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RESEARCH

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Multi-slice coronary computed tomography angiography in assessment of coronary artery disease on the basis of syntax score

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Abstract

Background The SYNTAX score (SS) was created to aid the Heart Team in assessing the severity and extent of coronary artery disease (CAD) in patients with multi-vessel disease, hence helping in the decision between percutaneous coronary intervention (PCI) and coronary artery bypass graft (CABG). SS is an important tool that assesses the angiographic complexity of the CAD based on Invasive coronary angiography (ICA). The study aims to evaluate the role of coronary Multi-Slice Computed Tomography (MSCT) angiography in the assessment of CAD on the basis of SS.

Results Our study involved 60 patients with a male to female ratio 78.4% to 21.6%. The mean age of the patients was 57 years. Then, we applicate SYNTAX score II (SS-II) by incorporating a combination of SS-I and clinical variables. MSCT findings were compared with the data collected by cardiac catheterization. SYNTAX scores produced from coronary CT-angiography (CCTA) and those derived from ICA are concordant ($P=0.001$). Direct correlation and significant relationship between SS-II for PCI and the mortality rate with the CT-derived SS-I. There was an inverse relationship between the CT-derived SS-I and SS-II for CABG. There was an inverse relationship between the CT-derived-SS with CABG mortality rate.

Conclusions MSCT is a noninvasive imaging modality that has a significant value and high diagnostic accuracy compared to ICA in the evaluation of the complexity of CAD using SS and can be applied in clinical practice to determine the most convenient treatment procedure and predict long-term prognosis.

Keywords SYNTAX score, Coronary artery disease, MSCT, Invasive coronary angiography, CT-derived syntax score, PCI, CABG

Background

In addition to the severity of myocardial ischemia, patient and clinician preference, and other patient comorbidities, the complexity of CAD is a key factor in determining whether the surgical or PCI is the optimal treatment modality for inpatients with CAD [1]. Because myocardial revascularization increases the survival rate of patients with multivessel CAD, it is crucial to appropriately evaluate the disease's complexity [2].

SYNTAX is a common angiographic grading system that is used to assess the complexity of CAD using ICA. SS was derived from the SYNTAX Trial. It discusses numerous angiographic classifications of CAD complexity based on the location and kind of obstructive coronary lesions, gives a detailed risk assessment, and proposes the most successful coronary revascularization treatments [3].

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The SS is intended to aid the Heart Team in detecting the severity and degree of CAD in patients with multi-vessel disease, hence easing the selection between PCI and CABG [4].

The invasive coronary angiography SS may be used to assess the optimal revascularization strategy for individuals with complicated CAD (LM disease or 3-vessel disease). CABG is the gold standard for the treatment of the patient with high scores (≥ 33), while PCI is a potential approach for individuals with less complicated illness (SS equal to or below 22) [5].

Technological breakthroughs enabled the use of CCTA on patients with coronary artery disease symptoms. However, further study is necessary to evaluate the diagnostic capabilities of the most recent generation of CT scanners and the concordance between the appropriate therapy and the presence of multi-vessel CAD [6].

The most recent versions of multi-slice computed tomography (MSCT) may acquire noninvasively the same information as ICA, resulting in the widespread use of cardiac CT imaging [3, 7].

Moreover, Coronary computed tomography angiography has great diagnostic accuracy for identifying and excluding obstructive coronary stenosis, as well as the distribution, location, and the number of plaques [8].

Recent research has shown that CCTA is a feasible imaging tool for the syntax score application in individuals with CAD [9].

Methods

Patients

Of a total number of 134 patients, 58 patients were excluded as they did not meet the criteria for SS application, 7 patients were excluded as we cannot get the PCI result, 9 cases were missed during follow up; finally, 60 patients were enrolled in this study, 47 of them were male representing 78.4% and 13 were female representing 21.6% presented by symptoms suggestive of ischemic heart disease referred for evaluation by CCTA showing multi-vessels, LM or LM and other vessels affection.

From September 2020 to September 2022, patients with symptoms of ischemic heart disease were referred from the cardiology department and private clinics to the diagnostic radiology and medical imaging department at Tanta University Educational Hospital for evaluation by MSCT angiography of coronary arteries.

Consent was taken from all patients included in our study.

Inclusion criteria

Patients who had symptoms suggestive of ischemic heart disease referred for evaluation by MDCT, and the patients who proven to have multi-vessels coronary artery disease or left main coronary artery disease were enrolled in our study.

Exclusion criteria

Patients who were clinically unstable to withstand the duration of CT examination, impaired renal function (Creatinine level ≥ 1.5 mg/dl), history of allergy to IV contrast media used, pregnancy, patients who cannot tolerate the required breath holding time for examination, bad general condition needing life support, prior CABG or revascularization and patients with uncontrollable high heart rate (above 80 bpm).

Method

Patients were subjected to

1. history taking:

Personal history, present history and past history: relating to bronchial asthma, chronic renal disease, and other chronic illnesses. Prior coronary stent implantation, diagnostic catheterization, or coronary bypass surgery.

2. Clinical examination including vital signs monitoring.
3. Laboratory investigations:

- We reviewed the results of renal function tests to ensure that the patients were fit for contrast material injection. We did not proceed if serum creatinine was above (1.5 ≥ mg/dl).
- Total lipid profile

4. Assessment of emergency set:

- Oxygen container with mask and extension tubing.
- Sphygmomanometer
- Facility to transfer the patient to the emergency room if uncontrolled complication developed.
- Emergency drugs such as adrenaline, used for severe hypotension or anti-histaminic for contrast reaction.

5. Radiological examination including:

1. MSCT angiography for evaluation of the coronary arteries through the following steps:

I.Instructions:

On scheduling CT examination, patients were instructed to follow these instructions: Fasting for four to six hours before the scan, encourage water intake till one hour before scan, avoid caffeine products 12 h before the scan and avoid smoking on the day of CT exam, avoid exercising and strenuous physical activity on the day of CT exam.

II. Patient Preparation:

a) A detailed explanation of the procedure to all patients with reassurance was done to relieve any anxiety

b) Heart rate control:

- Heart rate and blood pressure were recorded on arrival to set a baseline for monitoring. Patients with HR below 65 bpm were not given any heart rate control medications; they were 15 patients. Higher HR patients were given oral β-blockers provided that there was no contraindication to their use as follows: HR ranging from 65 to 75 bpm was given 50 mg oral Metoprolol one hour before the scan; they were 28 patients. HR above 75 bpm were given 100 mg oral metoprolol one hour before the scan; they were 12 patients. Those with contraindications to β-blockers use were given 5.0 mg oral Ivabradine one hour before the scan; they were 5 patients. Every 30 min, blood pressure and HR were measured until the ideal HR (less than 65 beats per minute) was reached.

c) Setting up IV access:

- After controlling the patient's pulse rate, a 18G IV cannula was placed into the patient's preparation area.

d) At scanner room:

- On the scanning table, the patients were next ordered to lay supine with their arms elevated over their heads.
- After prepping the skin with alcohol, ECG electrodes were placed on the chest wall and the ECG trace was examined to check that the R wave utilized as the scan trigger had sufficient amplitude.
- After attaching the IV line, a saline test injection was done to ensure there was no extravasation.
- Patients were instructed to hold their breath to prevent respiratory motion abnormalities.

