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Full Length Research Paper

Diagnoses of coronary artery diseases using 64-Slice computed tomography angiography

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Coronary artery disease (CAD) is the important cause of death in the world. The aim of the study was to determine the diagnostic role of 64 multi-slice computed tomography (MSCT) in the detection of (CAD). A total of 31 patients (22 Males, 9 Females), their mean age is 49.4±12.2 years old ranged from (29-83) suspected to have coronary artery disease undergoing MSCT angiography were included. Gated coronary, Post-processing techniques were carried out to assess the presence of coronary artery disease. CAD was present in coronary artery in 16 patients (51%). All right coronary artery, second diagonal branch, first Marginal branch , Left anterior descending , circumflex , first diagonal branch were affected , with maximum calcified plaques act 35.7%, non-calcified plaques 41.7%, mixed plaques 66.6%, diffuse disease in23%, stenosis 33.3%, Cardiac Structure ,Morphology changes were seen in(50%) of the patients .The average coronary artery calcification score (CAC) score was 266.9Agatston ranged from 0-1552. (44%) of the patients had an Agatston score ≤ 10, (31%) ≤ 400 and (19%) ≤ 1000 and (6%) ≥ 1000Agatston.CAC is significant at *P* values 0.05 and 0.01 in the presentation of stenosis, diffused diseases, mixed plaques and calcified plaques. The correlation is not significant between the morphological changes detected and the calcium score values, the presentation of stenosis and diffused diseases. The study corroborates that 64-slice MSCT is a reliable, non-invasive, appropriate tool for diagnosing patients with CAD.

Keywords: Coronary artery stenosis, plaques, Computed tomography, Coronary angiography.

INTRODUCTION

Coronary artery disease (CAD) is the leading cause of death in Western countries. Invasive coronary angiography is the gold standard technique for diagnostic and therapeutic purposes in CAD, owing to its superior spatial and temporal resolution. Recently, invasive coronary angiography has been challenged by the emergence and fast growing technique of multislice computed tomography (MSCT) angiography, which is less invasive (McCollough and Zink, 1999; Nieman et al., 2001; Achenbach et al., 2001).

The diagnostic accuracy of MSCT angiography in CAD has been significantly improved with the increased performance of MSCT from the early generation of 4-slice

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CT scanners to later models such as 16, 64, dual-source, 256 and 320 slice CT scanners (Nieman et al., 2001; Dewey et al., 2009).

In particular, MSCT angiography has been reported to demonstrate a very high negative predictive value (more than 95%), indicating that it can be used as a reliable technique for excluding patients suspected of CAD, thereby reducing the need for invasive coronary angiography. MSCT angiography is also able to provide independent prognostic information for predicting disease progression and cardiac events (Gaemperli et al., 2008).

This is of clinical significance because a normal cardiac CT angiography suggests that patients have normal coronary arteries and can be safely reassured without further testing or invasive examinations such as coronary angiography.

Another advantage of MSCT angiography over coronary angiography lies in the fact that MSCT allows for the characterization of atherosclerotic plaques and the identification of plaque components (Schroeder et al., 2004; Hoffmann et al., 2006).

Coronary angiography is restricted to visualize the luminal stenosis, but failed to provide information about the type of plaques or identify vulnerable plaques that could lead to thrombosis or myocardial infarction (Takumi et al., 2007).

Therefore, MSCT angiography, a less invasive imaging modality, has been increasingly used for the detection of coronary stenosis, the evaluation of coronary plaques and the prediction of disease progression.

Catheter-based invasive coronary angiography (ICA) is the gold standard of reference technique for direct assessment of the severity of coronary stenosis.

However, this applied tool can be associated with certain risks and complications. It should also be possible to more accurately determine the absence or presence of stenotic lesions and to rule out atherosclerotic changes at coronary bypass anastomoses (Anders et al., 2006). The use of noninvasive assessment tools was recently considered mainly because it offers safety, patient convenience, and faster performance [16-17]

The accuracy of this tool for significant stenosis can be determined based on pooled data from the studies, however, heterogeneity of methods and patient selection would reduce the accuracy of results of pooled data (Shabestari et al., 2007; Bax and Schuijf, 2005).

