DIAGNOSTIC ACCURACY OF MULTI DETECTOR COMPUTED ANGIOGRAPHY FOR DETECTION OF CORONARY ARTERY DISEASE

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ABSTRACT:

AIMS AND OBJECTIVES: To compare the accuracy of Multi Detector Computed Tomographic (MDCT) angiography with conventional coronary angiography in detection of significant coronary artery stenosis.

MATERIALS AND METHODS: Study was conducted at the Cardiology Department, Punjab Institute of Cardiology, Lahore from 15th May 2009 till 31st December 2009. Thirty patients having intermediate probability of coronary artery disease (CAD) undergoing MDCT and conventional coronary angiography were studied in this observational analytical study. All patients were scanned on a 64 slice scanner (GE, Lightspeed VCT, WI, USA). Conventional coronary angiography (CCA) was performed with the Judkins trans-femoral technique. MDCT angiography results identified coronary artery Disease (CAD) following the 17-segment modified American Heart Association classification model. Stenosis were evaluated by two independent observers and classified as significant if the mean luminal narrowing was ≥50% . These were compared with CCA on the same 17 segment model. Measures of diagnostic accuracy were calculated as true-positive, true-negative, false positive, and false-negative results. With this sensitivity, specificity, positive and negative predictive values were computed.

RESULTS: The mean age of the study population was 46.8±9.3 years. Mean Calcium score was 185.9±250 HU. A total of 483 segments were analyzed. Analysis of these segments revealed that 93(19.3%) segments were true positive, 367(75.98%) were true negative, 11(2.3%) were false positive and 12(2.5%) were false negative. The sensitivity of MDCT in detection of significant coronary artery disease was observed to be 88.5% while the specificity was 97%. It was observed that the negative predictive value of MDCT for detection of coronary artery disease was 96.8 and positive predictive value was 89.4%.

CONCLUSION: MDCT (64-slice) coronary angiography provides high specificity and NPV to rule out significant stenosis in patients suspected of having CAD. MDCT angiography can be used as a tool for noninvasive detection of coronary artery disease.

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INTRODUCTION

Coronary artery disease (CAD) is the leading cause of morbidity and mortality in developed countries and also in our part of world causing more than 25% of deaths.[1,2] Atherosclerotic disease will be the major cause of global morbidity and mortality by 2020[1]; this trend has serious implications for countries in south Asia[3].

For detection of ischemia non invasive testing was done previously [4], with the advent of 64-slice MDCT coronary angiography has allowed the detection of CAD non Invasively,[5] with high diagnostic accuracy. Noninvasive imaging for the detection of CAD has evolved significantly over the past 50 years. The newer CT Systems have a substantial increase in spatial and temporal resolution as well as a shortening of the imaging acquisition time, making it possible to visualize the beating heart. This is why MDCT angiography has gained popularity for the detection of CAD.[6,7] By far, MDCT is the rapidly evolving noninvasive diagnostic cardiac imaging modality in the USA. The percentages of difficult reporting have gradually decreased from 20%–40% with 4-slice systems to now as low as 3%– 10 % with 64-slice systems.[7]

Most importantly, the negative MDCT studies rules out CAD, indicating that the technique may be most suitable as a non-invasive tool to rule out significant CAD and avoid further imaging or invasive angiography.[8] So the study was planned to evaluate the diagnostic accuracy of MDCT.

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MATERIALS AND METHODS:

This was an observational and analytical study and was conducted in the Cardiology Department of Punjab Institute of Cardiology, from 15th May 2009 till 31st December 2009.

Patients presenting with chest pain and at least one risk factor for Coronary Artery Disease (CAD) having intermediate probability for CAD between the ages of 30 to 70 years were included in the study.

Patients with prior history of myocardial infarction. Patients with previous history of PCI, Stenting, CABG or other heart surgery. Patients having arrhythmias, ICDs, Pacemakers. Hemodynamically unstable patients with contraindications to beta-blockers or iodine contrast. Patient with unable to hold breath for 15 seconds. Patients with renal insufficiency (Creatinine > 1.5 mg/dl). Obese patients with Body Mass Index > 40.Kg/m2, and patients with calcium score more than 1000 Agatston score were excluded from the study.

A total of thirty patients were included after an informed consent. Conventional Coronary Angiogram was done 1 to 2 weeks later to the MDCT angiogram. Sampling technique was convenient sampling.