III. Contrast media injection:

A non-ionic contrast medium (Ultravist 370 mgI/ml) was administered into the peripherally implanted IV cannula using a dual head powered automated injector, followed by a 50-cc saline flush. The quantity of contrast agent was adjusted based on the patient's weight (1 ml/kg).

IV. CT scan protocol:

320-row multidetector CT scanner (Aquilion One, Toshiba Medical Systems, Otawara, Japan) installed at Tanta University Educational Hospital was used for scanning.

XXII. Image acquisition:

- The acquisition settings include 0.35 s gantry rotation time, variable mA (range: 250–580 mA), and variable kv (range: 100–135 kv). The scan window was set at 70–80% of the R-R interval, whereas the heart rate exceeding 70 beats per minute had two heartbeat acquisition. When the heart rate ranged between 65 and 70 beats per minute, the scanning window was altered to capture the end of systole by including 30 to 80 percent of the R-R interval.

VI. Image reconstruction and Post-processing:

The reconstructed pictures were sent to a workstation so that multiplanar reformatted images in the sagittal, axial, and coronal planes could be collected (Vitrea Fx, Vital Images, USA). As further evidence of coronary artery disease was evaluated using: maximum intensity projection, 3D volume rendered pictures, semitransparent 3D volume rendered images, and curved planar reformations.

VII. Image analysis:

Evaluation of coronary arteries:

- In addition, the coronary arteries were evaluated for sites of significant stenosis (≥ 50) or occlusion that might be contributing to the patient's problems. Lumen assessment was made possible by examining 3.0 mm axial MIP images and curved planar reformatted images.
- CT-SS calculation: The CT-SS was calculated using version 2.28 of the SS calculator.
- PCI results were used as a golden role for comparison with our result.

Statistical analysis

All data were imported into Microsoft Office Excel 2007 spreadsheets and evaluated statistically using SPSS Statistical Software (version 20.0.0: IBM Corp: Armonk, NY). The qualitative data were presented statistically and mathematically. The presentation of quantitative data as mean and standard deviation (SD). The Chi-square test was used to analyze categorical data. $P < 0.05$ was used as

Table 1 Descriptive statistics according to demographic data (age), clinical data, range of syntax score, SS-II and mortality rate for PCI and CABG

	Range	Mean ± SD
Age	41–76	57.200 ± 8.872
Weight	60–110	84.617 ± 5.201
CRCL	100–133	118.250 ± 8.186
LVEF	55–77	70.283 ± 5.843
Total syntax score by CT	10–54.5	25.192 ± 10.777
Total syntax score by PCI	10–45	23.525 ± 9.809
Syntax Score II PCI	12.2–33.4	23.542 ± 5.419
Syntax Score II CABG	2.7–49.5	18.152 ± 8.929
PCI mortality rate	0.7–9	4.323 ± 2.014
CABG mortality rate	0.7–7.4	2.737 ± 1.533

the significance criteria. ANOVA was undertaken divide the total number of observations by the number of observations to get the mean value. SD is a measure of how dispersed the data are in relation to the mean.

Results

This study included 60 patients (47 males and 13 females) with a male to female ratio 78.4% to 21.6%. The patients' age ranged 41 to 76 years, and the mean age of the patients was 57 years, the weight of the patients ranged from 60–110 (mean 85) kg. Left ventricular ejection fraction (LVEF) ranged from 55 to 77% (mean 70.2%). Total SS by CT Ranging from10 to 54.5 and by PCI ranging from 10 to 45. SS-II for PCI ranging from 12.2 to 33.4 and for CABG 2.7 to 49.5 with PCI mortality rate ranging from 0.7 to 9%, and CABG mortality rate ranging from 0.7 to 7.4% (Table 1).

This study included 60 patients, 47 patients showing multi-vessels affection (78.4%), 3 patients had vascular affection of LM only (5%) and 10 patients had LM and other vessels affection (16.6%), 43 patients (71.67%) showing right system dominance, 8 patients (13.33%) showing left system dominance while 9 patients (15%) showing co-dominance of the arterial systems, according to the diffusely affected vessels 19 patients (31.67%) showing diffusely affected vessels in the coronary system.

As regards the co-factors affecting the result of SS-II, 27 patients out of 60 were smoker (45%), 17 patients were diabetic (28.33%), 25 patients showing abnormal lipid profile (42.67%), 9 patients had COPD (15%) and 2 patients (3.33%) had peripheral vascular disease (Table 2).

The CT-SS results that were diagnosed by MSCT are correlated with coronary catheter angiography findings. Our main result was that there was a significant relationship between the score given by coronary CTA and the score given by ICA with ($P = 0.001$) (Table 3 and Fig. 1).

Table 2 Diseases and co-factors associated with the CAD

Descriptive statistics				
	No		Yes	
	N	%	*N*	%
COPD	51	85.00	9	15.00
Smoking	33	55.00	27	45.00
DM	43	71.67	17	28.33
Dyslipidemia	35	58.33	25	41.67
PVD	58	96.67	2	3.33

Table 3 Correlations between the syntax score by CT Syntax score, CTA derived SS, SS-II, PCI & CABG mortality rates

Correlations		
	Total score by CT	
	r	*P*-value
Syntax score by PCI	0.900	< 0.001*
Score II PCI	0.616	< 0.001*
Score II CABG	− 0.235	0.071
PCI mortality rate	0.546	< 0.001*
CABG mortality rate	− 0.043	0.746

*Statistically significant *P* value < 0.001

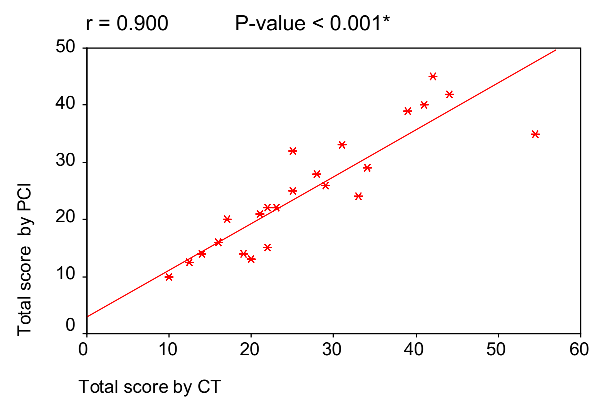

Fig. 1 Correlation between the CT syntax score and PCI syntax score

After application of SS-II, we found a direct correlation and significant relationship between SS-II for PCI with the CT-derived SS-I (P value < 0.001) (Table 3 and Fig. 2). Also, there was a direct correlation and significant relationship between the CT-SS and PCI mortality rate.