The coronary artery calcium score (CAC) is a relatively new modality for cardiac risk estimation and stratification (Third Report of the National Cholesterol Education Program (NCEP) et al., 2002; Greenland et al., 2007). In the last decade, several studies showed that CAC is a valuable risk marker as it is directly related to atherosclerotic plaque burden and independently predicts severe cardiac events in patients with known CAD (Uebleis et al., 2009) or all cause mortality (Budoff et al., 2007).

The Agatston score has been defined by Agatston and Janowitz and dates back into the 1980s. The original work was based on Electron Beam computed tomography (EBCT). For quantification of coronary calcium, the Agatston Score is calculated as the product of the lesion's surface area and a weighting factor ranging from one to four, which was assigned according to the peak attenuation of the lesion (Agatston et al., 1990). Territories with stents are expectedly excluded from quantificat ions.

Budoff et al. reported that the 10 year survival in asymptomatic patients with CAD was 99.4% in patients with a CAC score (Agatston Score) of 0 but was only 87.8% in those with an Agatston Score greater than 1000.CAC was stronger predictor of the outcome (Chang et al., 2009).

The aim of the present study was to determine the ability of multislice CT angiography for the detection of CAD

MATERIALS AND METHODS

Patients

A total of 31 patients (22 Males, 9 Females), their average ages, is 49.6years old ranged from (29-83) suspected to have CAD undergoing multislice CT examinations were included in the study. (The Optima CT 660, GE Discovery CT750 HD, GE Medical Systems, and Milwaukee, USA) in radiology department. Exclusion criteria were: unstable angina, allergic to iodinated contrast material, renal insufficiency, severe respiratory function impairment and heart failure.

Methods

Non-contrast study was performed followed by 64 detector OPTIMA 660 high resolution gated cardiac volume study in the trans axial projection using 0.625 mm slices with non-ionic contrast material (Xenetix) during 5 seconds breath hold. Axial two dimensional and three dimensional images were reconstructed using an AW work station for patients with a heart rate more than 70 beats per minute, a beta-blocker was used to slow down the heart rate prior to CT scans, different post-processing techniques including maximum-intensity projection (MIP), curved multiplanar reconstruction (CPR), and volume rendering (VR) were applied.

Coronary Artery Section and Evaluation Standard

The American College of Cardiology (ACC) and the American Heart Association (AHA) classification of coronary segments were adopted as guide lines and basis for imaging evaluation. Right coronary artery (RCA)

Table 1. Demographic characteristics and clinical data of the patients included in this study.

Gender		Age *(Years)*	CAC* *(Agatson)*	HR* (*Beat/Min*)	Protocol	
Male	Female	49.4±12.2 Max 83-Min 29	266.9 (0-1552)	61.7±7.8 Max 75-Min 47	Prospective	Retrospective
22	9				12	19

*CAC stands for Calcium Score Values, HR for Heart rate.

Table 2. Descriptive table for in the Coronary arteries, Diseases Presentation, Plaques Classification included in this study.

Affected Arteries	Diffuse Disease Presentation %	Stenosis Presentation %	Plaques Classification %		
			Mixed	Non-Calcified	Calcified
RCA	23	11.1	-	16.7	28.6
D2	23	7.4	-	-	14.3
M1	15.9	3.7	-	-	7.1
LAD	15.9	33.3	66.6	25	35.7
LCX.	15.9	29.6	-	41.7	14
D1	1.7	14.8	33.4	16.7	14.3

Data are presented as percentages. Abbreviations: Right coronary artery (RCA) ,Left coronary artery (LCA), Left anterior descending (LAD),diagonal branches (D1, D2) ,Circumflex (CX) ,Marginal branches (M1).

is divided into proximal, middle and distal segments. The left coronary artery is divided into left main coronary artery (LM) and left circumflex branch (LCX). LAD is divided into proximal, middle and distal segments, LCX into proximal and distal segments. All the coronary segments were evaluated gradually in segmentation. The evaluation was possible even with a few artifacts but still met the demands of the diagnosis. The vessel was not evaluated if any segment of the coronary main branch could not be evaluated.

