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Evaluation of coronary artery disease by computed tomography angiography and calcium scoring on a 16-slice MDCT scanner in diabetic and nondiabetic patients

Vikrant Agarwal, Bijon Kundu, Surendra K. Sharma
EKO X-ray and Imaging Institute, 54, Jawaharlal Nehru Road, Kolkata - 700 071, West Bengal, India

Correspondence: Dr. Vikrant Agarwal, EKO X-ray and Imaging Institute, 54, Jawaharlal Nehru Road, Kolkata - 700 071, West Bengal, India.
E-mail: vikrantagarwal_999@yahoo.co.in

Abstract

Objectives: To evaluate the coronary arteries by CT angiography (CTA) and calcium scoring (CS) with 16-slice MDCT for detection of coronary artery disease (CAD) by plaque detection, plaque characterization as well as quantifying luminal narrowing and to correlate the incidence and severity of CAD in diabetic and nondiabetic subjects. **Materials and Methods:** One hundred and five patients (76 men, 29 women) aged 26-89 years underwent MDCT angiography with CS. Significant luminal stenosis was defined as a reduction in lumen diameter greater than or equal to 50%. The presence of calcification was determined by using the Agatston method. Incidence and severity of CAD were noted in diabetic (DM) and nondiabetic (nonDM) patients. **Results**: On comparing the CS in patients with DM and nonDM, there was a marked increase in the CS in diabetic patients. Seventy six per cent of diabetic patients showed calcific plaques whereas only 37% of nonDM patients showed calcific plaques. **Conclusion:** DM patients show significantly more CS than nonDM patients. Calcific plaques are more common in DM than nonDM patients. Double and triple vessel involvement is more common in DM than the nonDM patients.

Key words: Calcium score, diabetes, multidetector computed tomography, coronary angiography

Cardiovascular diseases are the major causes of death in adults in most developed and developing countries and are now the commonest cause of death worldwide. These disorders also lead to substantial morbidity and disability and are a main source of the rising cost of health care.

Risk factors for coronary artery disease can be divided into modifiable and unmodifiable categories. Modifiable risk factors include smoking, hypertension, hyperlipidemia, high total cholesterol, high low-density lipoprotein (LDL) and low high-density lipoprotein (HDL), diabetes, abdominal obesity, sedentary lifestyle, high homocysteine levels, high C-reactive protein levels and mental stress.[1]

Unmodifiable risk factors include age, male sex and family history. Aggressive lowering of cholesterol levels has reduced individual morbidity and mortality rates but not the overall cardiovascular death rate.

In atherosclerotic disease, calcification also occurs in the coronary arteries. Coronary calcification is associated with future cardiac events[2,3] and can be modulated by medical therapy.[4] It is also associated with coronary luminal stenosis.[5,6]

This study was conducted to evaluate the coronary arteries by CT angiography (CTA) and calcium scoring (CS) with 16-slice MDCT. The aim was to evaluate CAD with respect to plaque detection, characterization, as well by as quantifying luminal narrowing and to correlate the incidence and severity of CAD in diabetic (DM) and nondiabetic (nonDM) patients.

Materials and Methods

Patients

The study was conducted from March 2005 to October 2005. 105 patients (76 males and 29 females) were studied. Patients were instructed to abstain from caffeine containing products for at least 12h. Four hours fasting was required. For CT angiography, the target heart rate was 65 beats per minute,[7] for which 100 mg metoprolol was given if necessary.

Imaging

Using an 18-G intravenous needle, CT coronary angiography was performed on a 16-slice MDCT (Lightspeed 16, GE, Bangalore) scanner. Calcium scoring was first performed with prospective ECG gating. Sublingual nitroglycerine spray was administered to promote better visualization of the coronary arteries. 80 ml of 350 mg/ml iodinated contrast was used at a rate of 4 cc per sec, followed by a 50 cc saline bolus chase. For angiography, a breath-hold, ECG-gated CT was performed (0-625 X 16 mm collimation, pitch of 0.3-1, 0.5-sec rotation time, 120 kV and 360 mA). The mean scanning delay was 20 sec (range, 16-22 seconds) and the mean breath hold was 16 sec (range, 14-20 sec).