There was an inverse relationship between the CT-derived SS-I and syntax score II for CABG (Table 3 and

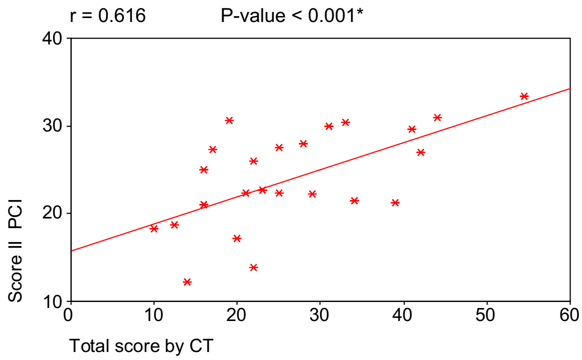

Fig. 2 Correlation between the CT syntax score syntax II score for PCI

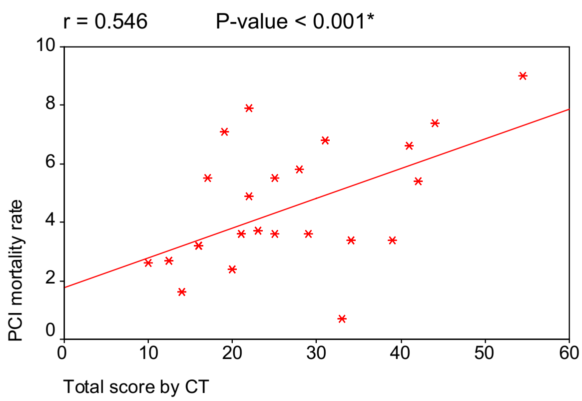

Fig. 3 Correlation between the CT syntax score I and syntax II score for CABG

Fig. 3). Also, there was an inverse relationship between the CT syntax score CABG mortality rate.

There was a statistically significant difference between the treatment recommendation by anatomical SS-I and SS-II of the anatomy and comorbidity for PCI Vs CABG, by application of syntax I there were 31 patients out of 60 (51.6%) recommended undergoing PCI and by syntax score II 2 patients recommended to undergo PCI (3.33%), by syntax I 17 patient undergoing CABG and become 16 patients after using syntax score II and 12 patients out 60 (20%) recommended for PCI or CABG and increased to become 42 patients (70%) (Table 4).

There was a statistically significant difference between the group of patients having diffuse affection coronary artery and the patients who did not have diffuse coronary artery affection (Table 5).

As regard the cofactors and diseases associated with CAD, there was statistical significance as regard the diabetes (*P* value < 0.001), dyslipidemia, (*P* value 0.002), smoking (*P* value 0.012), also there were statistically significant difference between the different groups of SS grading and total syntax score I (*P* value < 0.001). There was direct but non-significant relation between the SS and the PVD and COPD (Table 5).

Discussion

Prior to coronary interventional procedures and therapy, a patient's awareness of the likelihood of problems may reduce the incidence of complications. The SYNTAX score (SS) is a grading system used to assess the complexity of CAD, choose the most effective revascularization procedure, and identify patients at risk for significant adverse events after PCI [7, 10].

Due to their efficacy, these assessments have been included in clinical practice for predicting long-term prognosis and determining the most expedient CAD therapy strategy [11].

The efficiency of MDCT in identifying and visualizing coronary artery lesions is increasing. MDCT has been shown as a feasible approach for detecting the severity of the coronary vascular affection in patients with suspected CAD, with good diagnostic accuracy and negative predictive values over 95% [12].

Few studies have assessed the use of coronary CT angiography to guide patient care, such as assessing the necessity for revascularization or the most effective revascularization technique (e.g., PCI vs CABG surgery) [13].

In this study, we evaluate the role of coronary MSCT in the assessment of multi-vessel CAD on basis of SS.

SS derived from CCTA, and ICA are concordant, which is consistent with the findings of Bartorelli et al. [14], who discovered that CCTA provides an anatomy and noninvasive functional road map for planning for

Table 4 Comparison between the treatment recommendation by syntax score I and syntax score II

	Recommendation by syntax I		Recommendation by syntax II		Chi-Square	
	N	%	*N*	%	X^2	*P*-value
PCI	31	51.67	2	3.33	42.182	< 0.001*
CABG	17	28.33	16	26.67		
PCI or CABG	12	20.00	42	70.00		
Total	60	100.00	60	100.00		

*Statistically significant *P* value < 0.001

Table 5 Relation of the syntax score by CT Syntax score, syntax score grading and different factors

	Total score by CT	ANOVA or T-Test		
	N	Mean ± SD	F or T	*P*-value
Diffuse disease				
No	41	21.085 ± 8.662	− 5.207	< 0.001*
Yes	19	34.053 ± 9.628		
COPD				
No	51	25.010 ± 11.388	− 0.309	0.759
Yes	9	26.222 ± 6.685		
Smoking				
No	33	28.303 ± 9.125	2.589	0.012*
Yes	27	21.389 ± 11.567		
DM				
No	43	22.035 ± 10.383	− 4.053	< 0.001*
Yes	17	33.176 ± 7.126		
Dyslipidemia				
No	35	21.671 ± 8.684	− 3.223	0.002*
Yes	25	30.120 ± 11.634		
Vulnerable plaque				
No	49	25.051 ± 10.975	− 0.212	0.833
Yes	11	25.818 ± 10.323		
PVD				
No	58	25.302 ± 10.948	0.423	0.674
Yes	2	22.000 ± 0.000		
Grading by CT				
Mild	31	16.984 ± 3.548	139.214	< 0.001*
Intermediate	14	26.857 ± 3.060		
Severe	15	40.600 ± 6.893		
CABG	16	38.125 ± 8.137		

*Statistically significant *P* value < 0.001

myocardial revascularization strategies, and Shalev et al. [3], who evaluated the feasibility and accuracy of a CCTA-derived SS to predict complex CAD. Comparing the CCTA-derived SS to an ICA-derived SS reference standard, the research group demonstrated outstanding concordance and diagnostic accuracy. In addition, higher SYNTAX scores determined from CCTA were associated with more complex coronary revascularization. While Yuceler et al. [12] showed strong agreement between the SS-ICA and SS-MDCT, researchers identified substantial agreement between the SS-ICA and SS-MDCT. The SS-MDCT average score was 14.5, whereas the SS-ICA average score was 15.9. In the group with low SS, there was a significant connection between SS-MDCT and SS-ICA ($r = 0.63$, $P = 0.043$), however, in the group with high SS, there was no correlation.