Characterization of plaques

Coronary artery plaque was characterized into the following three types based on the CT attenuation: calcified plaques indicate plaques with high density, non-calcified plaques refer to plaques having lower density compared with the contrast-enhanced vessel lumen, mixed plaques indicate plaques with non-calcified and calcified elements within a single plaque, or within a segment of the coronary artery .CAC was measured by chest computed tomography (CT) using multi-detector CT system. The amount of calcium was quantified by using the Agatston scoring method.

Data collection

Study data, including detailed data were collected on case report forms (CRF's) .MSCT angiograms were evaluated by an invasive radiologist with several years of experience of scoring MSCT coronary angiograms. 3D volume rendered reconstructions were used to obtain general information of the status and course of the coronary arteries. Then, the original Trans axial slices were inspected for the presence of narrowing, assisted by curved multiplanar reconstructions. Segments containing coronary stents and coronary artery bypass graft (CABG) were included in the analysis.

Statistical analysis

Categorical variables were summarized by calculating the number and percentage, whereas the mean and standard deviation were calculated for continuous variables, SPSS (version 16) was used for data analyses.

RESULTS

Patient characteristics

31 patients successfully underwent the DSCT 22 Males, 9 Females, aged 29-83 years, average age 49.6years. (Table 1). shows demographic characteristics and clinical data of patients. 27 segments were stenosis and 13 segments were diffuse disease; (Table 2) shows the distribution and characteristics of plaques in the coronary artery and its branches. 29 segments were correctly diagnosed as plaques, Coronary diseases were presented in 16 patients involving different artery branches, while in the remaining 15 patients, and the

Table 3. The Correlations Between the Variables.

Correlations Variables	Average Calcium Score	Stenosis Presentation	Diffused Presentation	Calcified Plaques	Non Calcifed Plaques	Mixed Plaques
Averege Calcium Score	-	002**	000**	029*	241	002**
Stenosis	002**	-	004**	000**	000**	006**
Diffused Presentation	000**	004**	-	134	98	000**
Calcified Plaques	029	000**	134	-	000**	068
Non Calcifed Plaques	241	000**	098	000**	-	168
Mixed Plaques	002	006**	000**	068	168	-

***** Correlation is significant at the 0.01 level,*Correlation is significant at the 0.05 level (2-tailed).***

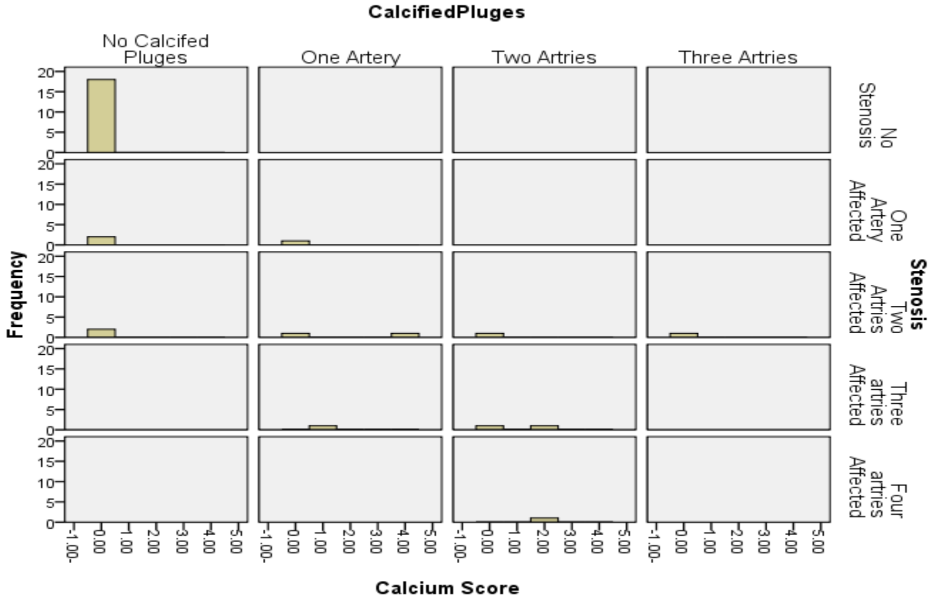


Figure 1. Cross Tabulation between Calcium Score Values, Calcified Plaques and Stenosis.

