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NON INVASIVE COMPUTED TOMOGRAPHIC CORONARY ANGIOGRAPHY IN PATIENTS WITH SUSPECTED CORONARY ARTERY DISEASE

Radiology

KEYWORDS: coronary, angiography, MDCT, calcium, stenosis

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ABSTRACT

BACKGROUND- Coronary artery disease is a major cause of morbidity and mortality. CT Coronary angiography is a useful tool in evaluation of patients with suspected coronary artery disease with excellent temporal as well as spatial resolution. **AIMS & OBJECTIVES-1.** Quantification of coronary calcium by MDCT and it's implication for determining risk of cardiovascular events. 2. Detection of significant coronary stenosis (>50percent narrowing of it's lumen). **MATERIAL AND METHODS**- This study was hospital based prospective study and was performed on 30 patients with clinical features suggestive of coronary artery disease. CT Coronary angiography was performed on 64-MDCT scanner Ingenuity (Philips Medical Systems). 80 ml of non ionic contrast iohexol with concentration of 300 mg iodine/ml was given followed by 50 ml saline flush at injection rate of 5.5ml/sec into antecubital vein. **RESULTS**- Out of 30 patients, 21were males and 9 were females. Sixteen patients had calcium score of 0, eight patients had a calcium score 11-100, five patients had calcium score 101-400 and one patient had calcium score of 400-800. Thirty patients had 48 lesions, RCA had 4 obstructive and 5 non-obstructive lesions, LAD had 14 obstructive and 13 non-obstructive lesions and LCx had 6 obstructive and 4 non-obstructive lesions. The CTCA had diagnostic sensitivity of 100%, positive predictive value 80% and negative predictive value was 100%. Out of 48 plaques 10 were calcified plaques, 22 non calcified plaques and 16 mixed plaques. **CONCLUSION**- Contrast-enhanced 64-slice CT is a clinically robust modality that allows non-invasive visualization of coronary arteries and identification of coronary lesions with excellent accuracy. Its high diagnostic accuracy made it an excellent non-invasive diagnostic tool in work up of patients with suspected CAD.

INTRODUCTION

Coronary artery disease (CAD) is the major cause of mortality and morbidity in developing as well as developed countries. The incidence, prevalence, hospitalisation and mortality from CAD in Asian Indians are three to four times higher than the Europeans and Americans.[1]

Coronary artery calcification (CAC) has been shown to be a predictive marker of coronary atherosclerotic disease. The American College of Cardiology (ACC) and American Heart Association (AHA) describe calcium scoring as an independent predictor of coronary events in asymptomatic subjects. The total amount of CAC correlates with the overall coronary plaque burden, and the progression of coronary artery disease is associated with increasing CAC.[2]

Conventional invasive coronary angiography (ICA) is the gold standard for clinical evaluation of known or suspected CAD. The risk of adverse events is small, but serious and potentially life threatening sequelae may occur, including arrhythmia, stroke, coronary artery dissection, and excess site bleeding (total complication rate of 1.8%, mortality rate of 0.1%). Furthermore, catheterisation induces some discomfort and mandates routine follow up care.[3,4]

Coronary CT angiography (CCTA) is a non-invasive imaging modality which can be used to evaluate the anatomy of the coronary arteries. CCTA allows direct visualization of the coronary artery wall and lumen with the administration of intravenous contrast. The degree of coronary luminal stenosis can be reliably estimated, as can the presence or absence of both calcified and non-calcified plaques.[5,6]

The introduction of 64-detector computed tomography coronary angiography (CTCA), there has been exponential growth in the quantity of scientific evidence to support the feasibility of its use in the clinical evaluation of individuals with suspected coronary artery disease (CAD).

Calcification of coronary arteries is characteristic of atherosclerotic disease and can be assessed by using electron-beam and multisection CT. Coronary calcification is associated with future cardiac events and can be modulated by using medical therapy and is associated with coronary luminal stenoses.