Also, we found that there was a statistically significant difference between the treatment recommendation by anatomical SS I and SS-II of the anatomy and comorbidity PCI Vs CABG, ($P < 0.0001$) this was consistent with the finding of Xu et al. [15] who found that compared with the strictly anatomic SS-scoring systems combining clinical variables and anatomic SS (clinical SS, logistic SS, and SS-II) had better discrimination and similar calibration for the prediction of long-term mortality Specifically, the SS-II had better discrimination (C-statistic: baseline SS ¼ 0.591 vs. SS-II ¼ 0.694, $P < 0.0001$) than the anatomic SS alone, The SS-II significantly improved mortality predictability by appropriately reclassifying several patients. Chen et al. [16] conducted a meta-analysis comparing the SS to the clinical SS to determine their potential to predict adverse clinical outcomes; the clinical SS was associated with a greater predictive value for predicting all causes of mortality. According to Escaned et al. [17], patients with 3-vessel diseases and the vast majority of SS-II trial participants should use this critical decision-making tool.

We discovered a direct correlation and significant relationship between SS-II for PCI, which represents the absolute risk (%), and CT-derived SS I ($P = 0.001$), as well as a direct correlation and significant relationship between the CT-SS and PCI mortality rate, indicating that patients with a high SS have an increased risk of mortality with PCI. Patients with a low SS-II had a considerably low mortality rate following PCI, while patients with a high SS-II had a significantly higher risk of mortality.

We discovered an inverse relationship between SS-II and CABG mortality and a direct relationship between SS-II and PCI mortality rate, indicating that individuals with a higher SS-II had a lower CABG mortality rate and a greater PCI mortality rate. Head et al. [18] observed a significant treatment selection by SS interaction ($P = 0.01$) in a subgroup analysis based on lesion complexity, which is consistent with our findings. Despite the primary conclusion of the trial that PCI with drug-eluting stents is inferior to CABG, there were no differences in MACCE between CABG and PCI in patients with a SS of 22 or below (13.6 percent vs. 14.7 percent, respectively; $P = 0.71$). CABG was better than PCI in individuals with SYNTAX scores of 33 or more (10.9% vs. 23.4%, respectively; $P < 0.001$).

Kundu et al. [19] discovered that the SS and SS-II are helpful predictive markers for directing the therapy of diabetic individuals with advanced coronary artery disease. PCI should be explored as an alternative to CABG in patients with low to moderate SYNTAX scores (equal to or less than 32), but CABG is preferable in operable individuals with high SYNTAX scores (equal to or more than 33).

We found that there is significant and direct relationship between the SS and SS-II with PCI and mortality rate and this was in line with Cavalcante et al. [20] who found that the rate of the composite of death, MI, or stroke was similar in the PCI and CABG arms in patients with low and intermediate (equal to or less than 32) SYNTAX scores while it was significantly higher in the PCI arm in patients with high (equal to or more than 33) SYNTAX scores (24.5 vs.13.2%, respectively; $P=0.018$).

Also, we found that 47 patients out of 60 cases were male representing 78.3% of the cases and 13 cases out of 60 were female representing 21.7%. This came in agree with Rong et al. [21] found that male patients accounted for 71.4%, also Suh et al. [13] found that 61% were male, and Shalev et al. [3] who found that 66% were male.

The mean age of the patients was 57 (± 8.8) year, Rong et al. [21] found that the mean age of 68.4 ± 9.4, Yuceler et al. [12] found the mean age of 64.6 ± 6.3 years.

We found that 17 patients were diabetic (28.33%), 25 patients showing abnormal lipid profile (42.67%), 9 patients had COPD (15%) and 2 patients (3.33%) had peripheral vascular disease, and the smoker's percentage (45%), Pozo et al. [9] found that 20% were diabetics, 46% had hyperlipidemia, 22% smoker and ex-smoker, 65% had peripheral arterial disease, and Shalev et al. [3] found that Diabetes account about 41% of the cases, smoking at 21%, and dyslipidemia 15% of the cases.

We found a significant relationship between smoking, diabetes, and dyslipidemia. This is consistent with the findings of El-Kersh et al. [22], who showed that there was a statistically significant link between diabetes, dyslipidemia, and smoking, but not with age, as we did not discover a significant correlation with age. We agree that there was an association between the patient's weight and diabetes that is statistically significant.

The observed negative association between SS and LVEF parallels the findings of Van Dongen et al. [23], who discovered that patients with a SS above the median had a lower LVEF and a greater death rate. We discovered that the SS is a negative independent predictor of LVEF.

Finally, the present study and the previous reports demonstrate that Coronary computed tomographic angiography (CCTA) has high diagnostic accuracy compared to ICA Coronary computed tomographic angiography (CCTA) and in clinical practice can be used to determine the most convenient treatment procedure and predict long-term prognosis for CAD management.

The limitation of the study was as follow

The limited number of the cases who underwent CT angiography showing multi-vessels coronary arteries affection as in assessment of patient with typical chest pain the PCI is more commonly done, but in our study we insure that the CT scan noninvasively can diagnose the patient and guide the heart team for the appropriate strategy of the treatment. Some cases were excluded as we cannot obtain their PCI result, and we need longer time to detect the long-term major adverse effect to assess the external validation of syntax score PCI and CABG.

Conclusions

Our study aimed to evaluate the role of coronary Multi-Slice Computed Tomography angiography in the assessment of multi-vessel coronary artery disease on the basis of syntax score our main findings were as follows:

1. SYNTAX scores derived from CCTA are concordant with those derived from ICA with *P* value (0.001).
2. Statistically significant difference between the treatment recommendation by anatomical syntax score I and syntax score II of the anatomy and comorbidity PCI Vs CABG.

The present study and the previous reports demonstrate that Coronary computed tomographic angiography (CCTA) has high diagnostic accuracy compared to ICA Coronary computed tomographic angiography (CCTA) and in clinical practice can be used to predict long-term prognosis and determine the most convenient treatment modality for CAD management.

Illustrating cases

Case 1: (Fig. 4)

Multidetector coronary CT angiography findings

(A): Unenhanced CT axial image demonstrating CACS by Agatston units which equal 713 (high scoring). **(B & C):** curved MPR images showing mixed eccentric plaque are noted at LAD proximal segment exerting focal subtotal occlusion (8 mm). Another multiple mixed eccentric plaques are seen at LAD mid and distal segments, the largest exerts moderate stenosis at the mid-segment (60%, length: 6.5 mm). **(D & E)**: curved MPR images showing two mixed eccentric plaques are seen at LCx mid-segment exerting maximally severe stenosis (70%, length of diseased LCx segment = 20 mm).

(F): curved MPR image showing A mixed eccentric plaque is seen at RCA proximal segment exerting moderate stenosis (60%, length: 5 mm). Another few mixed concentric and eccentric plaques are seen at RCA mid-segment exerting moderate stenosis (70%). **(G):** 3D (VR) showing proximal LAD severe stenotic lesion.