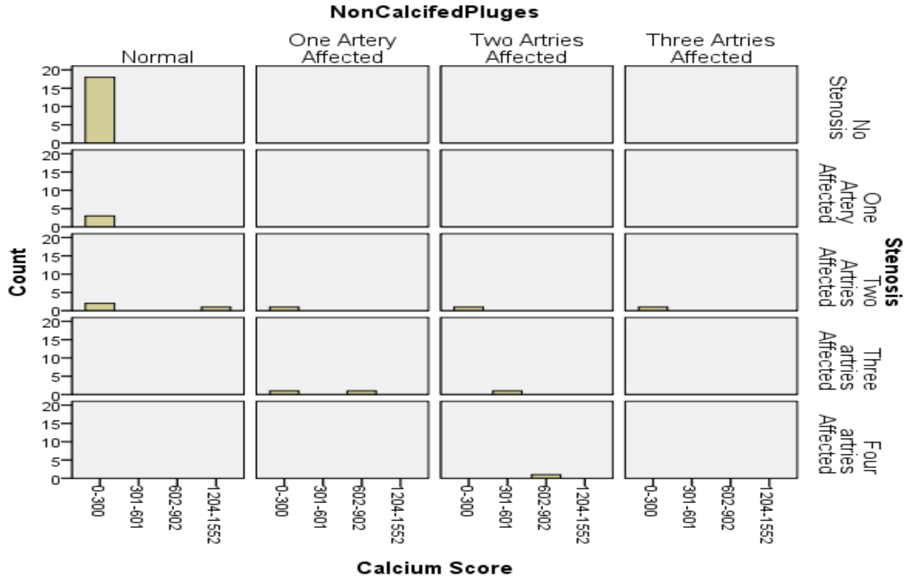


Figure 2. Cross Tabulation between Calcium Score Values, Non Calcified Pluges and Stenosis

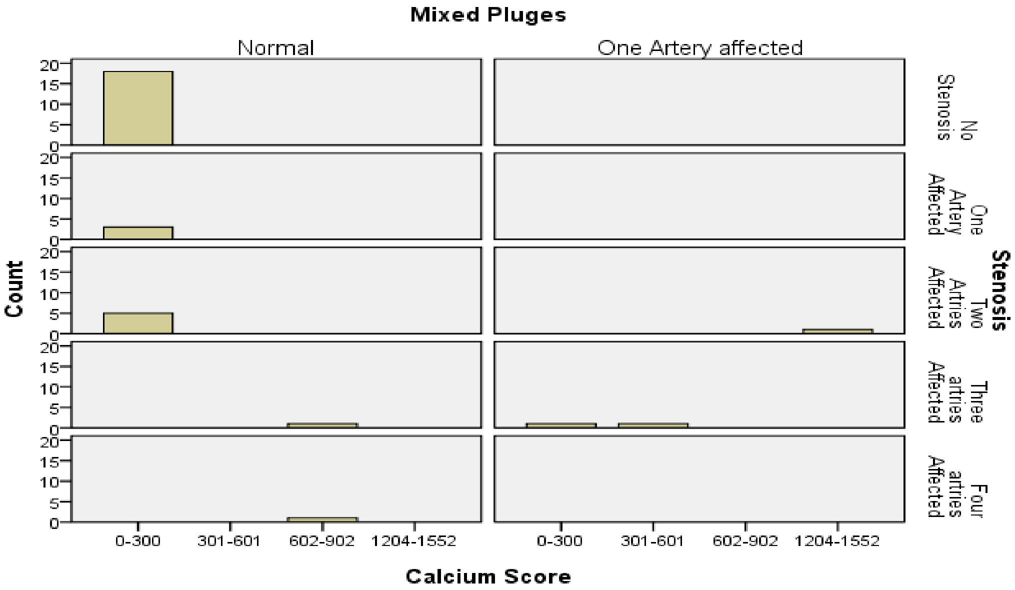


Figure 3. Cross Tabulation between Calcium Score Values, Mixed Plaques and Stenosis.