Coronary arteries were assessed according to the 17-segment modified American Heart Association classification. The coronary arteries are segmented as Right coronary artery (RCA) proximal, middle and distal segments, Posterior descending artery (PDA), Posterolateral branch (PLB), Left Main artery (LMA), Left anterior descending (LAD) proximal, middle, distal, first diagonal and second diagonal, Left circumflex (LCX) proximal, middle, distal, first marginal and second marginal, Ramus intermedius.[7]

MATERIALS AND METHODS

The present study was a hospital based prospective study and was carried out in the department of Radiodiagnosis and Imaging in collaboration with the department of Medicine, Maharishi Markandeshwar Institute of Medical Sciences and Research Hospital, Mullana, Ambala. The study was performed on thirty patients attending Medicine OPD (Out-Patient Department) and IPD (In Patient Department) with clinical features suggestive of Coronary

artery disease. Patients with arythmia, coronary stents and coronary bypass grafts were excluded. Pregnant females, patients with deranged renal functions or past history of allergy to contrast media and contraindication to beta-blockers were excluded. A complete history of patients was taken and detailed clinical examination was performed after obtaining the written informed consent in all cases. Relevant laboratory investigations was done and noted in the proforma. Following this patients were subjected to non-invasive CT Coronary Angiography. All findings were recorded as per proforma attached.

The present study was performed on 64-MDCT scanner (Ingenuity, Philips Medical system). Patient was premedicated with oral metoprolol (25 mg) one night before the study and half an hour before the study. Sublingual nitroglycerine single spray (0.4 mg) was given just before the scan to induce coronary vasodilatation. An initial non-enhanced ECG-gated scan of the cardiac area was performed from the level of carina upto the cardiac apex for calcium scoring of coronary arteries. Then CT angiography for coronary arteries was done. Scan parameters were as follows: Slice thickness 3 mm, rotation time 0.48 s, pitch 0.27, tube voltage 120 kV, and tube current 800 mAs with scan time of 8 s. CT angiography was done using automatic bolus tracking. Prescan was taken at the level of aortic root with the region of interest (ROI) placed on descending aorta. Helical scanning was performed in a single breath hold from 1 cm below the carina to the bottom of the heart using biphasic saline chasing technique, keeping the threshold in ascending aorta at 120 HU with scan delay of 3 s. 80 milliliters of non-ionic contrast medium (iohexol 300 mg I/ml) at a flow rate of 5.5 ml/s was given followed by 50 ml of saline at the same rate to wash out the contrast from the right ventricle. ECG was recorded simultaneously and stored on computer workstation. Prospective or retrospective ECG gating was done for CT coronary angiography. Raw helical CT data and ECG trace were used to reconstruct the images. Post processing was done by using a combination of various post processing techniques including multiplanar reformations (MPRs), curved MPR image, maximum intensity projections (MIPs), and volume-rendered images (VR) for evaluation of coronary arteries.

Main objectives were-
Quantification of coronary calcium by MDCT and its implication for determining risk of cardiovascular events.

Detection of significant coronary artery stenosis (>50% narrowing of the lumen).

1. CORONARY CALCIUM SCORING :-
Coronary calcium scoring was done by Agatston method[8] using workstation (Extended Brilliance Workspace, Philips Medical system). Calcium scores were calculated for LMA (Left main artery), LAD (Left anterior descending), LCX (Left circumflex), RCA (Right coronary artery), and PDA (Posterior descending artery).

2. CORONARY CT ANGIOGRAPHY :
The coronary arteries were segmented according to the guidelines of American Heart Association (AHA). Quantification of stenosis was done as per Leber AW et al[9] – no stenosis (no narrowing), mild stenosis (<50%), moderate stenosis (50-70%), severe stenosis (70-99%) and complete occlusion. The obstructive disease was classified by number of vessels involved into single, two, or three vessels disease categories. Three main vessels taken for this categorization was: RCA, LAD, and LCX. Atherosclerotic plaques causing obstructive or non-obstructive lesions were classified into non-calcified, calcified and mixed on the basis of CT attenuation values.
The findings of MDCT was recorded in the proforma attached and results correlated with clinical observations/ laboratory reports/ therapeutic follow up/ other radiological investigations (wherever performed).

OBSERVATIONS AND RESULTS
Out of 30 patients in our study 21 (70%) were males and 9 (30%) were females. Most of the patients were in the age group of 51-60 years (40%).The youngest patient was of 35 years and the eldest patient was of 75 years. Maximum patients (73.33%) presented with angina followed by atypical chest pain and anxiety.

Sixteen patients had calcium score of 0, eight patients had a calcium score 11-100, five patients had calcium score 101-400 and one patient had calcium score of 400-800. (Table 1) The calcium score increased after 45 years. After the age of 75 years no patient had calcium score of zero. CT coronary angiography was performed by "retrospective ECG gating" in 29 patients. In one patient we did prospective gating. Out of 30 cases, 27 patient had good to adequate image quality which was sufficient for interpretation of the vessels. Out of 8 patients in high heart rate group, excellent image quality was obtained in no patients. Among 22 patients with low heart rate, 4 patients had excellent image quality and 11 patients had good image quality.

