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Value of Multi-slice CT Calcium Scoring System and Coronary CT Angiography in Predicting and Evaluating the Coronary Artery Diseases in Patients with Stable Angina

Mai Abd El-Aziz Abd El-Aty Ads^{1*}, Mohamed Refaat Habba¹, El-sayed Hamed Zidan Bakr²,
Magdy Mostafa El-nisr¹, Mahmoud El-zoghbi¹, Ahmed Tohamy Ahmed¹

¹Department of diagnostic radiology, Suez Canal University Hospital

²Department of diagnostic radiology, Zagazig University

*Corresponding author: Mai Abd El-Aziz Abd El-Aty Ads

E-mail: Mairadiology@gmail.com

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Abstract

Background: Cardiac chest pain may be caused by either coronary artery disease (CAD) or non-CAD related etiologies. **Aim:** To identify the role of CTA coronary arteries in management plan of high and moderate risk coronary artery disease patients and prediction of coronary artery pathology in angina patients presenting with chest pain. **Patients and methods:** This was a cross-sectional analytic study conducted on 50 patients presented with signs and symptoms suggestive of stable angina at Radiology department at Suez Canal University Hospitals and Zagazig University Hospitals. **Results:** The overall SIS of the study population was 2.14 ± 2.71 . Most of the patient had less than 2 segments involved (66%). 20% of the patients had high risk plaque while 50% of the patients had stable plaque. Regarding the morphology of the plaque, 20% of the population had two or more features for diagnosis. There was significant positive correlation between CAD-RADS and high risk plaque, the stability of the plaque, the degree of stenosis, CVD risk and Framingham risk score $p < 0.001$. **Conclusion:** CT coronary angiography could be considered as a good non invasive predictor for further plan management for coronary disease patients.

Key words: Multi-slice CT Calcium Scoring, Coronary CT Angiography, Stable Angina

Introduction

Chest pain can arise from a variety of etiologies including cardiac and non-cardiac causes. However, of those potential causes, the most threatening arise from cardiac disease ^(1, 2). Cardiac chest pain may be caused by either coronary artery disease (CAD) or non-CAD related etiologies. The latter includes ischemic syndromes in the absence of CAD as well as non-ischemic cardiac pain ⁽³⁾. Coronary computed tomography angiography (CCTA) allows the detailed exploration of the coronary wall anatomy. Recently, a large literature, including different sub-analyses of the international CONFIRM (Coronary CT Angiography Evaluation for Clinical Outcomes: An International Multicenter Registry) study, demonstrated coronary CTA as a robust prognostic tool for the stratification of patients with suspected but unknown coronary artery disease (CAD) ⁽⁴⁾. Moreover, to better evaluate the extent of atherosclerotic burden, the segment involvement score (SIS), the segment stenosis score (SSS), and the computed tomography (CT)-adapted Leaman score have been applied to coronary CTA findings, demonstrating that they are independent long-term predictors of hard cardiac events ^(5, 2).

Identification of high-risk plaque by non-invasive imaging may help to discriminate patients at increased risk for ACS. While detailed plaque histology cannot be derived from CTA, several plaque features have demonstrated significant association with future ACS, including: the Bnapkin-ring sign, spotty calcification, low attenuation plaque, a large necrotic core, and positive remodeling ⁽²⁾. The most important predictor of stenosis progression was the baseline volume of the plaque, not the presence of high-risk characteristics. As outlined earlier, stenosis progression seems to be a factor that contributes to the risk for rupture, and in this context ⁽³⁾.

This study aimed to identify the role of CTA coronary arteries in management plan of high and moderate risk coronary artery disease patients and prediction of coronary artery pathology in angina patients presenting with chest pain.

Patients and methods

This was a cross-sectional analytic study (observational) conducted on 50 patients presented with signs and symptoms suggestive of stable angina at Radiology department at Zagazig University Hospitals.

Inclusion criteria: All patients presented with signs and symptoms suggestive of stable angina.