Table 4. The Correlation between Cardiac Structure And Morphology, Average Calcium Score, Stenosis And Diffusion Presentation

Correlations Between The Variables				
Variables	**Cardiac Structure And Morphology**	**Calcium Score**	**Stenosis**	**Diffused Presentation**
Cardiac Structure And Morphology	-	904	075	218
Calcium Score	904	-	002	000**
Stenosis	075	002**	-	004**
Diffused presentation	218	000**	004**	-

***. **Correlation is significant at the 0.01 level (2-tailed)**.*

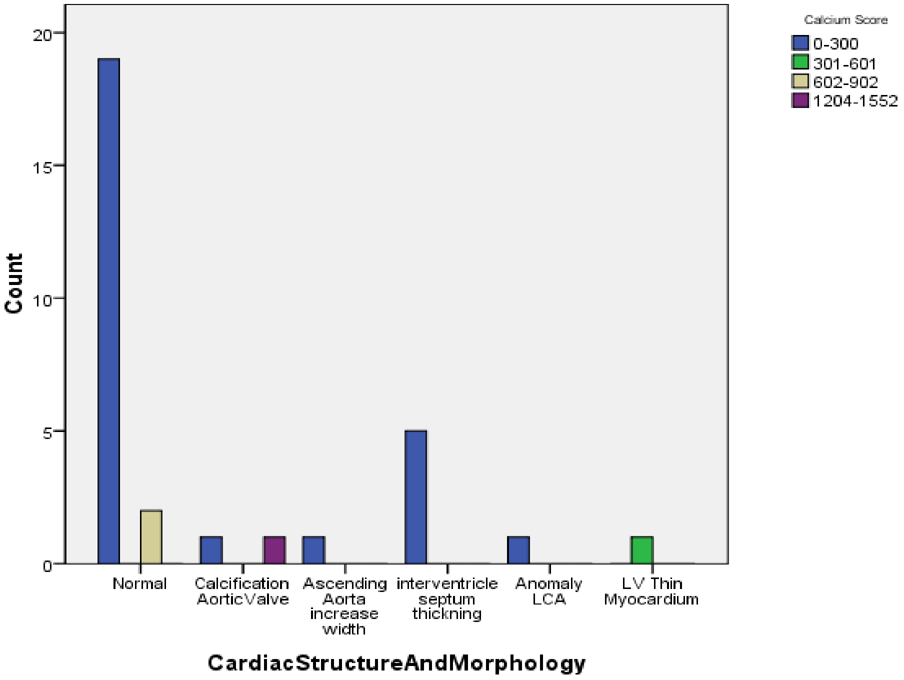


Figure 4. Correlation between Cardiac Structure Morphology and Average Calcium Score Values.