MDCT Scan Protocol and Image Reconstruction

All patients were scanned on a 64 slice scanner (GE, Light speed, VCT, WI, USA). An initial non-enhanced ECG gated scan was performed for calcium scoring. Data acquisition was performed within a single breath-hold of about 5–10 seconds. Synchronization of data acquisition and contrast enhancement was achieved by calculating the veno-arterial transit time, using a small bolus of contrast agent (15 ml) and retrospective analysis of the enhancement pattern over time (so-called 'test bolus' technique). 65—100 ml of Non-Ionic contrast injection was administered at the rate of 5 ml/s followed by a saline of 40 ml. Data acquisition was started after 10 sec delay of time calculated after bolus infusion. The scan parameters were: detector configuration 64 mm x 0.625 mm slices, collimation of 40 mm, rotation time 350 ms, tube voltage 120 kV, ECG modulated effective 250—750 mA, resolution of 0.4 mm, a slice thickness of 0.6 mm, a temporal resolution of 175 ms with single sector. Electrocardiographically gated datasets was reconstructed automatically at 75% of the R-R cycle length. Additional 10% increments were reconstructed from 0-90%. The simultaneous acquisition of 64 parallel cross sections enabled the imaging of the entire coronary tree in a single breath hold of about 6—8s.

MDCT Image Evaluation:

All scans were analyzed independently by consensus of two physicians. Total calcium scores of all patients were calculated, and expressed as Agatston scores. Patients having calcium score of more than 1000 Agatston were excluded.

CTA was analysed on a workstation (Advantage 4.3, GE Healthcare, WI, USA) using a combination of axial images, multiplanar reconstruction, curvilinear reconstruction with vessel tracking, straight vessel views, cross sectional views and 3D volume rendered images. Each vessel was interrogated one at a time from cranial to caudal direction. Once a location of luminal narrowing was identified in the vessel straight view, diameters were measured in cross sectional view using electronic caliper across the best cross section of the vessel for verification and quantification of stenosis.

All available coronary segments were visually scored for the presence of significant stenosis. Maximum-intensity projections were used to identify coronary lesions and (curved) multiplanar reconstructions to classify lesions as significant or nonsignificant. Only good quality images on a per-segment basis were used for comparison on a 17-segment modified American Heart Association classification model.[9]

CCA was performed with the Judkins trans-femoral technique. Left system was engaged by Judkins left catheter and right system was engaged by Judkins right catheter. All coronary angiograms were performed by experienced operators who were blinded to the study. All CCAs were done within 2 weeks after MDCT with a Phillips Integrix 3000. Two independent experienced cardiologists and blinded to the MDCT findings analyzed all coronary segments using the 17-segment modified AHA classification. Each stenosis was further evaluated with quantitative coronary angiography (QCA) software (CAAS®, Pie Medical, Maastricht, The Netherlands). Each segment was classified as insignificant if the stenosis was ≤50%. Stenosis were evaluated in two orthogonal views and classified as significant if mean luminal reduction exceeded 50%.

OPERATIONAL DEFINITIONS:

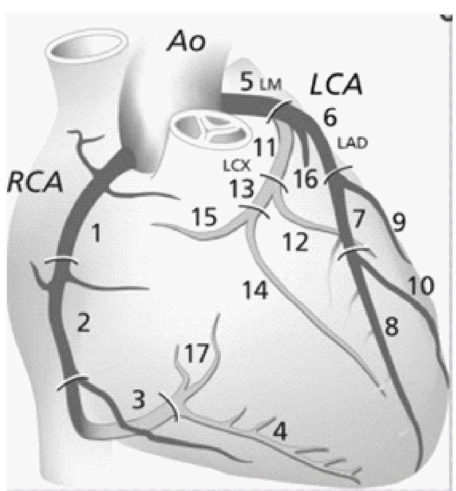
Agatston Score: The Agatston score is a commonly used scoring method that calculates the total amount of calcium on the basis of the number, areas, and peak Hounsfield units of the detected calcified lesions.

17-segment modified American Heart Association classification model:[9]

The segments are as follows: The right coronary artery (RCA) segment 1, proximal RCA; segment 2, middle RCA; segment 3, distal RCA; segment 4a, posterior descending artery (PDA); and segment 4b, posterolateral ventricular (PLV) artery. The left main coronary artery as segment 5. The left anterior descending (LAD) coronary artery will include segment 6, proximal LAD; segment 7, middle LAD; segment 8, distal LAD; segment 9, first diagonal (D1); and segment 10, second diagonal (D2). The Left Circumflex (LCx) branch of the left coronary artery segment 11, proximal LCx; segment 12, first obtuse marginal (OM1); segment 13, middle LCx; segment 14, second obtuse marginal (OM2); segment 15, distal LCx; segment 16, Ramus Intermediate (RI) branch; segment 17. Segments 1, 5, 6, and 11 will be defined as proximal segments; segments 2, 7, and 13 will be defined as middle segments; and segments 3, 4a, 4b, 8, 9, 10, 12, 14, 15, and 16 will be defined as distal segments or side branches.[9]

STATISTICAL ANALYSIS:

17-Segments modified American Heart Association classification model.



