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ORIGINAL ARTICLE

Role of Multi-slice CT Coronary Angiography and Coronary Arteries Calcium Score in Evaluating Patients with Anginal Pain

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ABSTRACT

Keywords: coronary angiography, CAD, calcium score, unstable angina.

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Background: One of the most prevalent complaints is chest pain; it may be cardiac or not. The most common cause is coronary atherosclerosis. **purpose:** Assess the coronary artery disease in angina patients with CT coronary angiography (CTA), a noninvasive technique. **Subjects and methods:** This study was conducted on 25 patients with angia chest pain. They underwent CT coronary angiography and Ca score estimation. **Result:** Among 25 patients complaining of recent-onset chest pain, 11 patients (44%) had normal CTCA, 8 patients (32%) had non-significant CAD, and 6 patients (24%) had significant CAD. In our study of 28 vessels, the most common affected vessel was the LAD artery, which was affected in 52% (13/28) of affected arteries, compared to the RCA, which was affected in 28% (7/28), the LCx, which was affected in 24% (6/28), and the LM, which was affected in only 8% (2/28) of the affected arteries. **Conclusion:** Coronary CT scans can be utilized as a non-invasive technique in the evaluation of patients with unstable angina as they can identify coronary artery disease (CAD), assess the level of blockage, and count the number of affected arteries.

INTRODUCTION

Cardiovascular disease (CVD) is a broad term used to address a constellation of diseases which affect the heart and vascular system. It remains the most common cause of death in the world **(1)**.

Coronary artery calcium (CAC) is considered a highly specific feature of coronary atherosclerosis **(2)**.

Vascular calcification was accepted until recently as an inevitable result of aging, and the development of CAC was considered a passive process. The development of CAC is now understood to be an active pathogenic process that is not inevitable, and mechanisms that underlie vascular calcification have been identified **(3)**.

In 1999 the first 'guidelines' for the clinical use of CAC scoring were published. Pathologic data had shown that CAC was pathognomonic of coronary atherosclerosis and that the area of calcification had a direct relationship to coronary atherosclerotic plaque area by direct histomorphologic examination **(4)**.

Coronary angiography using computer tomography has been suggested as a less invasive diagnostic technique. The detection of CAC by non-contrast CT scanning could represent an alternative diagnostic and prognostic tool. The CAC score provides a quantitative assessment of the overall atherosclerotic burden, a measure not readily available with other forms of testing. The CAC score has been shown to reliably predict events among various categories of subjects studied [(5)].

The rapid rise of coronary computed tomographic (CT) angiography from a research application to widely embraced clinical tool over the last decade has very few parallels in medicine. We currently observe a convergence of factors that has the potential of making coronary CT angiography a pivotal cornerstone in cardiovascular disease management, deserving the highest level of attention of our field [(6)].

Many CAD patients are asymptomatic, and early detection and treatment of CAD can reduce the incidence of acute myocardial infarction. Identifying the coronary arterial plaque pattern can provide more effective treatment methods. Non-calcified plaque has been shown to have a higher tendency to regress in response to established medical therapies [(7)].

Chest pain is a nonspecific symptom that can have cardiac or non-cardiac causes. The term angina is reserved for pain syndromes arising from presumed myocardial ischemia [(8)].

Multiple studies have shown that coronary artery stenosis can be identified with high sensitivity, specificity, positive predictive value, and negative predictive value via coronary computed tomography angiography (CCTA), given a sufficiently high image quality [(9)]. Our study aimed to evaluate the coronary artery disease among patients with angina pain by the role of multi-slice CT coronary angiography as a non-invasive technique.

Patients & Methods

Informed consent was obtained from all patients after being informed about the aims and process of the study as well as applicable objectives.

Study setting and design: A prospective observational descriptive study was conducted at the Department of Diagnostic and Interventional Radiology, Aswan University Hospital.

Inclusion criteria: All patients with intermediate pretest probability of CAD and no ECG changes and serial enzymes negative.

Exclusion criteria:

1. Pregnant women.
2. Previous MI, CABG, and Percutaneous coronary intervention.
3. Irregular heart rate.
4. Contraindications to iodine contrast.
5. Renal insufficiency (creatinine level 1.5 mg/dl).
6. Inability to sustain a breath holds for 8 s.

Methodology: All patients were subjected to full history taking; the data include demographic criteria (age, gender, and smoking history) and history of chest pain.