Image analysis

Significant luminal stenosis was defined as a reduction in lumen diameter greater than or equal to 50%.[8-10]

The presence of calcification was determined by using the Agatston method for multi-detector row CT with a 130-HU threshold. The calcific lesion had to have an area more than 1 mm^2.[11-12] The coronary arteries were assessed for stenosis. All CT angiographic assessments were performed on a workstation (Card IQ, Advantage Workstation 4.2; GE Medical Systems). An optimal ECG phase was selected. Because diastolic phases are more commonly used,[8-10,13] if a vessel was seen equally well in multiple phases, preference was given to a mid-diastolic phase. For CT angiography, each vessel was classified as significantly stenosed (50% stenosis) or not significantly stenosed.

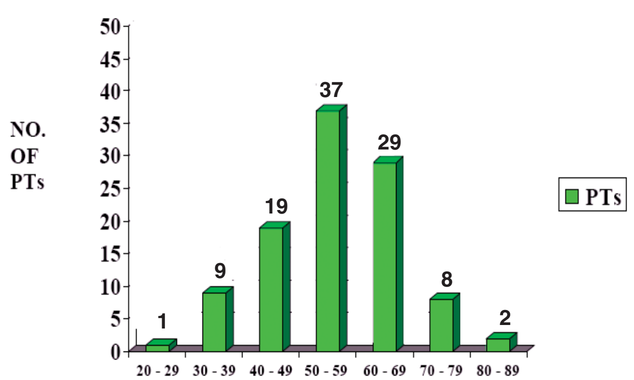

Figure 1: Histogram showing age distribution of patients

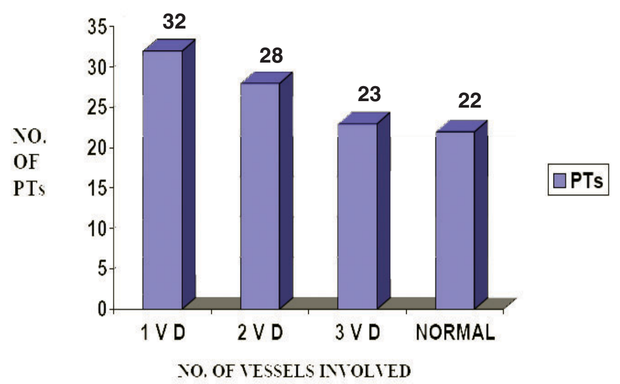

Figure 3: Histogram showing vessel involvement in patients

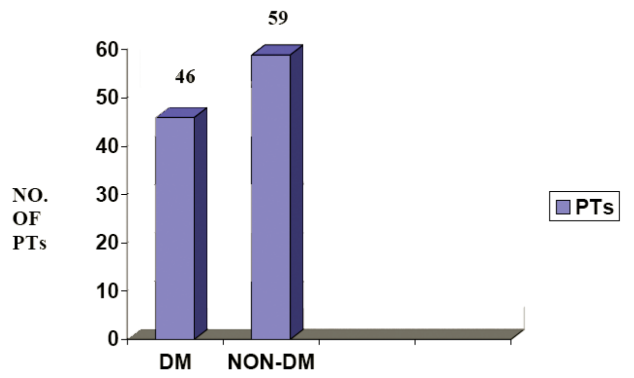

Figure 2: Histogram showing the number of DM and nonDM patients

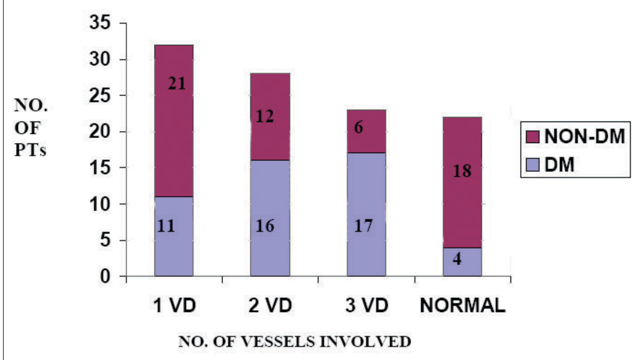

Figure 4: Histogram showing comparative vessel involvement in DM and nonDM patients