Exclusion criteria: Patients had history of severe or anaphylactic reaction to contrast, inability to cooperate with scan protocols, hemodynamic instability, decompensated heart failure, acute myocardial infarction, renal impairment with GFR less than 30%, high risk patients with acute ischemic chest pain and showing ECG changes, Irregular sinus rhythm and Patients who could not hold their breath due to respiratory diseases.

Sample size justification

The sample size was calculated using the following formula ⁽⁶⁾: The sample size was calculated using the following formula:

$$n = 2 \left[\frac{(Z_{\alpha/2} + Z_{\beta}) * \sigma}{\mu_1 - \mu_2} \right]^2$$

Where:

n = sample size

$Z_{\alpha/2} = 1.96$ (The critical value that divides the central 95% of the Z distribution from the 5% in the tail)

$Z_{\beta} = 0.84$ (The critical value that separates the lower 20% of the Z distribution from the upper 80%)

σ = the estimate of the standard deviation of total plaque volume = 67.53 mm^3 (2)

μ_1 = mean in the high-risk group = 101.3 mm^3 (2) μ_2 = mean in the moderate-risk group = 61.8 mm^3 (2)

So, by calculation, the sample size equal 25 individuals per group, after the addition of a drop-out proportion of 10%, giving a total sample size of 50 individuals ^(4,7). **Methods**

All patients were subjected to the following:

Clinical evaluation

Cardiovascular risk factors: Estimated risk of heart attack in 10 years was calculated in each patient using the Framingham Risk Score (FRS) and atherosclerotic cardiovascular disease risk estimator ^(4,8)

CTA Examination Patient preparation

Consent was obtained from the patients, no solid food for 4–6 h before exam, only clear fluids could be used, Patients must stop Metformin and its derivatives, 48 hours before exam otherwise no other medications discontinuity, no tea or coffee one day before examination to avoid increase in the heart rate, Cannula, 18- gauge was used and inserted in the right antecubital vein, heart rate assessment, in cases in whom heart rate exceeding 75 beats per minute, beta-blockers was given: 50 mg of metoprolol or atenolol orally 1 hour before the study. All steps of the study were explained in detail for each patient to evaluate patient's ability of breath-withholding for relatively long time. Steps of MDCT coronary

angiography examination (image acquisition)

Patient position and ECG lead attachment

Patient's position: Supine position. ECG lead attachment: Three ECG leads are attached to obtain an adequate ECG tracing with identification of QRS complex. Prepare the patient for injection of the contrast agent and to perform repeated test breath holds. **CT coronary arteries angiography:** All patients did CT coronary angiography using: a) 128 slices CT, Ingenuity Core TM, Philips and b) Dual source CT scanner (Canon medical system incorporated, Aquilion Prime SP, Tex-303 b, Japan).

CT protocol

Scanogram: The scan range covers the entire heart from the proximal ascending aorta to the diaphragmatic surface of the heart. **Calcium score assessment:** Total calcium scores of all patients were calculated with the dedicated software and expressed as Agatston scores. If coronary artery calcium (CAC) is exceeding above 1000 CT examining ends at this step and shifted to conventional angiography. **Contrast agent injection:** All patients received 100-120 ml of Iopromide (Ultravist 350, 370 mg/ml, Bayer Schering Pharma, Berlin, Germany) by injection at a flow rate of 5.5 ml/s followed by 60 ml of saline solution. Data acquisition was initiated with a delay of 8 s after reaching the threshold then choosing the optimal reconstruction window for most patients. Bolus tracking: Contrast agent application was controlled by bolus tracking in the ascending aorta (signal attenuation threshold 100 HU). **Angiography scan:** Data acquisition was initiated with a delay of 8 s after reaching the threshold then choosing the optimal reconstruction window for most patients. The acquired data was used for reconstruction of multi-planar reformatting (MPR), maximal intensity projection (MIP) and 3D volume rendering technique (VRT).

Administration Design: Approval was obtained from ethical committee of Radiological Department of Suez Canal University and an informed consent was obtained from all patients.