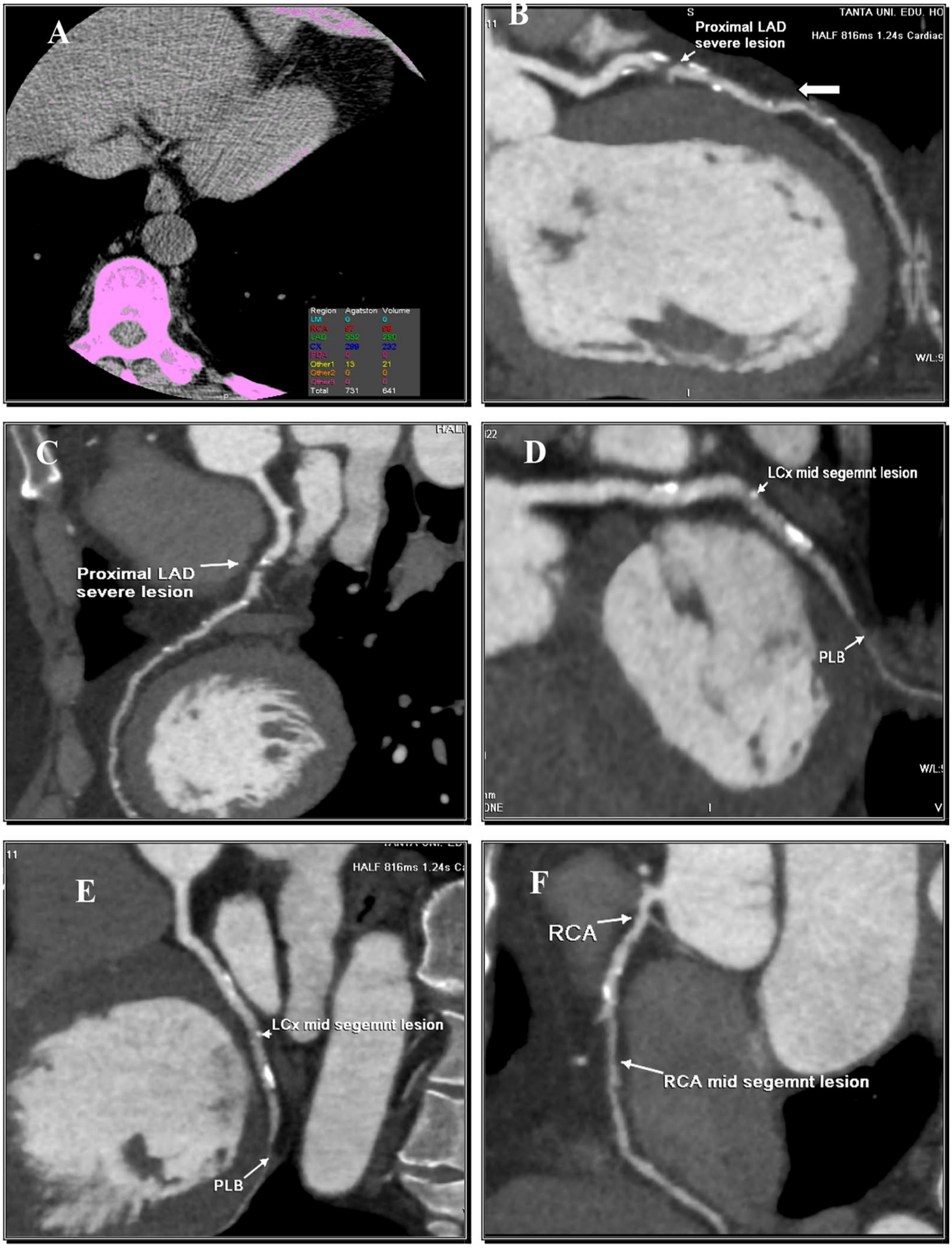

Fig. 4 Male patient aged 57 years old presented by exertional dyspnea showing: multi-vessels coronary vascular affection

