Original Article

NON-INVASIVE EVALUATION OF CORONARY ARTERY DISEASE BY MDCT AS COMPARED TO CONVENTIONAL ANGIOGRAPHY

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ABSTRACT:

OBJECTIVE: To visualize the coronary anatomy non-invasively by multidetector computed tomographic and its comparison with invasive angiogram.

MATERIAL AND METHODS: Data was collected at Cardiology Department of Punjab Institute of Cardiology, Lahore from 7th December 2010 to 6th June 2011 (6 months). 486 segments were analyzed of 30 patients.

RESULTS: Patients were 41.1±7.8 years of age. There were 18(60%) males and 12(40%) females. Six (20%) patients were diabetic. 6(20%) patients were smoker. Hypertensive patients were 12(40%). On conventional angiography 5(16.7%) patients had left main stem disease, 15(50%) had proximal LAD disease and 12(40%) had mid LAD disease. More than 50 percent stenosis was observed in proximal circumflex in 6(%) patients, mid LCX 4(13.3%) and distal circumflex 1(3.3%) patients. In right coronary artery >50 stenosis in 11(36.5%) patients in proximal segment, 4(13.3%) in mid RCA and 2(6.7%) in PDA. In LAD out of 150 segments 34(22.7%) were true positive, 105(70%) were true negative, 2(1.3%) false positive and 7(4.7%) were false negative, while 2(1.3%) segments were excluded due to poor quality. In left circumflex 16(10.7%) segments were true positive, 127(84.7%) were true negative, 3(2%) were false positive and 2(1.3%) were false negative and 2(1.3%) segments were excluded to due to artifacts. In right coronary artery 18(12%) were true positive, 128(85.3%) were true negative, 4(2.7%) false positive and none were false negative.

Analysis of all 486 segments revealed that 74(15.2%) segments were true positive, 388(79.8%) were true negative, 9(1.8%) were false positive and 11(2.3%) were false negative. Overall 4(0.82%) segments were excluded due to artifacts. The sensitivity of MDCT in diagnosing of significant CAD was observed to be 87.1% while the specificity was 97.7%. It was observed that the positive predictive value (PPV) was 89.1% and negative predictive value (NPV) of MDCT for diagnosis of coronary artery disease was 97.2%.

CONCLUSION:64-slice MDCT has high sensitivity and negative predictive value to rule out significant stenosis in patients suspected of having coronary artery disease. MDCT angiography can be used for non invasive diagnosis of coronary artery disease.

KEY WORDS: Coronary artery disease; Multi-detector computed tomographic angiography; Coronary angiography.

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INTRODUCTION

Ischemic heart disease (IHD) is a leading killer in US.[1] CAD is responsible for 1 out of 6 deaths in the US in 2006.[2] The prevalence of CAD was 11% in a young age people with major proportion of patients fall in moderate risk 22% group followed by 25% for high risk than that in low risk subgroups, which was only 5%[3].

In symptomatic patients, diagnosis of CAD is important for proper management. High risk individuals directly go for invasive angiography. Intermediate group is evaludated by ETT and Stress Thallium Scan.[4] Multidetector computed tomographic angiography is an excellent non-invasive tool.[5] MDCT has sensitivity of 93-99%, specificity 95-98% with NPV of 99-100%.[6] MDCT being a non-invasive procedure saves the patient from complications of invasive procedures.

OBJECTIVE:

Objective of the study was, to evaluate the accuracy of MDCTA for diagnosis of significant CAD in patients with intermediate pre-test prob-

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ability taking conventional angiography as a gold standard.

OPERATIONAL DEFINITIONS:

Intermediate pre-test probability of coronary artery disease:

Intermediate pretest probability patients are defined as those individuals with a 15–75% risk of CAD. Moreover, for men, this included those with atypical pain who were >30 years old, and for women those with atypical pain who were >50 years old. Intermediate pre-test probability patients have at least one of the major risk factors outside the desirable range or a positive family history of CAD.