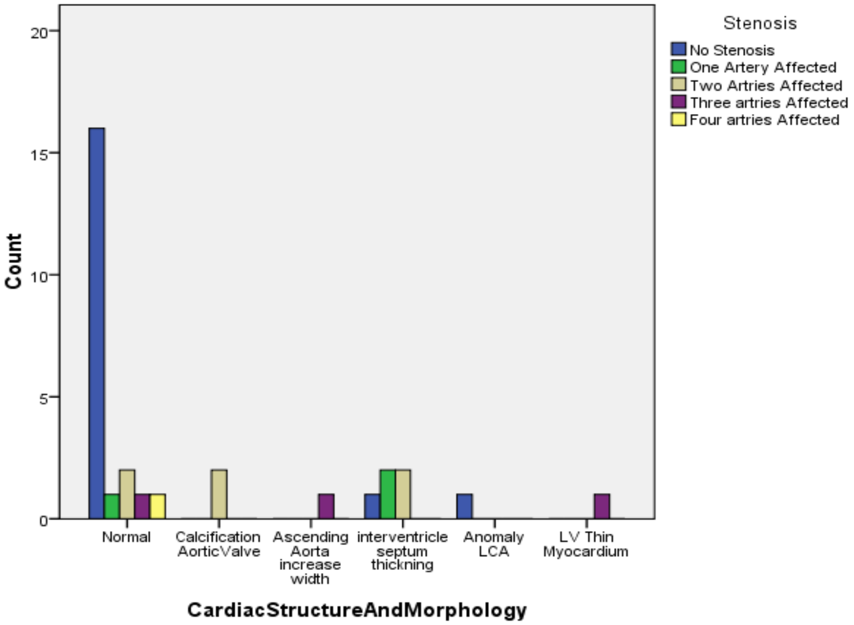
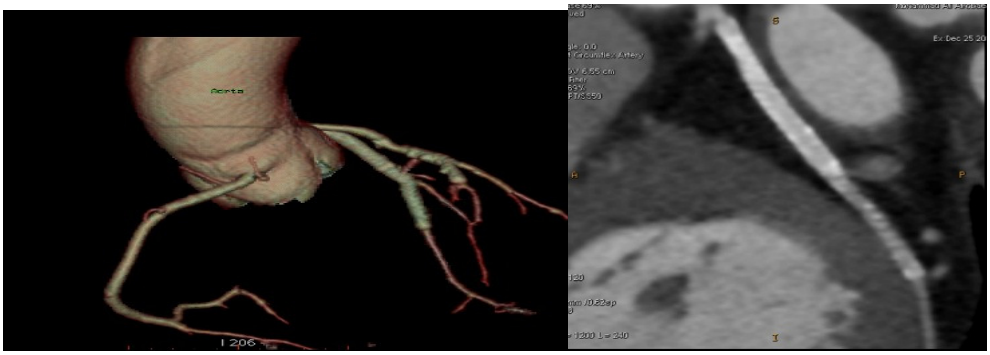
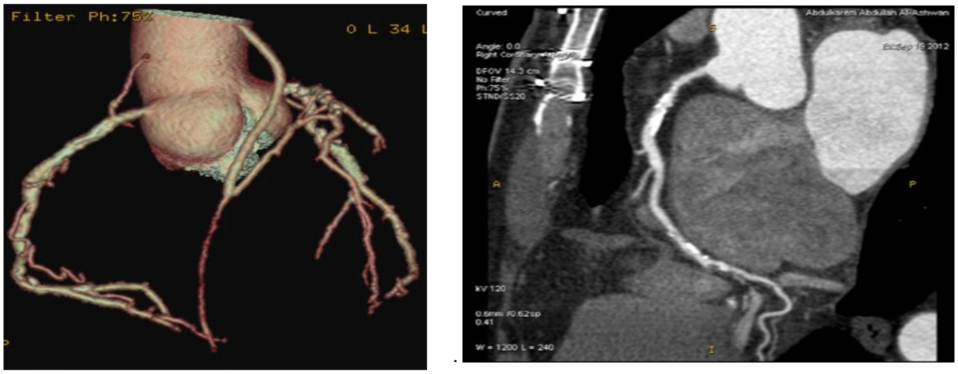


Figure 5. Correlation between Cardiac Structure Morphology and Stenosis.



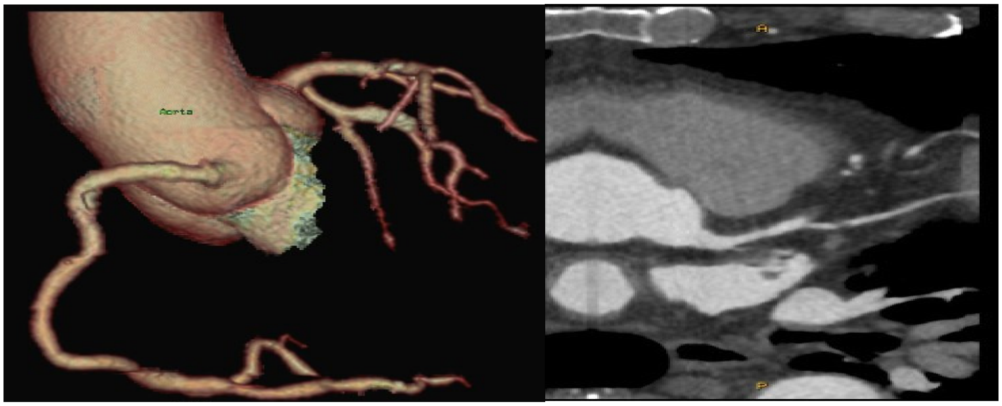
(A) (B)

Figure 6. Shows Coronary CT angiography of (A) 3D volume rendering image, and (B) curved multi planar reformatted(MPR) ,three stent placed in LAD and left circumflex.CAC score is 28.In the proximal part of the LAD showed atheromatous plaque with stenosis of the distal part of the left circumflex.