Patient preparation:

1. An IV line in the right arm is preferred.

2. All patients were instructed to fast 4–6 h prior to the examination with no discontinuity of their medications.
3. Mild oral sedation with diazepam (5 mg) was sometimes given 45 min prior to scan in particularly anxious patients.
4. Beta blockers were not administrated to all our patients; only those with heart rate above 75 bpm were given beta blockers (50 mg Atenolol) 45 min prior to the examination (contraindications to B blockers are excluded). This leads to increasing the diastolic phase of the cardiac cycle, which facilitates the acquisition process.

Procedure:

1. Preparation excludes any contraindication for the examination.
2. Informed consent mentioning all the examination details and the undergoing research.

The examination protocol as follows: The MDCT datasets were acquired using (Toshiba 160 slice Aquilion prime CT scanner).

1. A non-contrast scan will be performed to determine the calcium score.
2. Contrast material: A bolus of 70–80 ml of non-ionic contrast media.
3. The contrast-enhanced ECG gated scan will be obtained within one single breath-hold.
4. The obtained axial images were reconstructed using different reconstruction techniques on an advanced workstation.

Image acquisition:

- ***Scanogram:*** an AP view of the chest that is used to position the imaging volume of the coronary arteries that extends from the level of the carina down to about 1 cm below diaphragm. The center of the field of view is 2 cm to the left of the dorsal spine on the AP scout.

- ***Calcium score:*** Any area highlighted, which clearly represented CAC, was identified as a region of interest. Sequential axial sections were analyzed. The total calcified area (the score) was then calculated by the workstation software as equivalent Agatston score. If there was extensive calcification (CAC Score >1000), the CT examination ends at this step.
- ***Image reconstruction:***

A slice thickness of 0.6 mm reconstructions was used. The reconstruction of images at the workstation is a time-consuming process, aimed to select the most appropriate set of images for coronary artery visualization, avoiding those reconstructions with artifacts due to cardiac motion.

The reconstructed axial images at different points of the cardiac cycles are sent to an off-line workstation (Advanced workstation VITREA for images acquired via the definition dual source 160-multichannel system).

For analysis of the small and tortuous coronary arteries, it is of utmost importance to keep the reconstructed slice thickness for the coronary axial slices as thin as possible. A slice thickness of 0.6 mm reconstructions was used. The reconstruction of images at the workstation is a time-consuming process, aimed to select the most appropriate set of images for coronary artery visualization, avoiding those reconstructions with artifacts due to cardiac motion.

- ***Multi-slice CT coronary angiography:***

As a general rule in the CT definition of Toshiba the optimum phase of the cardiac cycle when all the coronary arteries are best visualized is the best diastole phase (usual range is 70–80% of the R–R interval of the cardiac cycle) in case of heart rate less than 75 b/m while it is the best systole phase (usual range is 40–50% of the R–R interval) in case of heart rate more than 75 b/m. The ECG recorded during the acquisition examined to look for exaggerated cycle variability and/or premature beats that could introduce artifacts in the images. For the aim of visualization of a lesion like/artifact in any segment of the coronary arteries, the whole cardiac phases are examined in an attempt to prove artifact and exclude true lesion.

Multiple post-processing techniques were used as automatic (and manual) volume rendering techniques (VRT, which were generally used to ascertain the morphology and course of the vessels), Multiplanar Reconstructions (MPR) and Maximum Intensity Projections (MIP).

Identification of coronary artery segments was based on the model suggested by the American Heart Association (AHA).

Evaluation of composition and morphology of the lesion. In regard to the composition of the plaque, a distinction was made between calcified and non-calcified plaques. Plaques with a mean attenuation of 130 HU or greater were graded as calcified, whereas plaques with a mean attenuation of less than 130 HU were graded as non-calcified.

Calcified plaques were identified on non-enhanced scans, and non-calcified plaques were identified on contrast enhanced scans.

Qualitative and quantitative assessment of obstruction of the vessel caused by the lesion.

A classification of atherosclerotic coronary artery lesions Is possible by applying this systematic analysis of MDCT.

This classification can be made according to the following aspects:

- The number of vessels involved.
- The location: proximal, middle or distal portions of the vessel.
- The extension of the lesion: focal or diffuse.
- The degree of obstruction.

a. Non-significant stenosis (less than 60 % of the vessel lumen, including mild and moderate degrees of obstruction).

b. Significant stenosis (equal or more than 60 %, including critical subocclusive and occlusive lesions.

The components of the lesion:

a. Non-calcified, mixed, or ‘‘soft’’ lesions.

b. Calcified lesions: The calcium component of the lesion can be focal, diffuse, eccentric or concentric.