Major risk factors: are Smoking, total cholesterol >200 mg/dl, HDL cholesterol < 40 mg/d, hypertension, Diabetes mellitus, overweight (BMI of >25 kg/m^2).

Significant stenosis:

Significant stenosis was defined as narrowing of >50% of the luminal diameter detected by MDCTA. Regarding invasive coronary angiography stenosis was evaluated and classified as significant if the mean luminal narrowing is 50% or greater by using a validated quantitative coronary angiographic algorithm.

True positive:

When at least one significant stenosis (>50%) is found in segment on MDCTA, respectively it is confirmed on same segment on conventional angiography.

True negative:

If significant stenosis is not found in same segment both by MDCTA and conventional angiography.

False negative:

When there is no significant stenosis is found in one segment on MDCTA, while on conventional angiography it was found on that segment.

False positive:

When there is a significant stenosis detected in one segment on MDCTA, while on conventional angiography it was not found on the same segment.

MATERIALS AND METHODS:-

This cros-sectional study was conducted at Cardiology Department, Punjab Institute of Cardiology, Lahore from 7th December 2010 to 6th June 2011 (6 months).

Sample size of 486 segments (30 patients) was calculated with 95% confidence level, 5% margin of error.

30 paitents of either sex with age range 30-55 years and having (BMI) between 25-40 Kg/m^2 were included.After informed consent, data was collected.

Patients with past history of ischemic heart disease, patients with history of contrast allergy. Patients with Increased serum creatinine level (>1.5 mg / dL).Pregnant female, patients with hemodynamic instability (blood pressure <90/60, patients with inability to hold breath for 25 seconds, patient with Agatston calcium score of more than 1000, on CT angiography were excluded.

In CT image evaluation, all scans were analysed independently by consensus of 2 physicians. Total calcium score was calculated. Agatston score of more than 100 to 999 is said to be significant. CT angiography will be analysed. All available coronary segments were visually analyzed for the presence of significant stenosis. Only good Quality images on a per-segment basis were used for comparison on a 17-segment modified American Heart Association (AHA) classification model.

In conventional coronary angiography, the procedure was performed with the Judkin's technique by a single consultant. Results obtained by Multidetector computed tomographic angiography was compared to conventional angiography by following the same 17-segment AHA classification model. True positive, true negative, false positive, false negative as per operational definition were determined.

Data was analyzed using SPSS version 12. Sensitivity, specificity, PPV and NPV and accuracy of MDCTA was calculated by using 2x2 table taking conventional coronary angiography as gold standard. Mean ± SD for quantitative variables like age were calculated. Frequency and percentage for qualitative variables like gender was calculated.

RESULTS:

The mean age of the study population was

Sensitivity=TP/TP+FN
Specificity=TN/TN+FP
PPV=TP/TP+FP
NPV=TN/TN+FN

41.1±7.8 years. There were 18(60%) males and 12(40%) females. Diabetes mellitus was present in 6(20%) patients. Smoking was observed in 6(20%) patients. History of hypertension was present in 12(40%) patients. Mean height of the study patients was 166.7±7.8 cm and mean weight was 74.6±16.5 kgs (Table 1).

A total of 486 segments were analyzed for the

presence of true positive, true negative, false positive and false negative.

On conventional angiography 5(16.7%) patients had left main stem disease, 15(50%) had proximal LAD disease and 12(40%) had mid LAD disease. More than 50 percent stenosis was observed in proximal circumflex in 6(20%) patients,

Table 1. Baseline demographics.

Characteristics	Numbers (Percentages)
Age mean years	41.1±7.8
Gender Males Females	 18(60%) 12(40%)
Diabetes Mellitus	6(20%)
Smoking	6(20%)
Hypertension	12(40%)
Family History	7(23.3%)
Dyslipidemia	4(13.3%)
Height mean Cm	166.7±7.8
Weight mean Kg	74.6±16.5

Table 2. MDCT and conventional angiographic findings of left main coronary artery.