Table 1 CT coronary calcium scoring (by Agatston[8] method) n=30

Calcium score	No. of patients	%age
0	16	53.33
1-10	None	None
11-100	8	26.67
101-400	5	16.67
400-800	1	3.33

Out of 30 patients, three patients showed myocardial bridging. (Figure 3) No coronary arteries showed abnormal origin. Twenty four (80%) of cases showed right coronary artery dominance whereas 4 (13.33%) cases showed left dominance and 2 (6.67%) cases showed co-dominance respectively.(Table 2) Out of 30 patients obstructive CAD was seen in 14 cases and non-obstructive CAD was seen in 10 patients. No CAD was seen in 6 cases. (Table 2) 14 patients of obstructive CAD had 17 lesions and 10 patients of non-obstructive CAD had 31 lesions. Out of 17 obstructive lesions 11 lesions were causing moderate stenosis, Four lesions caused critical stenosis and 2 lesions resulted in complete occlusion. There were 24 patients having CAD and 6 patients had normal coronary angiogram in suspected CAD. Single vessel was involved in 12 patients and two vessels were involved in 5 patients. The remaining 7 patients had triple vessel involvement. Thirty patients had total of 48 lesions, RCA had 4 obstructive and 5 non-obstructive lesions, LAD had 14 obstructive and 13 non-obstructive lesions and LCx had 6 obstructive and 4 non-obstructive lesions. One obstructive lesion was present in LMA and the ramus branch. (Table 3,4) (Figure 4,5)

Table 2 Classification and distribution of coronary artery disease (CAD) (n=30)

Classification of CAD	No. of cases	%age
Obstructive CAD (>50%)	14	46.67
Non obstructive CAD (< 50%)	10	33.33
Normal Coronary Angiogram	6	20

Table 3 Quantification of stenosis in obstructive and non-obstructive lesions
No. of lesions causing stenosis are 48 in 30 patients.

Grades of stenosis	No. of lesions	%age
Non-obstructive (<50%)	31	64.58
Obstructive (17)		
(i)Moderate (50-70%)	11	22.92
(ii)Critical (71-90%)	4	8.33
(iii) Occlusion	2	4.17

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Table 4 Distribution of obstructive and non-obstructive lesions
No. of obstructive and non-obstructive lesions seen in the involved vessels are n=48.

Name of artery	No. of lesions (obstructive)	Percentage of obstructive lesion	No. of lesions (Non-obstructive)	Percentage of non-obstructive lesion	Total
RCA (main vessel and its branches)	4	8.33	5	10.41	9
LMA	1	2.08	0	0	1
LAD (main vessel and its branches)	14	29.17	13	27.08	27
LCX (main vessel and its branches)	6	12.5	4	8.33	10
RIB	1	2.08	0	0	1

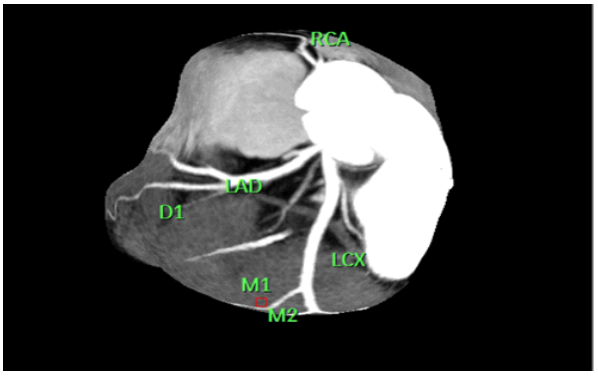

Figure 1: 3D MPR view of right and left coronary arteries and their branches

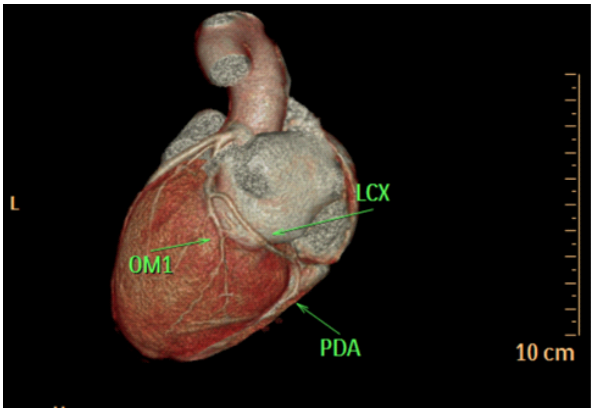

Figure 2: VRT view showing PDA arising from LCX supplying the posterior interventricular groove suggestive of left dominance