It was performed using the SPSS (release 12.0; SPSS, Inc; Chicago, IL) system for Windows. Continuous variables were expressed as mean±SD (Standard Deviation) while categorical variables were expressed as percentages.

Measures of diagnostic accuracy were calculated by true-positive, true-negative, false positive, and false-negative results. With these sensitivity, specificity, positive and negative predictive values were computed.

RESULTS:

The basic demographic data is shown in Table 1.A total of 483 segments were analyzed for the presence of true positive, true negative, false positive and false negative.

On conventional angiography the lesion distribution was as 1(3.3%) patient had left main stem disease, 15(50.0 %) had proximal LAD disease

Table 1: Baseline Demographic Variables

Characteristics	Numbers (Percentages)
Age mean years	46.8±9.3
Males	22(73.3%)
Females	8(26.7%)
Diabetes Mellitus	8(26.7%)
Smoking	10(33.3%)
Hypertension	17(56.7%)
Family History	12(40%)
Dyslipidemia	2(6.7%)
Height mean Cm	162.08±9.3
Weight mean Kg	68.35±15.3
Calcium Score	185.9±250

Figure-2: Baseline Demographic Variables

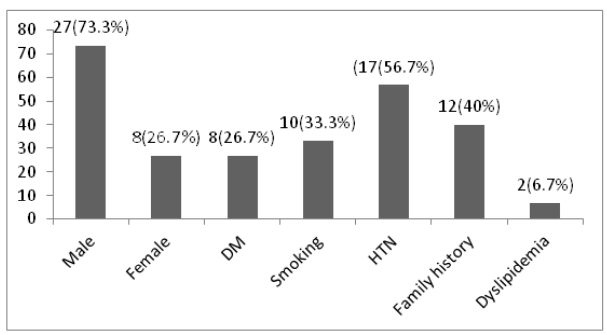
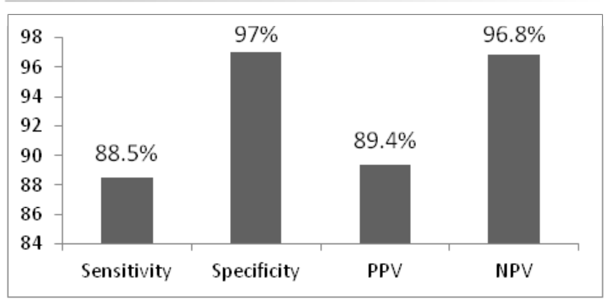


Figure 3: Final results of the study.



PPV= Positive predictive value; NPV=Negative predictive value.

Table-2: MDCT and Conventional angiographic finding of coronary artery of the study population.

Variables		True positive	True negative	False positive	False negative	Accuracy
LMCA		1(3.3%)	29(96.7%)	0	0	**1.0**
LAD		46(30.7%)	99(66%)	4(2.7%)	1(0.7%)	0.95
	Proximal	15(50%)	12(40%)	2(6.7%)	1(3.3%)	0.90
	Mid	16(53.3%)	13(43.3%)	1(3.3%)	0	0.967
	Distal	5(16.7%)	25(83.3%)	0	0	1.0
	D1	9(30%)	20(66.7%)	1(3.3%)	0	0.967
	D2	1(3.3%)	29(96.7%)	0	0	1.0
LCX		17(11.3%)	126(84%)	2(1.3%)	5(3.3%)	0.953
	Proximal	4(13.3%)	25(83.3%)	1(3.3%)	0	0.967
	Mid	9(30%)	20(66.7%)	0	1(3.3%)	0.967
	Distal	1(3.3%)	28(93.3%)	0	1(3.3%)	0.967
	OM 1	3(10%)	24(80%)	1(3.3%)	2(6.7%)	0.90
	OM2	0	29(96.7%)	0	1(3.3%)	0.96
RCA		28(18.7%)	111(74%)	5(3.3%)	6(4%)	
	Proximal	6(20%)	22(73%)	2(6.7%)	0	0.93
	Mid	15(50%)	15(50%)	0	0	1.0
	Distal	3(10%)	24(80%)	3(10%)	0	0.9
	PDA	2(6.7%)	26(86.7%)	0	2(6.7%)	0.93
	PLV	2(6.7%)	24(80%)	0	4(13.3%)	0.86
Ramus intermediate		1(3.3%)	2(6.7%)	0	0	1.0

and 16(53.3%) had mid LAD disease. Significant stenosis was observed in proximal circumflex in 4(13.3%) patients, mid LCX 9(30%) and distal circumflex 1(3.3%) patients. In right coronary artery significant stenosis was seen in 6(20%) patients in proximal segment, 15(50%) in mid RCA and 3(10%) in distal RCA.