Statistical analysis:

All statistics were performed using SPSSversion25 (BMCorp.Released 2017.IBMSPSS Statistics for Windows, Version 25.0 Armonk ,NY : IBM Corp.) .Continuous data were presented as mean ± SD and range .Qualitative variables were expressed as frequency (percentage). Analysis of continuous data with normal distribution were analyzed by appropriate parametric test and non-normally distributed data by appropriate non-parametric test. Categorical data was analyzed by chi-square test or Fischerexact where applicable. P value of <0.05 defined as statistically significant.

Results

This study was conducted on 25 patients with angina pain with intermediate pretest probability of CAD and no ECG changes and serial enzymes negative. The patients were examined by MDCT to detect the efficacyand sensitivity of CTA as a noninvasive method to diagnosis.The age of the studied group ranged from 40– 70 years with mean± SD of 58.88±9.15 years. The studied group included 13females (52%) and 12 males (48%).

Table (1): Socio-demographic data of the studied group (n =25).

		N=25
Age (years)	**Mean +/- SD** **Rang**	**58.88+/-9.15** **40-70**
Gender	**Male** **Female**	**12(48%)** **13(52%)**

Table (2):LM, LAD, CX, and RCA distribution of the study group.

	No	%
LAD	13	52
RCA	7	28
CX	6	24
LM	2	8

Table (3): Relation of significant stenosis according to pattern.

Pattern	Normal		Non-significant		Significant		Chi-square	
	No.	%	No.	%	No.	%	X2	p-value
Normal	11	100.0	0	0.0	0	0.0	32.824	**<0.001**
Diffuse	0	0.0	1	12.5	4	66.7		
Focal	0	0.0	7	87.5	2	33.3		

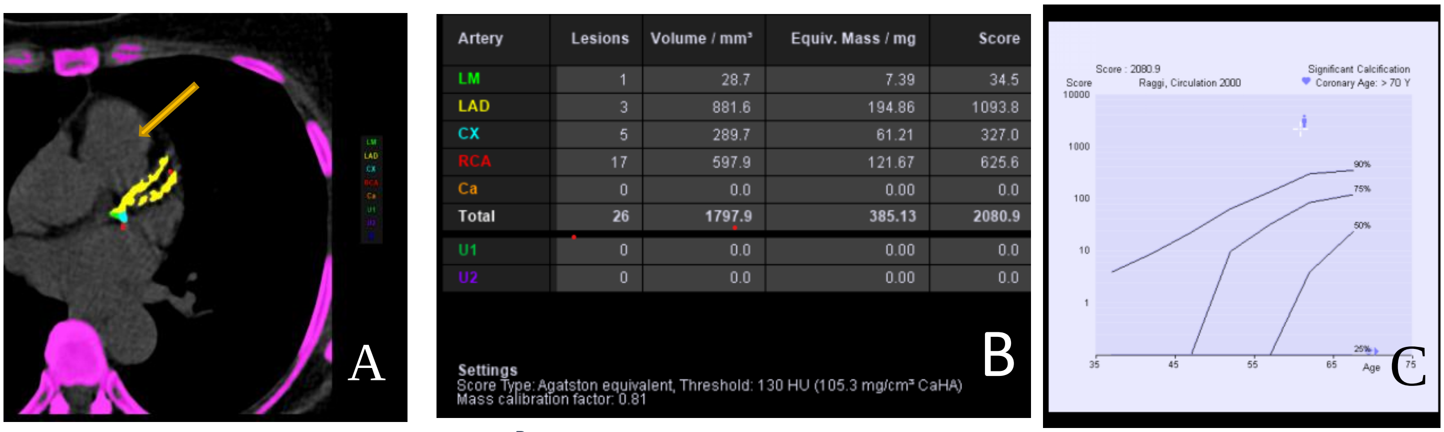
Table (4): Relation of significant stenosis according to plaque type.

plaque	Non-significant		Significant		Chi-square	
	No.	%	No.	%	X2	p-value
soft	3	20	7	58.3	32.824	**<0.001**
calcific	9	60	3	25		
mixed	3	20	2	16.7		

CASE PRESENTATION

Case 1

61 y female patient Diabetic and Hypertensive presented to Emergency room (ER)with acute chest pain ECG and cardiac enzymes are negative ,prepared CTA



Artery	Lesions	Volume / mm³	Equiv. Mass / mg	Score
LM	1	28.7	7.39	34.5
LAD	3	881.6	194.86	1093.8
CX	5	289.7	61.21	327.0
RCA	17	597.9	121.67	625.6
Ca	0	0.0	0.00	0.0
Total	26	1797.9	385.13	2080.9
U1	0	0.0	0.00	0.0
U2	0	0.0	0.00	0.0

Settings
Score Type: Agatston equivalent, Threshold: 130 HU (105.3 mg/cm³ CaHA)
Mass calibration factor: 0.81

A *B* *C*

Figure (1): (A)axial cut of non-contrast CT show dense calcification at the left anterior descending artery LAD (yellow arrow).(B&C) Ca score more than 1000 by Agatstone equivalent. The study was ended at this step.