ARTERY	NUMBER (PERCENTAGES) N=30
Left main coronary artery	
True Positive	5(16.7%)
True Negative	23(76.7%)
False Positive	0
False Negativev	2(6.7%)

Table 3. MDCT and conventional angiographic findings of left anterior descending coronary artery.

ARTERY	NUMBER (PERCENTAGES) n=30
Proximal LAD True Positive True Negative False Positive False Negative	 15(50%) 14(46.7%) 0 1(3.3%)
Mid LAD True Positive True Negative False Positive False Negative	 12(40%) 14(46.7%) 0 4(13.3%)
Distal LAD True Positive True Negative False Positive False Negative	 1(3.3%) 29(96.7%) 0 0
First Diagonal branch True Positive True Negative False Positive False Negative Excluded	 2(6.7%) 24(80%) 1(3.3%) 2(6.7%) 1(3.3%)
Second Diagonal branch True Positive True Negative False Positive False Negative Excluded	 4(13.3%) 24(80%) 1(3.3%) 0 1(3.3%)

LAD=left anterior descending coronary artery

Table 4. MDCT and conventional angiographic findings of left circumflex coronary artery.

ARTERY	NUMBER (PERCENTAGES) n=30
Proximal LCX True Positive True Negative False Positive False Negative	 6(20%) 22(73.3%) 2(6.7%) 0
Mid LCX True Positive True Negative False Positive False Negative	 4(13.3%) 25(83.3%) 1(3.3%) 0
Distal LCX True Positive True Negative False Positive False Negative	 1(3.3%) 28(93.3%) 0 1(3.3%)
First Obtuse marginal branch True Positive True Negative False Positive False Negative	 2(6.7%) 28(93.3%) 0 0
Second Obtuse marginal branch True Positive True Negative False Positive False Negative Excluded	 3(10%) 24(80%) 0 1(3.3%) 2(6.7%)

LCX=Left circumflex artery.

Table 5. MDCT and conventional angiographic findings of Right Coronary Artery.

ARTERY	NUMBER (PERCENTAGES) n=30
Proximal RCA True Positive True Negative False Positive False Negative	 11(36.7%) 19(63.3%) 0 0
Mid RCA True Positive True Negative False Positive False Negative	 4(13.3%) 26(86.7%) 0 0
Distal RCA True Positive True Negative False Positive False Negative	 0 28(93.3%) 2(6.7%) 0
Posterior Descending artery True Positive True Negative False Positive False Negative	 2(6.7%) 26(86.7%) 2(6.7%) 0
Posterior left ventricular True Positive True Negative False Positive False Negative	 1(3.3%) 29(96.7%) 0 0

RCA=Right coronary artery.

mid LCX 4(13.3%) and distal circumflex 1(3.3%) patients. In right coronary artery >50 stenosis in 11(36.5%) patients in proximal segment, 4(13.3%) in mid RCA and 2(6.7%) in PDA.

Segment wise analysis according to the 17 segment AHA model for individual arteries was performed shown in tables 2-6.

Table 7 shows the analysis of all segments in the three major coronary arteries. In LAD out of 150

Table 6. MDCT and conventional angiographic findings of Ramus Intermedius Coronary Artery.

ARTERY	NUMBER (PERCENTAGES) N=30
Ramus Intermedius	
True Positive	1(3.3%)
True Negative	5(16.7%)
False Positive	0
False Negative	0
Not Present	24(80%)

Table 7. MDCT and conventional angiographic findings of left anterior descending coronary artery, left circumflex and right coronary artery.

ARTERY	NUMBER (PERCENTAGES) N=150
LAD	
True Positive	34(22.7%)
True Negative	105(70%)
False Positive	2(1.3%)
False Negative	7(4.7%)
Excluded	2(1.3%)
LCX	
True Positive	16(10.7%)
True Negative	127(84.7%)
False Positive	3(2%)
False Negative	2(1.3%)
Excluded	2(1.3%)
RCA	
True Positive	18(12%)
True Negative	128(85.3%)
False Positive	4(2.7%)
False Negative	0

LAD=left anterior descending coronary artery; LCX=Left circumflex artery; RCA=Right coronary artery.