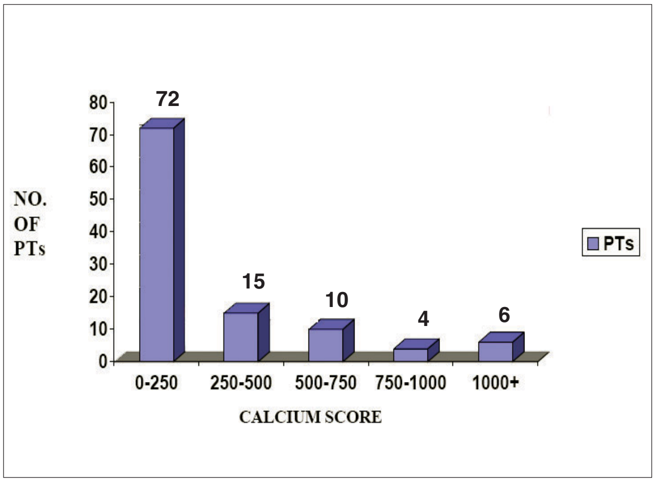

Figure 5: Histogram showing calcium scores in patients

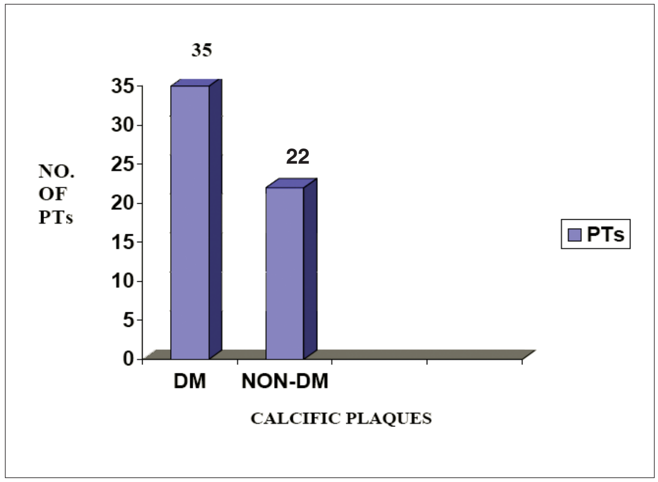

Figure 7: Histogram showing calcific plaques in DM and non-DM patients

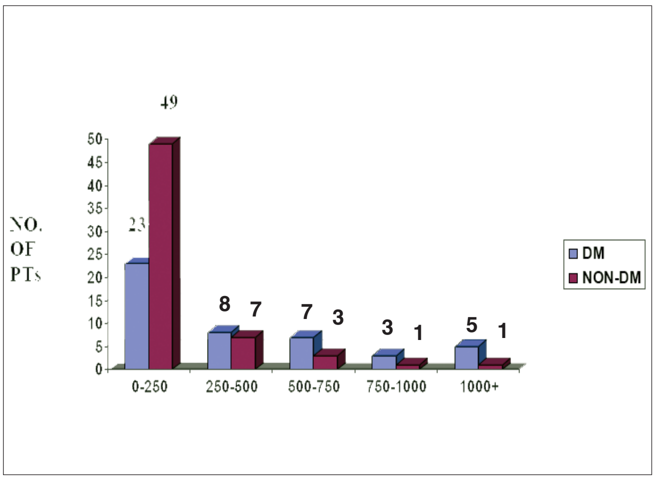

Figure 6: Histogram showing calcium scores in DM and non-DM patients

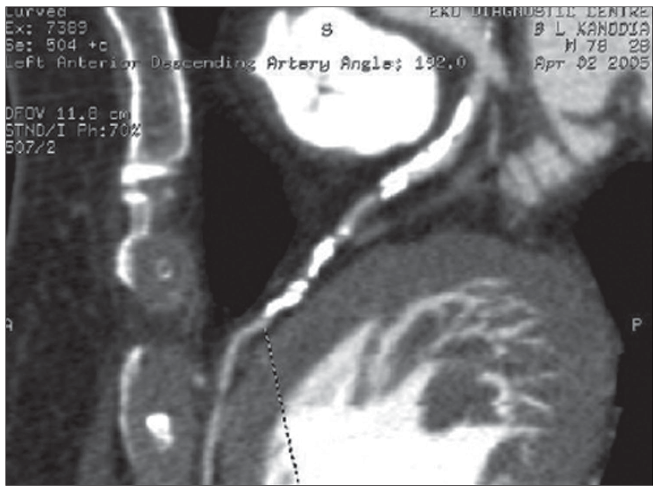

Figure 8: CT coronary angiogram MIP image showing a calcific plaque (arrow) in the LAD

Results

105 patients (76 males and 29 females) were studied from March 2005 to October 2005. Patients were in the age group of 26-89 years. Out of 105 patients, 66 patients were between the ages of 50-69 years [Figure 1]. 76 patients were males and 29 were females.

59 patients were normal and 46 patients had DM [Figure 2]. Fifteen patients had sugar levels between 101-120 and 15 patients had sugar levels between 121-160. Seven patients had sugar levels more than 160. Nine patients had sugar levels between 80-100.
32 patients had single vessel disease, 28 patients had double vessel disease, 23 patients had triple vessel disease and 22 patients had normal coronary arteries [Figure 3].