Segment wise analysis of MDCT angiography and CCA according to the 17 segment American Heart Association model for individual arteries was performed and is shown in table 2.

Table 2 shows the analysis of all segments in the three major coronary arteries. In LAD out of 150 segments 46(30.7%) were true positive, 99(66%) were true negative, 4(2.7%) false positive and 1(0.7%) were false negative. In left circumflex 17(11.3%) segments were true positive, 126(84%) were true negative, 2(1.3%) were false positive and 5(3.3%) were false negative. In right coronary artery 28(18.7%) were true positive, 111(74%) were true negative, 5(3.3%) false positive and 6(4%) were false negative

The sensitivity of MDCT in detection of significant coronary artery disease was observed to be 88.5% while the specificity was 97%. It was observed that the positive predictive value was 89.4% and negative predictive value of MDCT for detection of coronary artery disease was 96.8%.

DISCUSSION:

Coronary artery disease (CAD) is the leading cause of morbidity and mortality in developed countries and also in our part of world causing more than 25% of deaths.[1,2] Atherosclerotic disease will be the major cause of global morbidity and mortality by 2020[1]; this trend has serious implications for countries in south Asia[3].

MDCT is a minimally invasive coronary imaging tool. The 64 slice scanner has improved acquisition time and the entire scan can be done in 6—8 s. Before it can become clinically accepted modality it should accurately visualize all relevant segments of coronary arteries and should be comparable to CCA[10]. It has been observed in the present study that the 64 slice MDCT scanner provides an excellent correlation with CCA and accurately and consistently delineates the presence or absence of significant lesions in the coronary arteries. It is able to give reliable information on the presence, severity and characteristics of luminal stenosis and atherosclerotic plaque. In the current study the sensitivity of MDCT in detection of significant coronary artery disease was observed to be 88.5% while the specificity was 97%. The positive predictive value was 89.4% and the negative predictive value of MDCT was 96.8%. Our results are consistent with other studies.[11-14]

CACTUS trial should high specificity and sensitivity of MDCT as high as 75% and 99%.[12] Our results also show similar results. A recent meta-analysis by Vanhoenacker et al[5] showed a significant improvement in the accuracy for the detection of coronary artery stenoses for 64-slice CT when compared with previous scanner generations. The weighted mean sensitivity for the detection of coronary artery stenoses increased from 84% for four-slice CT and 83% for 16-slice CT to 93% for 64-slice CT, whereas the respective specificities were 93, 96, and 96%. In a recent registry by Maffei et al [13] revealed sensitivity, specificity and positive and negative predictive value of MDCT as 99%, 92%, 94% and 99%, respectively.

Patients with tachycardia or arrhythmias have bad quality image[15]. Extensive calcification also destructs image quality.[16] The image quality can be improved by dual source CT.[17] The newer technique can easily visualize almost all coronary segments without motion artifact.[18] The newer software techniques have reduced motion artifacts and false positive test results. [19]

256-slice MDCT system has better temporal resolution taking entire scan in a single cardac cycle with high sensitivity and specificity [20,21]. Karlsberg et al[22] have showed that MDCT has reduced CCA and also the morbidity and mortality. A lot of patients can be avoided from CCA and also from noninvasive tests like ETT,Spect and myocardial perfusion imaging. Our study also showed high sensitivity and specificity with excellent negative predictive value. So a lot of unnecessary CCA can be avoided, saving the cost and reducing mortality and morbidity.

MDCT can also provide information relevant to prognosis. Van Werkhoven[23] et al have showed in their study that risk assessment can be done by MDCT. Aldrovandi et al[24] showed in their study that MDCT has a 100% negative predictive value for major cardiac events at 24-month follow-up in patients with normal coronary arteries.

Cademartiri et al[25] showed that calcium scoring is important and in patients with zero calcium score MDCT angiography has Sensitivity, specificity and negative predictive value of 100%, 95% and 100% respectively.

CONCLUSION:

64-slice MDCT coronary angiography provides sufficiently high specificity and NPV to rule out significant stenosis in patients suspected of having symptomatic or asymptomatic CAD. MDCT angiography can be used as a tool for noninvasive detection of coronary artery disease.

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