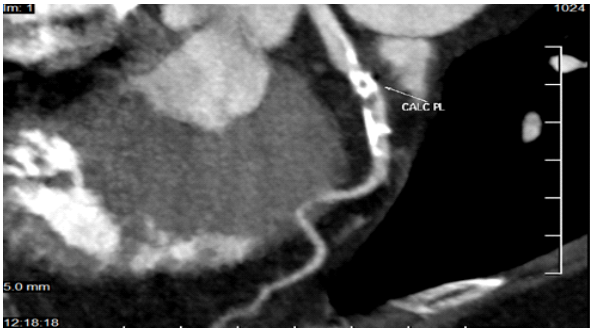

Figure 3: Curved MPR view showing calcified plaque in LAD with myocardial bridging of LAD.

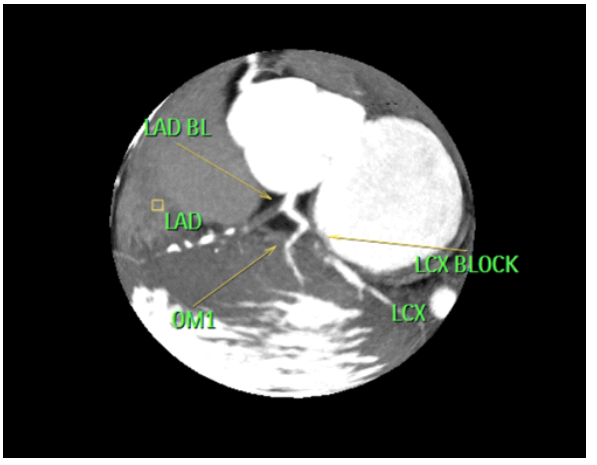

Figure 4: 3D MPR view showing mixed density plaque in proximal and mid LAD causing 80-90% stenosis. Non-calcified plaque in proximal LCX.

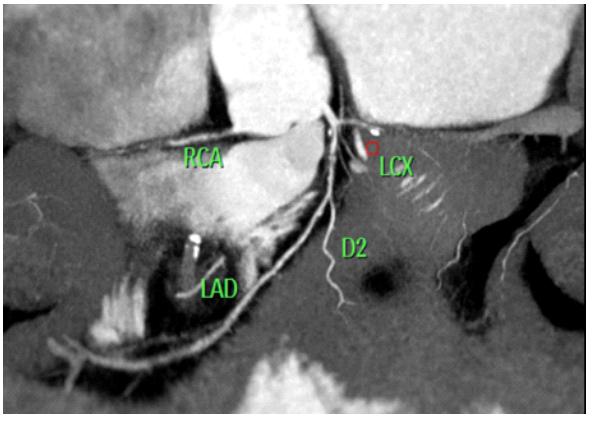

Figure 5: 2D MPR view showing complete occlusion of LCx and distal RCA and 60-70 stenosis of LAD.

16 lesions showed mixed density atherosclerotic plaques. Plaques were calcified in 10 lesions and non-calcified in 22 lesions. (Table 7) In patients with angina, obstructive CAD was seen in 10 cases. Nine cases showed non-obstructive CAD. In 3 cases normal CTCA was seen in suspected CAD. Patients having calcium score of 101-400 had obstructive CAD in 4 of the patients and 1 had non-obstructive CAD. Patients with calcium score >400 was found in 1 patient who had obstructive CAD. CTCA findings were in complete agreement in 8 (80%) cases with ICA findings out of 10 cases. However, in 2 cases increase or decrease in the percentage of stenosis was due to the calcified plaque in the vessels near the area of stenosis giving variation in the percentage of stenosis. Out of 4 cases with moderate stenosis (50-70%) observed on CTCA, 3 cases were in complete agreement with ICA findings. In critical stenosis 3 cases of CTCA were in agreement with ICA findings, one cases turned out to be having more than 90% stenosis (occlusion). Thus, in patients having more than 50% stenosis, the sensitivity of CTCA was 100%, positive predictive value 80% and negative predictive value was 100%.