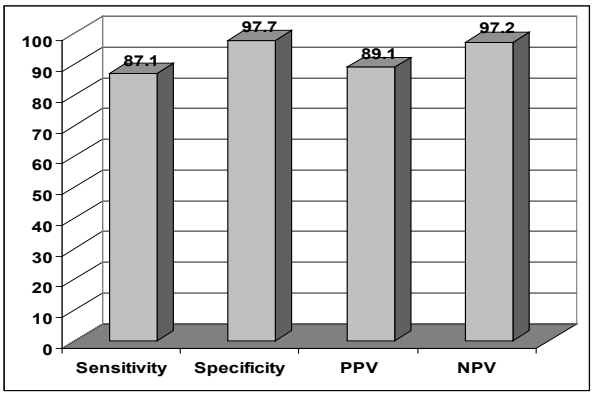
Table 8. Total segmental analysis of the study population.

ARTERY	NUMBER (PERCENTAGES) n=486
True Positive	74(15.2%)
True Negative	388(79.8%)
False Positive	9(1.8%)
False Negative	11(2.3%)
Excluded	4(0.82%)
Sensitivity	87.1%
Specificity	97.7%
Positive predictive value	89.1%
Negative predictive valve	97.2%

segments 34(22.7%) were true positive, 105(70%) were true negative, 2(1.3%) false positive and 7(4.7%) were false negative, while 2(1.3%) segments were excluded due to poor quality. In left circumflex 16(10.7%) segments were true positive, 127(84.7%) were true negative, 3(2%) were false positive and 2(1.3%) were false negative and 2(1.3%) segments were excluded to due to artifacts. In right coronary artery 18(12%) were true positive, 128(85.3%) were true negative, 4(2.7%) false positive and none were false negative.

Analysis of all 486 segments revealed that 74(15.2%) segments were true positive, 388(79.8%) were true negative, 9(1.8%) were false positive and 11(2.3%) were false negative. Overall 4(0.82%) segments were excluded due to poor quality and artifacts (Table-8).

Figure 1. Final results of the study.



The sensitivity of MDCT in diagnosing significance of CAD was observed to be 87.1% while the specificity was 97.7%. It was observed that the PPV was 89.1% and NPV of MDCT for detection of CAD was 97.2%. Table 8, Figure 1.

DISCUSSION:

In symptomatic patients, diagnosis and severity of ischemic heart disease is important for guiding proper treatment. Patients with acute coronary syndrome are frequently advised invasive coronary angiography. Patients with low risk of ischemic heart disease do not require further imaging. However, patient with intermediate probability of ischemic heart disease need further investigations like ETT and myocardial perfusion scan.[4] However, the sensitivity and specificity of diagnosing ischemic heart disease are less with these non-invasive diagnostic tests.

ETT is having sensitivity and specificity of 68% and 77%, stress echocardiography a sensitivity and specificity of 85% and 77%, and myocardial perfusion a sensitivity and specificity of 87% and 64%, respectively. [4] As a result of abnormal SPECT or Stress Echo often these patients lead invasive coronary angiography to rule out ischemic heart disease causing prolonged hospital stay and exposure to further radiations.