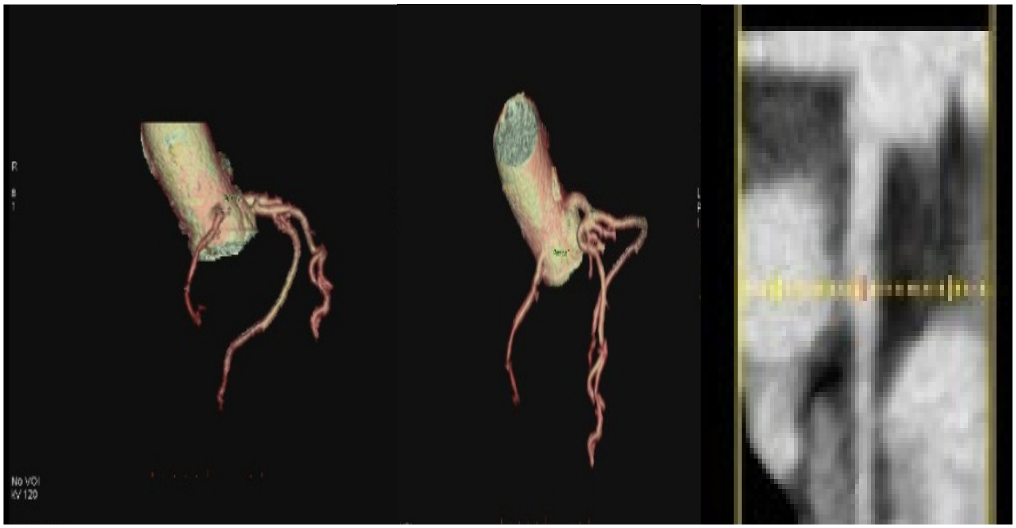
(A) (B)

Figure 7. Shows Coronary CT angiography with (A) 3D volume rendering image, and (B) curved multiplanar reformatted, (MPR) of CAC score is 843.grafting of the LAD with LIMA with 3 vessel disease. Subtotal stenosis in the proximal part of the left circumflex artery.



(A) (B)

Figure 8. Shows Coronary CT angiography of (A) 3D volume rendering image, and (B) curved multiplana reformatted, (MPR) of stent in the marginal artery. CAC score is 181.In the middle part of the LAD showed non-calcified atheromatous plaque with stenosis, mixed type of plaque with significant stenosis in the 1st diagonal. Eccentric calcified plaque with moderate stenosis in the 2nd diagonal.



(A) (B) (C)

Figure 9. Shows Coronary CT angiography of (A.B) 3D volume rendering image, and (C) curved multiplanar reformatted(MPR) of Coronary calcium score is zero.Left main coronary artery anomaly was noted in the distal part which looked like aneursymal dilatation with quadfurcation of the left main artery, left circumflex, ramus and left marginal artery.

coronary artery tree was normal and free of involvement by plaques. All of the plaques have calcium components to variable degrees with high rate involving the left anterior descending artery.

Cross tabulations between the Variables including CAC, Stenosis, Diffused presentation of CAD, and Plaques Types were presented in the (Figures 1, 2, 3)

DISCUSSION

Conventional coronary angiography (CCA) has been the technique of choice for visualization of the coronary arteries for several decades. In addition to being invasive CCA has disadvantages in detecting coronary artery anomalies because of limited number of 2D projection images obtained during catheterization and the absence of soft tissue information (Kosar et al., 2009). Over the last decade substantial advances have been made in non-invasive cardiac imaging. Coronary CT angiography had an increasingly important role in the diagnosis of coronary artery disease. MDCT angiography is considered the first line imaging modality in detecting coronary artery anomalies. Detection of CAD along with the complex anatomic relations with adjacent structures is excellent with MDCT (Hurlock et al., 2009; Kacmaz et al., 2008). In the present study the prevalence of the coronary artery diseases was 51.6% of patients with suspected coronary artery disease undergoing MDCT coronary angiography. Our result is slightly lower than that of Schmitt et al., 2005 who reported a prevalence of 2.5% and higher than result of Yang et al., 2009 who reported a prevalence of 1.097%.In the present study left coronary artery diseases were more common than right coronary artery anomalies. This is in agreement with the results of one series (Datta et al., 2005) and in disagreement with results of other studies (Yang et al., 2010; Knickelbine et al., 2009). It is possible that the lower prevalence of anomalous left coronary artery in their studies suggests that it may be more lethal than anomalous right coronary artery early in life. **In** the present study volume-rendered images acquired from3D CT data sets (MIP, CPR and VR) demonstrate clearly the cardiac and vascular anatomy.