Finding's analysis: CT image evaluation All images was evaluated by two independent readers (with 5- and 7-years' experience in cardiovascular imaging, respectively), who was blinded to the clinical information and results from CA. Data was evaluated using axial source images and multi-planar

reformation on a per-segment basis. Disagreements in data analysis between the two observers were resolved by consensus reading

Outcome measures

All diagnostic coronary artery segments were assessed for the presence of significant stenosis, defined as a luminal diameter narrowing of $>50\%$. The vessel diameters were measured on reconstructions perpendicularly oriented to the vessel course. Each vessel was analyzed on at least two imaging planes, one parallel and one perpendicular to the course of the vessel and calcium was scored **Patient**

assessment

Cardiovascular risk factors

Estimated risk of heart attack in 10 years was calculated in each patient using the Framingham Risk Score (FRS) “using online FRS calculator, (Framingham Risk Score, n.d.)” and atherosclerotic cardiovascular disease risk estimator. Based on RF burden, patients were defined as having a moderate clinical risk or a high clinical risk (3 or more RFs) ^(4,8). Participants reported smoking history and were classified as never, current, or former smoker. Fasting total cholesterol, HDL-cholesterol, and blood pressure were measured as previously described. Hypertension was defined as self-report and use of anti-hypertensive medications, or measured blood pressure. Diabetes was defined as self-reported medical diagnosis and/or using any hypoglycemic medication. Physical activity was assessed by questionnaire about all types of walking and exercise performed in the prior week and according to these criteria management was done ^(1,8)

Results

The mean age of the study population was 50.66 ± 8.87 . Most of the population was males (58%), smokers (54%) and obese (68%). (Table 1)

Most of the patient had high CVD risk (64%). The overall Framingham risk score of the study population was 16.96 ± 4.94 . (Table 2)

The overall Ca score of the study population was 114.86 ± 239.74 . Most of the patient had minimal Ca score (50%). (Table 3)

The overall SIS of the study population was 2.14 ± 2.71 . Most of the patient had less than 2 segments involved (66%). (Table 4)

20% of the patients had high risk plaque while 50% of the patients had stable plaque. Regarding the morphology of the plaque, 20% of the population had two or more features for diagnosis. (Table 5)

There was significant positive correlation between Ca score and hypertension, LDL level $p < 0.05$, the stability of the plaque, the degree of stenosis, CVD risk, Framingham risk score and CAD-RADS. (Table 6)

There was significant positive correlation between CAD-RADS and high risk plaque, the stability of the plaque, the degree of stenosis, CVD risk and Framingham risk score $p < 0.001$. (Table 7)

There was significant positive correlation between Framingham risk score and plaque burden with Ca score and SIS $p = 0.004$, < 0.001 respectively. (Table 8)

Table (1): Distribution of sociodemographic data of the study population

Variable	Number/ mean $\pm$ SD	Percent/ Range
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Age		50.66 ±8.87	30- 72
Gender	Male	29	58%
	Female	21	42%
Smoking		27	54%
Obesity		34	68%
Hypertensive		25	50%
Diabetes	Type 1	2	4%
	Type 2	12	24%
High total cholesterol		50	100%
High LDL		45	90%
Low HDL		35	70%

Table (2): Cardiac assessment of the study population

Variable		Number/ mean± SD	Percent/ Range
CVD Risk	Low	14	28%
	Moderate	4	8%
	High	32	64%
Framingham risk score	Overall	16.96 ± 4.94	10 – 25
	Intermediate	25	%50
	High	25	%50

Table (3): Ca score of the study population

Ca score	Number/ mean± SD	Percent/ Range
Overall	114.86 ±239.74	0 – 1270

Minimal	25	50%
Mild	14	28%
Moderate	8	16%
Extensive	3	6%

Table (4): Segment involvement score (SIS) of the study population

	Number/ mean± SD	Percent/ Range
Overall	2.14 ±2.71	0 – 9
≤ 2	33	66%
3-4	6	12%
5-7	8	16%
≥ 8	3	6%

Table (5): Assessment of the plaque in the study population

Plaque criteria		Number	Percent
High risk plaque		10	20%
Stable plaque		25	50%
plaque morphology	Spotty calcification	9	18%
	2 or more features for diagnosis	10	20%

Table (6): Correlation between Ca score and different variables

Variable	R	P value
Age	0.116	0.421
Hypertensive	0.368	0.008*
Diabetes	0.094	0.514

