant CAD and only one (33.3%) had non-significant CAD.

This is close to Hanifehpour et al,[24]who found the at the cut-off point of 100 for coronary calcium scoring, there was high specificity (87%), high sensitivity (79%), high efficiency (84%), high positive predictive value (79%), and high negative predictive value (87%) in the diagnosis of significant stenosis in the whole heart. Severity of arterial stenosis increased with increasing of calcium scoring(P values < 0.001).

This is also close to Koulaouzidis et al,[25] in their study ‘‘CTCA as Initial Work-Up for Unstable Angina Pectoris’’ found that among 43 patients there were 26 (60.5%) having CAD. Among 43 patients, 17 (39.5%) had normal CTCA, 22 (51.1%) had no significant lesion, and only 4 (9.3%) had a significant obstructive lesion

In our study, we detected 70 plaques distributed in all coronary arteries. The most commonly affected artery was the LAD which had 29 plaques representing 41.4 % of all plagues. The LCX had 12 plaques (17.1 %), the RCA had 15 plaques (21.4 %) and the small branches had 14 plaques.

This is close to Madhok et al,[26] who detected 187 plaques affecting all coronary arteries, 60 plaques (32.1 %) were detected in the LAD, 40 plaques (21.4 %) were affecting the LCX, 44 plaques (23.5 %) were seen in the RCA and 29 plaques (15.5 %) were detected in the small branches.

This slightly differs from Niazi et al,[17] who detected 60 plaques affecting all coronary arteries, 24 plaques (40 %) were detected in the LAD, nine plaques (15 %) were affecting the LCX, 18 plaques (30 %) were seen in the RCA and seven plaques (11.6 %) were detected in the small branches.

Among these 70 detected plaques, 29 of them (41.4 %) were significant and 41 plaques (58.6 %) were non-significant,

This is close to Chu et al,[18] who detected 480 plaques, 238 of them (49.6 %) were significant and 242 plaques (50.4 %) were non-significant.

This differs from Madhok et al,[26] who detected 187 plaques, 96 of them (51.3 %) were significant and 88 plaques (48.7 %) were non-significant.

The significant plaques in our study were 29, the most commonly affected vessel was LAD showing 10 plaques (34.5 %), five plaques (17.2%) were detected in the LCX, seven plaques (24.1 %) were detected in the RCA and seven plaques (24.1 %) seen within the small branches.

This is close to Madhok et al,[26] who detected 96 significant plaques, 43 of them (44.7 %) were affecting the LAD, 17 plaques (17.7 %) were affecting the LCX, 19 plaques (19.8 %) were affecting the RCA and 14 plaques (14.6 %) were seen within the small branches.

According to the number of affected vessels, we found 15 patient having single vessel affection only six (40 %) of them had significant CAD. 20 patients had multi-vessel affection eight of them (40 %) had significant CAD. No significant difference in the significance of stenosis was detected in relation to the number of vessels affected.

This is close to Newby et al,[20] who examined 452 patients with significant CAD, 207 of them (45.8 %) had single vessel affection and 245 of them (44.2 %) had multi-vessel affection.

This differs from Meijboom et al,[27] who examined 100 patients with significant CAD, 53 of them (53 %) had single vessel affection and 47 of them (47 %) had multi-vessel affection.

No significant relation was found the number of vessels affected in diabetic and non-diabetic patients (P value > 0.05).

This differs from Chu et al,[18] who examined the characteristics of coronary artery disease in symptomatic type 2 diabetic patients and found number of patients with multi-vessel (≥2) disease was significantly higher than that with single-vessel disease (85 of 113 (75.2%) vs. 28 of 113 (24.8%), p < 0.001).

In our study we had 39 patients having coronary origin of the chest pain, four patients had extra-cardiac cause of chest pain and seven had no detected cause.

The extra-cardiac causes of chest pain were extensive bilateral pulmonary embolism, Stanford type B aortic dissection, diaphragmatic eventration and pneumonic consolidative patch with mild pleural effusion.

According to pretest probability of CAD, patients were classified into three groups; 16% of patients had low probability, 64% had intermediate probability and 20% had high probability for CAD. We found significant relation between the pre-test probability and the significance of CAD. This is close to Meijboom et al[27] who studied patients with pretest probability of CAD in the high, intermediate, and low groups was 87%, 53%, and 13%, respectively. CT diagnostic performance was different in the different subgroups. The post-test probability of the presence of significant CAD after a positive CT scan was 96%, 88%, and 68%, respectively.

Conclusions

- The conventional angiography is the reference technique for assessment of coronary arteries in patients with CAD, still it has multiple complications.
- Non-invasive imaging of the coronary artery lumen and atherosclerotic plaque burden is possible using ECG-synchronized CTA.
- Higher quality and better non-invasive assessment of the coronary arteries are now established with recent advances in multi-detector CT technology.
- The results of coronary CTA can add important prognostic information regarding a patient's risk of future major cardiac events, and guide the initiation of preventive therapies.
- Coronary CTA can detect CAD, evaluate the degree of obstruction and determine number of affected vessels so it can be used in workup in patients with unstable angina.

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