The prevalence of CAD in this study was substantially higher than rates reported in the literature (7 vs. 1%). This is most likely due to a selection bias in our study based on clinical presentation.

This study was performed to determine the diagnostic role of 64-slice multi-slice computed tomography (MSCT) in the detection of coronary artery disease (CAD).

Although based on a small number of patients, results showed that the left coronary artery undergoes dimensional changes due to atherosclerosis; it is widely acknowledged that coronary plaques play a critical role in the pathogenesis of acute coronary syndromes due to local thrombus formation caused by plaque rupture or erosion, therefore, plaque composition rather than the degree of luminal narrowing may be predictive of the patient's risk for further coronary events (Schuijf et al., 2007). Regarding the results; it was found that the average calcium score is significant at *p* -value of 0.01 in the presence of stenosis, diffused presentation as well as mixed plaques and is significant at 0.05 in the calcified plaques without significant relation in the non classified plaques as presented in table 3.The correlations between the affected arteries and calcium score values, plaques type, stenosis and diffused presentation are presented in figures (1,2,3)

Extensively calcified lesions most likely represent atherosclerosis at later stages of remodeling and may reflect more stable lesions (Hong et al., 2005). Therefore, in the presence of coronary plaques, especially calcified plaques, coronary artery undergoes dimensional changes due to alternation process, resulting in corresponding diameter differences between the normal and diseased coronary arteries. Results from this study are consistent with other reports regarding the distribution and morphology of coronary plaques (Rodriguez-Granillo et al., 2007; Rodriguez-Granillo et al., 2006; Kaazempur-Mofrad et al., 2004; Kimura et al., 1996). Atherosclerotic plaques were commonly located at the LAD, particularly close to the ostium of LAD, whereas the left main stem and the LCx were less frequently affected. This could be used as guidance for analysis of possible effects of the hemodynamic on the local characteristics and distribution of plaques (Cademartiri et al., 2009).

The cardiac morphology was evaluated by assessing the calcified aortic valve, changing in vessels width or arterial anomalies as well as inter ventricular septum and myocardium changes. Valve calcification is seen in 2 subjects, inter ventricular septum changes is detected in 4subjects ranged between 9-10mm,anomalies in LCA is detected in one and increases in ascending aortic width is detected in two. The correlation is not significant between the cardiac changes detected and the calcium score values, the presentation of stenosis and diffused diseases, as it was presented in (table 4) and (figures 4,5).

This study confirms the visualization of lesions of coronary arteries, cardiac morphology revolution, as well as classification of plaques type in those diagnostic methods which was achieved in all patients, comparable to other studies done (Achenbach et al., 2006; Johnson et al., 2006; Scheffel et al., 2006).

Images concern with the presentation of CAD and calcium score values were presented in (figures7, 8,9)

CONCLUSIONS

With the development of new and exciting modalities, such as multi detector ECG gated cardiac MSCT, noninvasive imaging of small mobile structures, such as coronary arteries, has become possible. Because of the high prevalence, morbidity, mortality, and enormous socioeconomic burden of coronary artery disease, noninvasive detection of significant coronary artery stenoses has been the driving force behind the development of this technology. As the technology evolves, cardiac CT will become readily available, making interpretation a necessary clinical ability. Knowledge of the various coronary anomalies is important to those interpreting cardiac CT. In the future diagnostic algorithms combining non- invasive anatomic and functional imaging need to be evaluated in large patient populations to establish their efficacy, safety, and cost effectiveness. Importantly, these investigations should result in the development of comprehensive guidelines on the use of CTA in clinical practice as well. Moreover, the combined use of these techniques may enhance the assessment of the presence and extent of CAD.

Although further work is required to determine the prognostic utility of MSCT and to clarify its precise clinical role, the currently available data suggest that it will play an increasing role in the evaluation of patients with known or suspected CAD.

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