LDL	0.282	0.047*
HDL	0.128	0.377
High risk plaque	0.065	0.654
Stable plaque	0.672	<0.001*
Degree of stenosis	0.603	<0.001*
CVD Risk	0.329	0.02*
Framingham risk score	0.322	0.022*
segment involvement score	0.683	<0.001*
CAD- RADS	0.37	0.008*

Table (7): Correlation between CAD-RADS and different variables

Variable	R	P value
High risk plaque	0.533	<0.001
Stable plaque	0.443	0.001
Degree of stenosis	0.686	<0.001
CVD Risk	0.452	0.001
Framingham risk score	0.433	0.002

Table (8): Correlation between Framingham risk score and plaque burden

Variable	R	P value
Plaque burden Ca	0.401	0.004
Plaque burden SIS	0.534	<0.001

Discussion

Patients were assessed by clinical history, laboratory results and Coronary arteries CTA.

50 patients were selected divided into two groups “moderate risk group & high risk group” each group of 25 patients. All patients underwent CTA coronary arteries.

Our results showed that mean age of the study population was 50.66 ± 8.87 . The population studied was males (58%), smokers (54%) and obese (68%) in agreement with **Lee et al**,⁽⁹⁾ stating that 54% was male, agreement could be due to similar sample size.

The difference in demographic features of our study to others could be relied to large sample size in the three studies “in thousands” stated in the three studies compared to 50 patients in our study. Our results

stated that most of the patient had high CVD risk (64%) with Ca score 114.86 ± 239.74 , most of the patient had minimal Ca score (50%) & mild Ca score (28%) with only 6% had extensive Ca score. Also patients with less than 2 segments involved was (66%) with 12% had 3-4 segments, 16% had 5-7 segments & 8% had >8 stenotic segments involved.

Our results agreed with **Mehta et al**,⁽¹⁰⁾ that showed about 80.6% of the study population had minimal & mild Ca score with 19.4 % had moderate & severe Ca score.

20% of the patients had high risk plaque while 50% of the patients had stable plaque. Regarding the morphology of the plaque, 20% of the population had two or more radiological features for diagnosing high risk plaque with spotty calcification feature seen in 18% of high risk plaques.

Lee et al,⁽⁹⁾ showed that spotty calcification was seen in about 20% of plaques causing no significant patients symptoms while seen in 42 % of culprit lesions causing patients symptoms.

Our study showed that 34% of patients had significant stenosis, most of patients 43% were CAD RADS 0, 14% CAD-RADS 1 & 20% CAD-RADS 4a, in agreement with⁽¹¹⁾ that showed 33.4% were CAD-RADS 0, 11% CAD-RADS 1 & 19 % were CAD-RADS 4a

In controversy to **Bittner et al**,⁽¹¹⁾ stated that 33.9% were CAD-RADS 0, 32% CAD-RADS 1 & 7.7 % were CAD-RADS 4a. The disagreement could be due to the long-term interval the study was conducted through with a large population study over 10 thousand patient in 3 years interval. Our results showed that 60% (15/25) of high risk group had significant stenosis with significant correlation (p value <0.001) as well as significant correlation between CAD-RADS reporting system, high risk plaque & degree of stenosis

This agreed with **Bittner et al**,⁽¹²⁾ showing significant relation between CAD classification systems, presence of high risk plaque & degree of stenosis.

The results showed significant relation between Ca scoring system & degree of stenosis, segment involvement stenosis & stable plaque with no correlation between Ca scoring & Age, Sex, hypertension, diabetes in controversy with **Mehta et al**⁽¹⁰⁾ showing significant relation between Ca scoring system & Age, Sex, hypertension, Diabetes, HDL & LDL

This disagreement could be due to difference in study sample selection as in **Mehta et al**,⁽¹⁰⁾ the selected population including many races opposite to our study.

Limitations

The study showed some limitations that presents as there is no follow up interval for the patients risk symptoms or plan of management. Also the small sample size in each group affecting correlation significance between multiple variables that can affect outcomes.

Conclusion

CT coronary angiography could be considered as a good non invasive predictor for further plan management for coronary disease patients.

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