In the present study, CT coronary angiography detected significant CAD (>50% stenosis) in 46.66% of cases in patients who were suspected of having CAD. Non obstructive CAD was seen in 33.33% cases and 20% cases had normal coronary angiogram.

DISCUSSION

The present study was conducted in the department of Radiodiagnosis and Imaging, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala. A total of thirty

patients who were clinically suspected of having coronary artery disease (CAD) were included after meeting the inclusion criteria. The findings of MDCT were correlated with clinical observations/ laboratory reports/ therapeutic follow up and invasive coronary angiography (ICA) (wherever performed).

Coronary artery calcification (CAC) has been shown to be a predictive marker of coronary atherosclerotic disease. Sixteen patients had calcium score of 0, eight patients had a calcium score 11-100, five patients had calcium score 101-400 and one patient had calcium score of 400-800. The present study was in agreement with studies by Earls JP et al and Mohlenkamp S et al who found that coronary calcification is a strong and independent predictor of CHD in all age groups and the risk of Coronary Heart Disease (CHD) increases with increasing calcium scores.[10,11] Budoff MJ et al reported that the patients with low absolute Coronary Artery Calcification (CAC) are low-risk while persons with an absolute CAC > 400 are high risk, regardless of age, sex, and race/ethinicity.[12]

Leschka S et al reported that motion artifacts of vessels were seen in cases with high heart rate leading to degradation of image quality and no or minimal motion artifacts were seen in cases with low heart rate.[13] Our study was in accordance with it.

Maruyama T et al found that the image quality was significantly greater for images obtained with prospective gating technique than for images obtained with retrospective gating technique. Prospective ECG gating method was used for one patient in our study having persistently low and stable heart rate and excellent image quality was obtained.

All cases showed normal origin of coronary arteries. However myocardial bridging was seen in three (10%) cases. Kosar P et al reported myocardial bridging in 37% cases.[15] The prevalence of coronary anomalies could not be commented and compared as our study population is very small.

Right coronary artery dominance was seen in majority (80%) cases in present study. Similarly, Kosar P et al in a study of 700 patients with suspected CAD reported right coronary artery dominance in majority (76%) of cases.[15]

In present study 46.67% cases were having obstructive CAD (>50%). Thus in 53.33% cases there were non-obstructive or normal CTCA for suspected CAD. Almost similar results were seen in a study by Ovrehus KA et al in which they included 63 patients. They reported the prevalence of significant or obstructive CAD as 32%.[16]

Multivessel involvement was seen in 50% of cases in present study. Single vessel involvement was seen in majority i.e., 73% cases in a study by Choi EK et al.[17] The cause for the difference in percentage may be due to the reason that sample size in author's study was large and included 1000 cases.

Majority of lesions were present in LAD followed by RCA and LCX. Choi EK et al found that 61 % obstructive lesions were located on the left main or proximal to mid LAD.[17]

Hausleiter J et al reported in his study of 161 patients, atherosclerotic plaques were present in 77 segments, of which mixed density plaques were seen in most of the segments as in our study.[18]

Bonello L et al found the incidence of obstructive CAD to be 23%.[19] CTCA findings were in complete agreement in 8 (80%) cases with ICA findings out of 10 cases. However, in 2 cases increase or decrease in the percentage of stenosis was due to the calcified plaque in the vessels near the area of stenosis giving variation in the percentage of stenosis. The sensitivity was 100%, positive predictive value was 80% and negative predictive value of 100%.Hadamitzky M et al reported 3-4 times increased risk of significant coronary events in patients with obstructive CAD as compared to non-obstructive CAD.[20] Similar results were shown by Overheus et al.[16]

CT Coronary Angiography is a good first line screening investigation for patients suspected of having CAD with angina/ atypical chest pain/ anxiety.

CONCLUSION

Contrast-enhanced 64-slice CT is a clinically robust modality that allows non-invasive visualization of coronary arteries and identification of coronary lesions with excellent accuracy. Its high diagnostic accuracy with excellent negative and positive predictive value made it an excellent non-invasive diagnostic tool in work up of patients with suspected CAD. It should be included in routine work up of patients with CAD before selecting them for ICA.

LIMITATIONS

Slight limitation is the insufficient ability of CT to exactly quantify the degree of stenosis probably due to the calcified plaque in the vessels near the area of stenosis. The another limitation of radiation dose can be minimized by using prospective ECG gating and lowering x-ray tube voltage (kVp).

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