In those with single vessel disease, 11 patients had DM and 21 patients were nonDM. In those with double vessel disease, 16 patients had DM and 12 patients were nonDM. In those with triple vessel disease, 17 patients had DM and six patients were nonDM. In patients who had normal coronary arteries - four had DM and 18 patients were nonDM [Figure 4].

72 patients had a calcium score (CS) between 0-250. Fifteen patients had CS between 250-500. Twenty patients had CS more than 500 [Figure 5].

On comparing the CS, in the 0-250 range there were 49 nonDM patients as compared to 23 DM. However when a CS of more than 250 was compared, the ratio of DM to nonDM patients showed a marked increase [Figure 6]. Seventy six per cent (35 in 46) of DM patients showed calcific plaques whereas only 37% (22 in 59) of non-DM patients showed calcific plaques [Figure 7].

Discussion

CAD refers to the presence of atherosclerotic changes within the walls of the coronary arteries, which causes impairment or obstruction to normal blood flow with resultant myocardial ischemia. CAD is a progressive disease process that generally begins in childhood and manifests clinically in mid-to-late adulthood. Diabetes, hyperlipidemia and hypertension are amongst the important risk factors.

A number of mechanisms are involved in the diabetic coronary artery disease which may be metabolic, cellular or molecular.[14]

The basis for excess CAD-related morbidity and mortality in DM is not completely understood. Although most of the classic risk factors (e.g., hypertension, dyslipidaemia, left ventricular hypertrophy, overweight) are over-represented in diabetes, they explain only a small fraction of the increased ischemic heart disease (IHD) incidence seen in DM patients.[15] Recent evidence has indicated that severe hyperglycemia and a long duration of the disease both enhance the risk of fatal and non-fatal ischemic events but the effect is quantitatively small compared with the overall IHD excess.[16] Also, the pathologic basis of CAD in diabetes is controversial. Although several autopsy[17-19] and angiographic studies[20,21] have reported more severe and diffuse atherosclerotic involvement of the coronary vasculature in diabetic subjects, negative reports are well-represented in the literature.[22-25] Thus, alternative mechanisms have been proposed to explain IHD in diabetes: functional abnormalities of small vessels,[26,27] reduced metabolic resistance of the myocardium to ischemia,[28] linkage disequilibrium between the genes responsible for diabetes and cardiovascular disease[29] and new cardiovascular risk factors.[30] Among the latter, abnormal urinary protein excretion has emerged as one of the most consistent IHD risk predictors, especially among diabetic patients.[31,32]

CT-based coronary angiography is a noninvasive alternative, made possible by the development of high-speed multi-detector CT (MDCT) scanners.[33] Current multi-detector row CT scanners provide an in-plane resolution of 0.5 mm or better and an effective through-plane (z-axis) resolution of 0.34-0.8 mm,[33] factors which approach the requirements for successful noninvasive imaging of the coronary arteries.[34]

After data processing, images can be viewed as cross-sections of the heart or as 3-D reconstructions of the heart and coronary arteries or as 3-D reconstructions that appear as planar images along the length of the arteries.[35] MDCT coronary artery calcium scoring in asymptomatic patients with risk factors as well as in symptomatic patients is now possible.[36] Progression or regression of coronary atherosclerosis with medical treatment as well as bypass graft or stent patency may be evaluated.

The two most important risk factors for coronary calcium are age and gender [Figure 8]. Hoff *et al*. showed that the CS is higher for men than women in all age groups. Men and women with DM have an increased extent of coronary calcium.[37] Asymptomatic individuals can be categorized into low, intermediate and high level of risk. CS alone does not increase the risk of pre-scan, low risk individuals to a high-risk category, requiring preventive measures. Furthermore, a negative CS in a high-risk individual will not reduce the risk to a level at which preventive measures could be withheld. CS is helpful in intermediate category individuals, where a positive or a negative CS reclassifies them into high or low risk groups and thus provides further support for either instituting or withholding long term preventive measures.[38-44]

Conclusion

DM patients show significantly more calcium score than non-DM patients. Calcific plaques are more common in DM (76%) than nonDM (37%) patients. Double and triple vessel involvement is more common in DM than the nonDM patients.

MDCT coronary angiography has a lot to offer and is the future for noninvasive diagnostic imaging of the coronary arteries depending on the clinical indication of each individual patient.

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