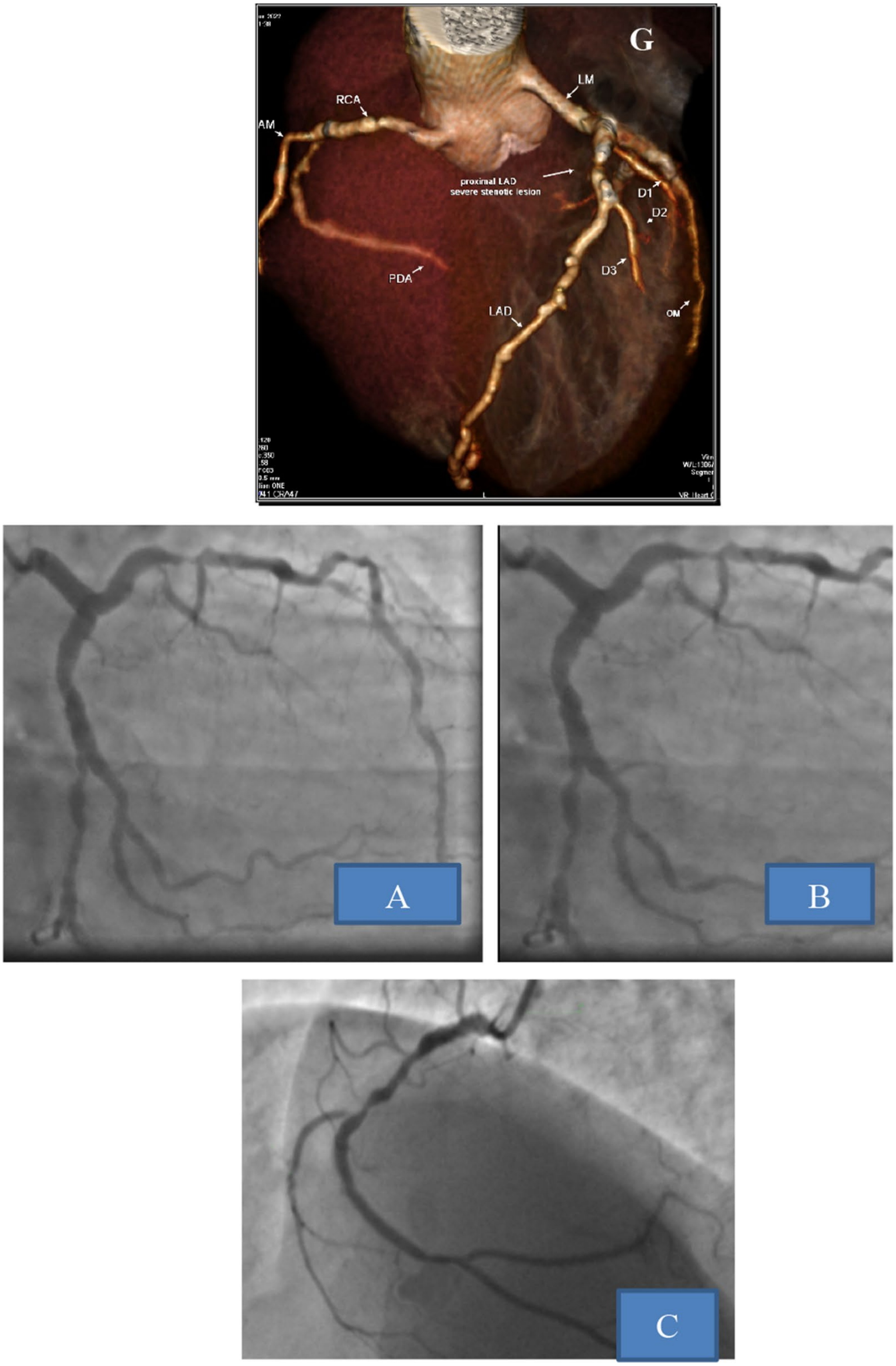

Fig. 4 continued

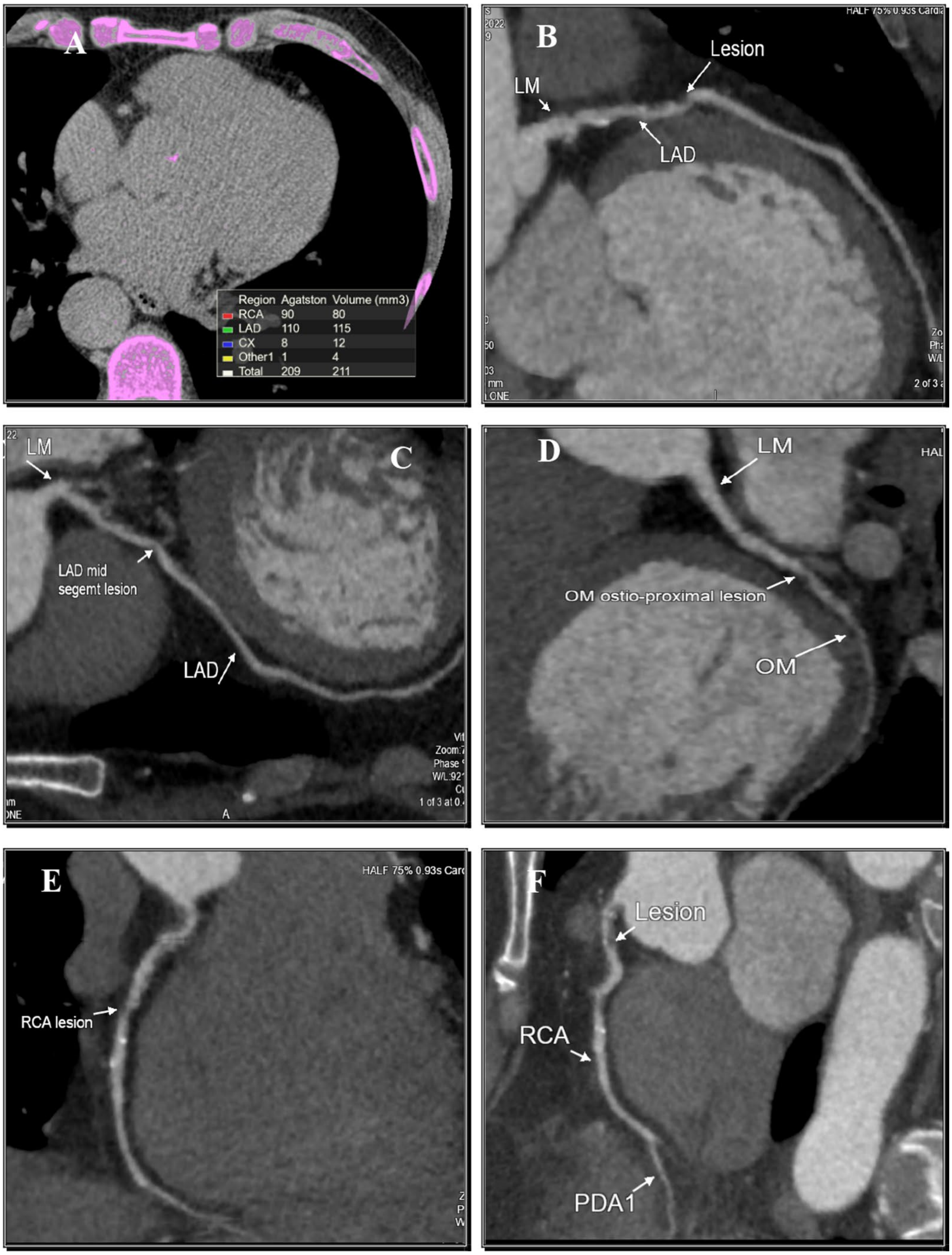

Fig. 5 Male patient aged 60 years old presented by atypical chest pain: showing multi-vessels coronary vessels affection