MDCT angiography is an alternative test for this group of patients.[5] Studies comparing MDCTA with conventional coronary angiography as the reference standard have shown the sensitivity between 93% and 99% and specificity to be between 95% and 98%, with a NPV of 99–100%. All these percentages are better than other non-invasive investigations.[6]

In the current study the sensitivity of MDCT in diagnosing significant CAD was seen to be 87.1% while the specificity was 97.7%. The PPV was 89.1% and the negative predictive value of MDCT was 97.2%. Our results are comparable to other studies.[7,8]

In a study by Leschka S, MDCT was done in 67 patients with suspected ischemic heart disease was compared with invasive coronary angiography. Forty-seven patients had significant coronary stenoses on invasive angiography with 18% affected segments. Overall sensitivity was 94%, specificity 97%, PPV 87%, and NPV was 99%.[7]

In another study by Hoffmann et.al CTCA was compared with invasive coronary angiography sensitivity, specificity, PPV and NPV of MDCT were 95%, 98%, 87%, and 99%, respectively.[8]

In a study by Bedi et. al, MDCT had a sensitivity of 98.5% and a specificity of 99.1%. The PPV was 82.3% and the NPV was 99.8%. On a per-artery basis the values were sensitivity 99.4%, specificity 84.6%, positive predictive value 97.7% and negative predictive value 95.6%.[9]

In CACTUS trial, the overall sensitivity, negative predictive value, and specificity for CAD detection by MDCT were 99%, 99%, and 75%, respectively.[10] A study by Vanhoenacker, recent meta-analysis shown better accuracy for diagnosing CAD for 64-slice CT comparing previous scanner generations. The sensitivity for the detection of CAD 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%.[11]

The results of recent studies have shown the accuracy of 64-slice CT for diagnosing CAD in suspected 800 cardiac patients has a sensitivity of 89% with a specificity of 96%, a PPV and NPV of 78% and 98%, respectively.[12-21] The NPV was consistently high in all studies, indicating that the CTCA is most useful non-invasive tool to rule out significant disease avoiding invasive angiography.

Several studies have shown the accuracy of CTCA in specific clinical settings. Meijboom et al[6] studied the diagnostic value of 64-slice MDCT in patients referred for valve surgery showing sensitivity of 100% with a specificity of 92% and positive and NPV of 82 and 100%, respectively. Other clinical conditions included are DCMP (sensitivity 99%, specificity 96%, positive and negative predictive values 81 and 99%.)[22] and patients with LBBB (sensitivity 97%, specificity 95%, PPV and NPV 93 and 97%).[23] Patients who had acute chest pain and have low risk of CAD are candidates for CTCA. Hoffmann et al[24] conducted a study in patients presenting with acute chest pain to the emergency department to rule-out an ACS in the absence of ischaemic ECG changes and negative initial biomarkers. Out of 103 patients studied by 64-slice CT, 14 patients were diagnosed clinically to have an ACS. Both the absence of significant coronary artery stenosis (73 of 103 patients) and non-stenotic coronary atherosclerotic plaque (41 of 103 patients) correctly diagnosed the absence of an acute coronary syndrome (NPV 100%). The PPV was low showing false-positive results in majority of scans. A small number of patients with acute chest pain were actually included in the study.[24] In a study by Goldstein et. al 197 patients with low-risk acute chest pain had 64-slice CT scan or 'standard of care' evaluation. CTCA was turned out to be safe, not missing acute coronary syndrome, faster, and had lower cost compared with 'standard of care'. [25]

CONCLUSION:

64-slice MDCT coronary angiography provides sufficiently high sensitivity and NPV to rule out significant stenosis in patients suspected of having CAD. MDCTCA can be used as a non invasive tool for diagnosis of significant CAD.

RECOMMENDATIONS:

1.The clinical application of coronary CT angiography to detect or rule out coronary artery stenoses seems most beneficial and, according to current data, can be recommended in patients with intermediate risk of CAD in whom the clinical presentation stable or with acute symptoms mandates the evaluation of possible underlying CAD.

2.The use of coronary CT angiography should be restricted to patients in whom diagnostic image quality can be expected (e.g. absence of arrhythmias), and scans need to be expertly performed and interpreted.

Author's Contribution

AS: Collected the data and conducted the study. SRB: Helped in conducting the study.MAR: Helped in analysis of data.TN: Data analysis and proof reading.MA: Gave frequent advises.

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