Case 2

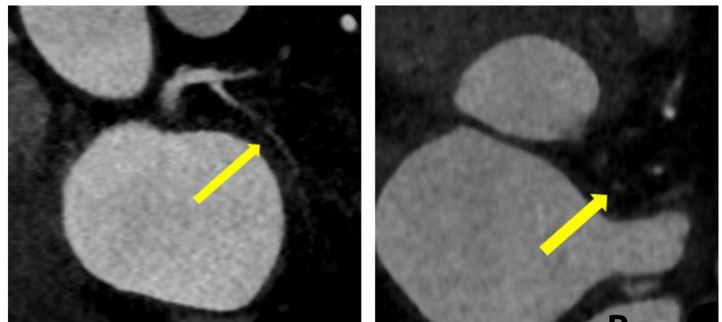
62y male patient diabetic, smoker and with positive family history of CAD

Presented to the ER with chest pain radiating to left shoulder and dyspnea

CTA with done after Ca score was less than 1000.

Artery	Lesions	Volume / mm³	Equiv. Mass / mg	Score
LM	1	31.8	5.48	36.6
LAD	7	289.0	73.04	364.0
CX	3	32.9	5.03	24.5
RCA	3	199.4	51.82	249.7
Ca	0	0.0	0.00	0.0
Total	14	553.2	135.37	674.8
U1	0	0.0	0.00	0.0
U2	0	0.0	0.00	0.0

A



B

A

B

Figure (2): (A)) Ca score more than by Agatstone equivalent.

(B) Reformatted cut of CTA show near total occlusion of LCX by a soft plaque (yellow).

C

DISCUSSION

In the current study, we discovered that 56% of patients who reported recent-onset chest discomfort also had CAD. There were 25 patients who reported recent onset chest pain; 11 (44%) had normal CTCA, 8 (32%) had non-significant CAD, and 6 (24%) had significant CAD.

These findings corroborated those of **Koulaouzidis et al.(2012)**(10), who found that among the 43 unstable angina patients included in their study, 17 had normal CTCA, 22 had non-significant lesions, and only 4 had severe obstructive lesions. One patient (10%) in our study had non-significant CAD, and one patient (10%) had substantial CAD out of the 10 patients with CACS=zero. Among 6 patients with CACS = 1–99, there were 2 patients (33.3%) who had significant CAD and one patient (16.6%) who had non-significant CAD.

There were 6 patients (75%) with non-significant CAD and 2 patients (25%) with substantial CAD among the 8 patients with CACS = 100–399.

The remaining patient, who had CACS 100, had severe CAD (100%).

Our findings were consistent with those of **Villines et al. (2011)**(11), who found that of CACS=0 individuals, 13% had non-significant stenosis, 3% had significant stenosis, and 84% had normal CTCA.

In a study conducted by **Chang et al. (2011)**(12), 795 patients had CACS = 0 (2.1% of them had CAD), 169 patients had CACS = 0.1–99 (9.5% of them had CAD), 60 patients had CACS = 100–399 (53.3% of them had CAD), and 23 patients had CACS = 100 (13.5% of them had CAD). With increased CACS, the chance of severe CAD rose. Similarly, a study (**Mohamed K. 2018)** (13) discovered that zero calcium scores were detected in 14 cases (28%) of all tested individuals.

Two of them (14.3%) had significant CAD, and two had non-significant CAD. In our study, we found a weak relationship between CAD and diabetes, as only 3 patients (21.4%) out of 14 patients with CAD were diabetic.

However, **Niazi et al. (2015)(6) found that** CAD was more common in diabetic patients (18,58%) than non-diabetic patients (13,42%). Also, significant stenotic lesions were more common in diabetic patients (70%) than non-diabetic patients (30%). Exactly as Bartnik et al. found in their prevalence study of patients with CAD across Europe in 2004, they found that 58% of patients had DM, 36% of them had impaired glucose regulation, and 22% were newly diagnosed.

In conclusion CTCA is crucial in the assessment of patients with suspected coronary disease. Computed Tomography Coronary Angiography (CTCA) is an emerging tool for the non-invasive assessment of coronary artery disease (CAD). CTCA does have some potential advantages over invasive angiography. The 3D volume acquisition allows an excellent appreciation of the anatomy of the coronary vessels and their relationships to other structures, as well as providing an opportunity to identify other pathologies that may present with coronary-type chest pain.

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