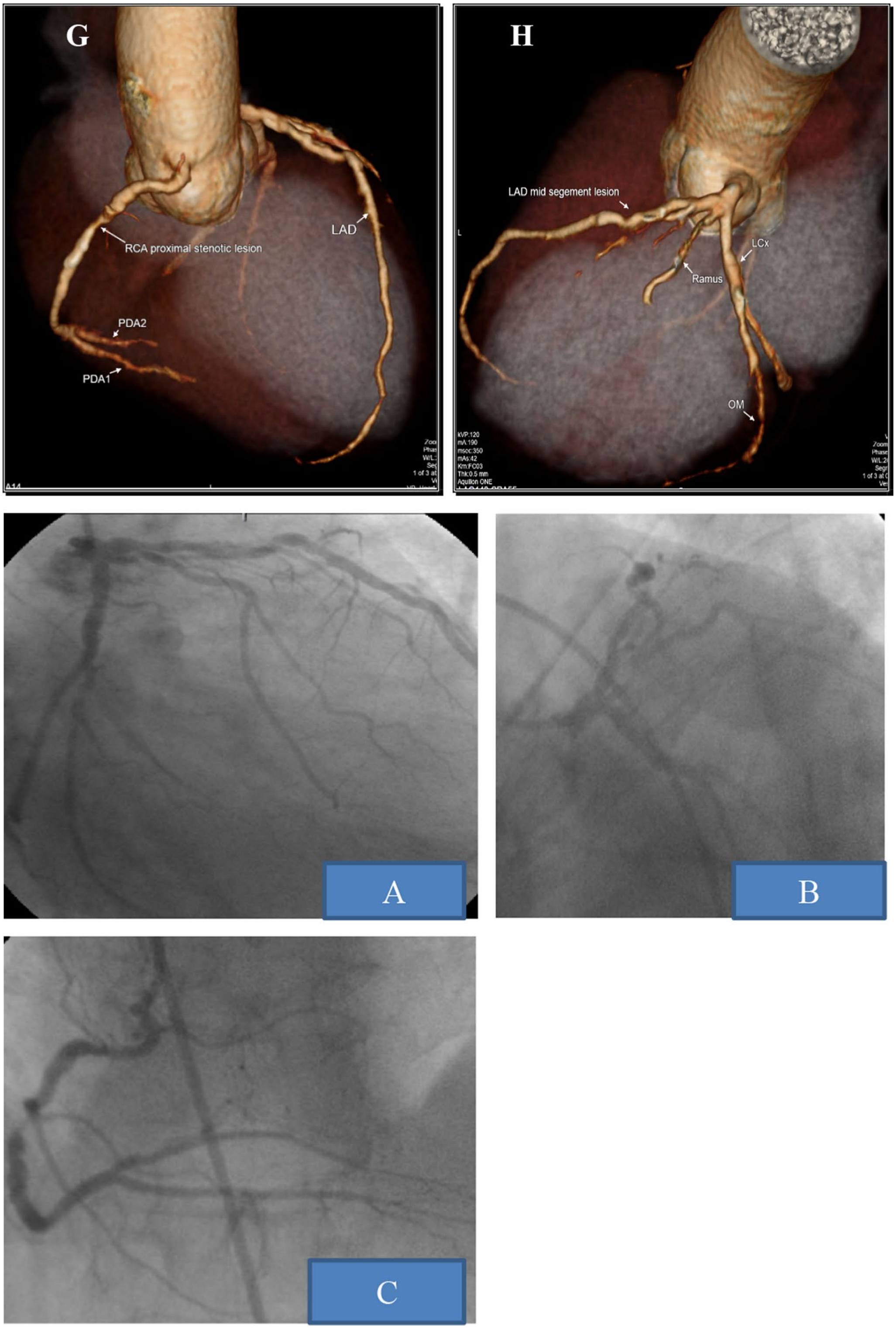

Fig. 5 continued

Syntax score: 29.

Syntax score II recommendation: PCI or CABG.

Invasive coronary angiography finding:

(A&B): left coronary angiogram MLO images showing LAD proximal segment focal subtotal occlusion, LAD mid-segment moderate stenosis, LCx mid-segment severe stenosis **(C)** Right coronary angiogram image showing RCA proximal and mid-segment moderate stenotic lesions.

Case 2: (Fig. 5)

Male patient aged 60 years old presented by atypical chest pain: showing multi-vessels coronary vessels affection.

Multi-detector coronary CT angiography findings:

(A): Unenhanced CT axial image demonstrating CACS by Agatston units which equal 209 (moderate scoring).

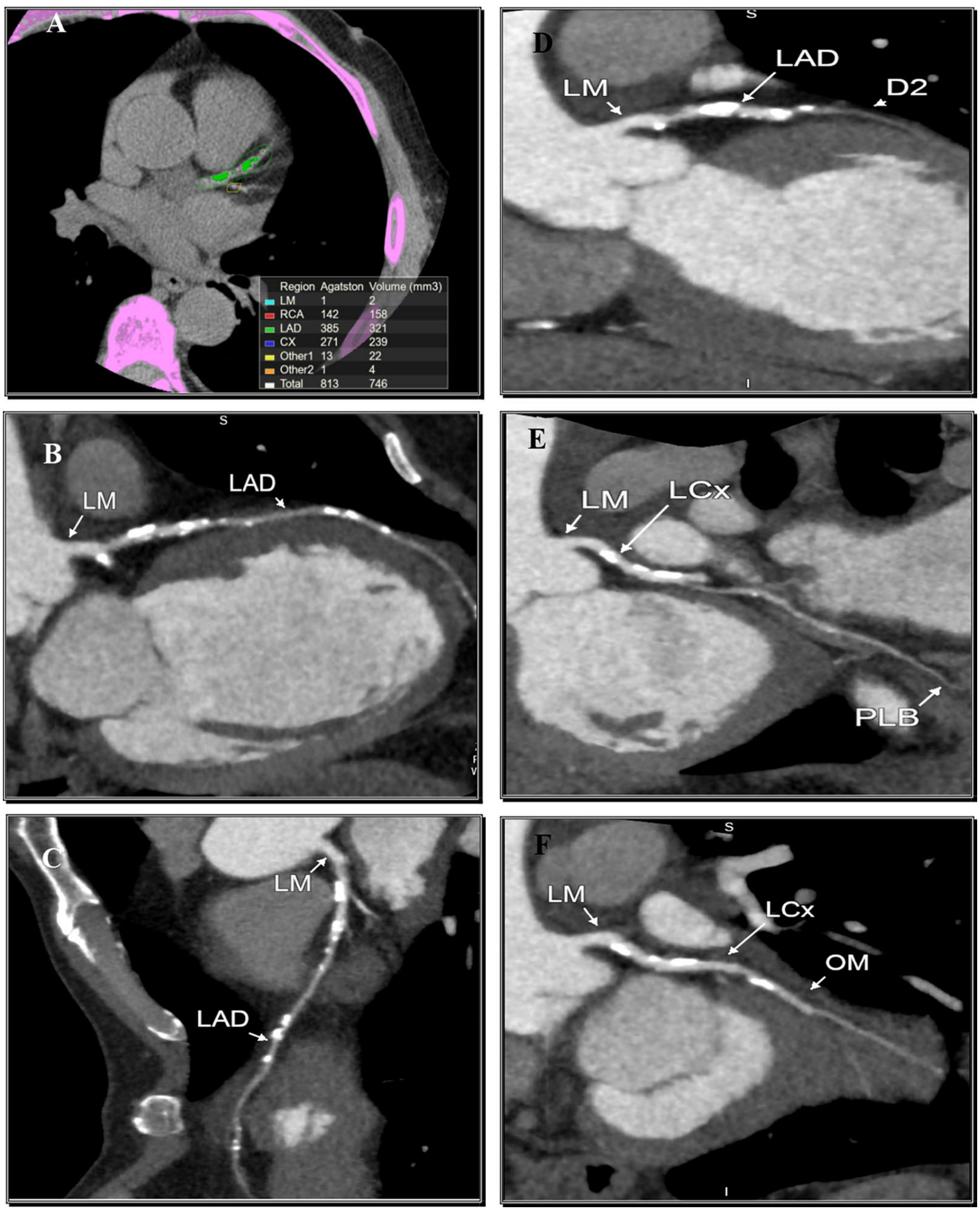

Fig. 6 Male patient aged 65 years old presented by atypical chest pain showing: 3 vessels coronary vascular affection

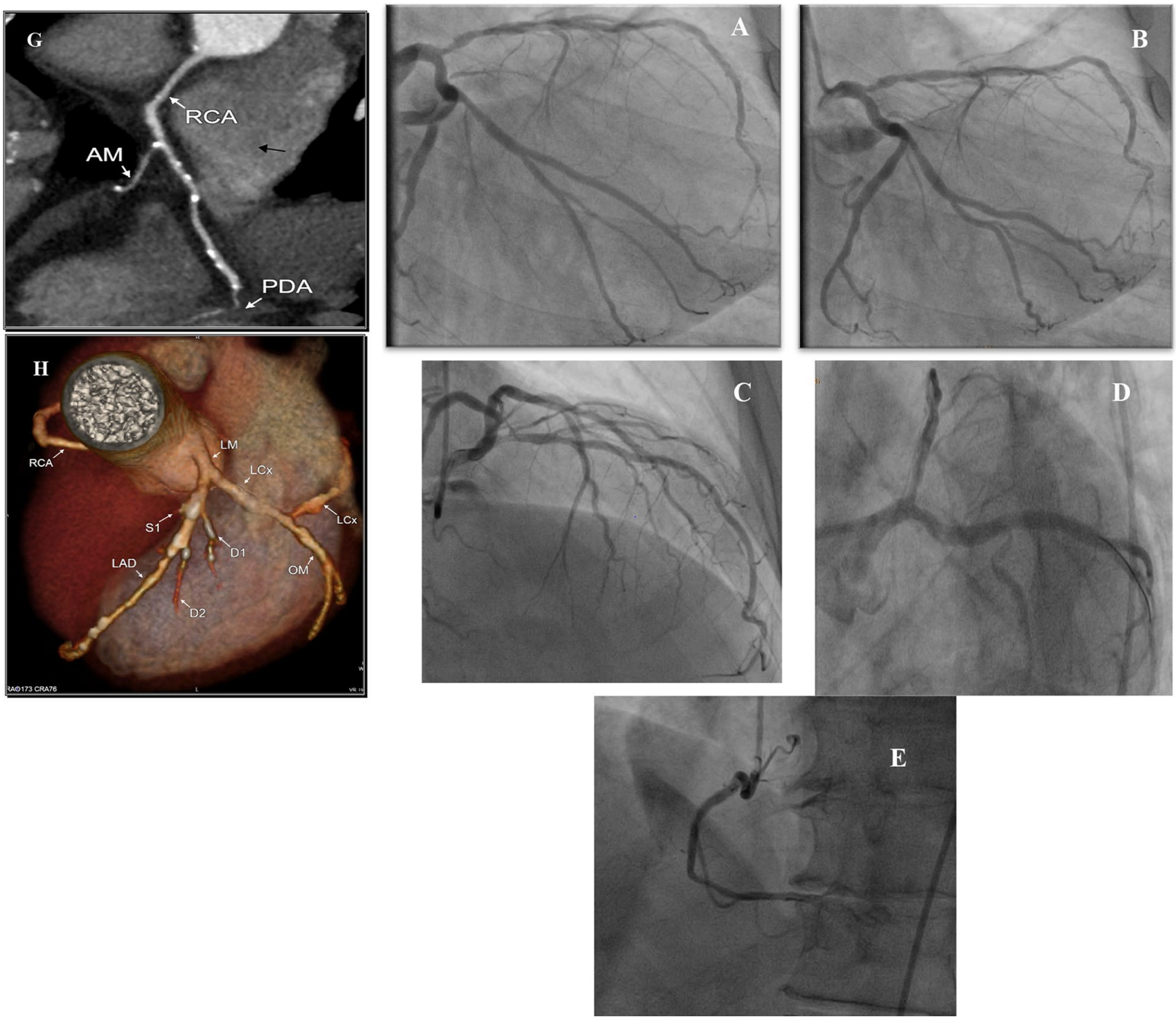

Fig. 6 continued

(B & C) Curved MPR image showing mixed plaque at LAD proximal to mid-segment exerting moderate stenosis (70%, length 23 mm).

(D): curved MPR image showing OM1 eccentric soft plaque seen at the ostio-proximal segment (65%, length 5 mm).

(E&F): curved MPR image showing proximal RCA soft plaque exerting severe stenosis followed by multiple mixed plaque exerting mild stenosis, RCA mid-segment eccentric soft plaque exerting severe stenosis (length 20 mm).

(G): 3D (VR) showing RCA mid-segment stenotic lesion.

(H): 3D (VR) showing lad mid-segment stenotic lesion.

Syntax score: 16.

Syntax score II recommendation: PCI or CABG

Invasive coronary angiography findings:

(A& B): Left coronary angiogram images showing LAD proximal to mid-segment moderate stenosis, OM1 ostio-proximal segment moderate to severe stenosis.

(E&F): right coronary angiogram showing proximal RCA severe stenosis, RCA mid-segment severe stenosis.

Case 3: (Fig. 6)

Male patient aged 65 years old presented by atypical chest pain showing: 3 vessels coronary vascular affection.

Coronary CT angiography findings:

(A): Unenhanced CT axial image demonstrating CACS by Agatston units which equal 813 (severe scoring).

(B & C): curved MPR image showing An eccentric positively remodeled soft plaque seen at LAD ostio-proximal segment exerting severe stenosis (70%, length 8 mm) measured about 17 mm, followed by multiple calcified eccentric plaques are seen at LAD proximal and mid-segments exerting moderate stenosis (60%) at proximal segment and mild stenosis (40%) at mid-segment.

(D): curved MPR image showing calcified eccentric calcified plaques at the ostium of D2 exerting moderate stenosis.

(E): curved MPR image showing A calcified eccentric plaque is seen at LCx proximal segment exerting moderate stenosis (50%) followed by two eccentric calcified plaques at mid-segment exerting mild stenosis (30%).

(F): curved MPR image showing OM ostio-proximal mixed plaque exerting severe stenosis (70%, length:12 mm).

(G): curved MPR image multiple calcified eccentric plaques are seen at RCA proximal and mid-segments exerting mild to moderate stenosis (40–50%).

(H): 3D (VR) showing LAD proximal segment lesion, LCx artery ostial stenotic lesion.

Syntax score: 41.

Syntax score II recommendation: PCI or CABG

(A& B): Left coronary angiogram MLO image showing LAD ostio-proximal segment severe stenosis, LAD proximal segment moderate stenosis and LCx proximal segment moderate stenosis.

(C): Left coronary angiogram showing D2 proximal moderate stenosis.

(E): Left coronary angiogram showing OM ostio-proximal segment severe stenosis.

(G): Right coronary angiogram showing RCA mid-segment exerting moderate stenosis (50%).

Abbreviations

SS-I	SYNTAX score
SS-II	SYNTAX score
CAD	Coronary artery disease
MSCT	Multi-slice computed tomography
ICA	Invasive coronary angiography
PCI	Percutaneous coronary intervention
CABG	Coronary artery bypass graft
SS-II	SYNTAX score II
CTA	Computed tomography angiography
CT	Computed tomography
LM	Left main coronary artery\
CCTA	Coronary computed tomographic angiography
LVEF	Left ventricular ejection fraction
MPR	Multiplanar reconstruction
MIP	Minimum intensity projection
SD	Standard deviation
PVD	Peripheral vascular disease
Crcl	Creatinine clearance
LAD	Left anterior descending artery
LCx	Circumflex coronary artery
RCA	Right coronary artery

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
"This study was approved by the ethics committee of Tanta University Hospital. Ethics committee reference numbers is 34041/8/20. Some patients provided verbal consent, and the ethics committee approved this procedure as it suits this research project, and written consent is unnecessary according to national regulations.

Consent for publication
The patients provided consent, and the ethics committee approved it according to national regulations. All patients included in this research gave informed verbal consent to publish the data contained within this study. All participants enrolled in the study provided informed verbal consent to participate.

Competing interests
The authors declare no competing interests.

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