DOI: 10.47799/pimr.0903.09

Evaluation of Diagnostic Performance of MDCT Coronary Angiography in Comparison with Conventional Coronary Angiography

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Date of Submission: 12/05/2021 **Date of Review: 17/08/2021** **Date of Acceptance: 22/10/2021**

ABSTRACT

Background: Coronary artery disease is now becoming increasingly prevalent than before especially in younger age groups. We in the current study tried to evaluate the potential of 128 slice MDCT coronary angiography for the detection of stenotic coronary lesions by comparing the results of computed tomographic coronary angiography to a gold standard set by Conventional coronary angiography.

Methods: A total of n=30 patients with clinically suspected Coronary artery disease. They were evaluated with 128 Slice CT Scanner (PHILIPS INGENUITY) and conventional coronary angiography. All patients were examined with a 128 slice MDCT scanner (Philips Ingenuity 128 slice Netherlands) using standard cardiac CT protocol. Gantry rotation time was 400 ms with a half sector acquisition protocol and multisector reconstruction permitting an effective temporal resolution between 50 and 200 ms depending on patient heart rate.

Results: In the n=30 Patients included in the study with CCA, the n=450 coronary segments included in the study were found to contain a total number of n=138 stenoses among them non-significant stenoses. The accuracy of MDCT detection of coronary stenoses greater than 50% diameter of vessel lumen is about 94.78. When raising the threshold for stenosis from 50% to 70% of the vessel lumen, so that only hemodynamic relevant stenoses enter the evaluation, the sensitivity decreases from 88%. The MDCT detection in the patient group with heart rates below 60 beats per minute higher values for sensitivity 93% and specificity 97% were observed, compared to sensitivity 87% and specificity 93% of the patient group with heart rates above 60 beats per minute.

Conclusion:The present study revealed that a high negative predictive value (98.08%)suggests that 128- Slice MDCT coronary angiography is a good screening modality for evaluation of patients with mild to intermediate-risk factors who might otherwise require invasive angiography.

KEYWORDS: Conventional coronary angiography, Coronary artery disease, MDCT coronary angiography

INTRODUCTION

Coronary heart disease (CHD)is now increasing rapidly and acquiring an epidemic status in India. It is one of the major causes of disease burden and deaths, Among Indians, the risk of coronary artery disease is 3-4 times higher than white Americans. The adult prevalence has increased in urban areas from about 2% in 1960 to 10.5%in 2000; while in rural areas, it increased from 2% in 1970 to 4.5% in 2000. Indians are facing this disease before 40 years of age and showing a higher incidence of hospitalization due to chest pain and other cardiac symptoms. [1]World Health Organization (WHO) has reported that cardiovascular diseases are the number one cause of death globally: more people die annually from cardiovascular diseases than from any other cause. Over 80% of cardiovascular diseases deaths take place in low- and middle-income countries and occur almost equally in men and women. World Health Organization WHO reports stated that coronary disease accounted for more than 7.3 million deaths worldwide. In industrialized countries, CAD is responsible for 1/3rdof total deaths. [2] Conventional coronary angiography(CCA) is the gold standard technique for the diagnosis of CAD, due to its superior spatial and temporal resolution. For several years, CCA has been without competition in the diagnosis of coronary heart disease since it is the only established method by which stenosis of coronary vessels can be directly visualized. It also offers the option of treatment through percutaneous transluminal coronary angioplasty (PTCA) and stent implantation. However, recently the diagnostic value of conventional coronary angiography has been challenged by the emergence and fast-growing use of a less invasive imaging technique, multi-detector computerized tomography (MDCT)angiography. [3]The drawbacks of CCA, like its advantages, are inherent to the invasive nature of the procedure. Catheterization involves considerable discomfort for the patient and complications ranging from hemorrhage at the site of catheter insertion to coronary rupture may occur. Multi-detector computed tomography coronary angiography(MDCTA) is currently considered a promising alternative to conventional coronary angiography (CCA). The technique is relatively non-invasive. Images can be obtained quickly, there are few complications, and the preliminary studies

show that it may be cost-effective. Based on this background we in the current study tried to evaluate the potential of 128 slices of MDCT coronary angiography for the detection of stenotic coronary lesions by comparing the results of computed tomographic coronary angiography to a gold standard set by Conventional coronary angiography.

MATERIALS AND METHODS:

This is a prospective comparative Meta-analytic study done at the Department of Radiodiagnosis Prathima institute of medical sciences, Karimnagar, Telangana State, India. Institutional Ethical permission was accorded for the study. Written consent was obtained from all the patients of the study. All patients attending the cardiology OPD with complaints of chest pain and suspected of having CAD, who were scheduled for conventional coronary angiography. Inclusion Criteria were all-Age group and patients scheduled for CCA. Exclusion Criteria were renal insufficiency (creatinine> 2.5 mg/dl), unstable angina, acute myocardiaI infarction and known allergy to contrast media and pregnant woman. Based on the inclusion and exclusion criteria n=30 patients with clinically suspected Coronary artery disease. They were evaluated with 128 Slice CT Scanner (PHILIPS INGENUITY) and conventional coronary angiography. Initially, the CTA examination was performed, and the reconstructed images were evaluated by an on-staff radiologist. The evaluation of the CCA examination was performed by a physician blinded to the results of CTA. At a later point in time, the results of CCA were validated by quantitative coronary analysis(QCA). The location and extent of each diagnosed coronary lesion were recorded separately for each modality. Finally, a comparative analysis of CCA and CTA results was performed, yielding sensitivity, specificity, positive and negative predictive value of CTA compared with CCA. The influence of potentially interfering factors such as heart rate, coronary calcification, was demonstrated in a separate evaluation.

MDCT Angiography:Patients asked not to consume coffee or tea 24 hours before study and fast for 6 hours before the study. Patients were also asked to avoid metformin 1day before the study. Detailed patient history was taken, medications, routine investigations, and non-invasive stress test results were recorded. 50 mg metoprolol was given orally if HR was>65beats per minute. Sublingual nitroglycerin spray was given just before contrast administration.MDCT-CA protocol:All patients were examined with a128 slice MDCT scanner (PhilipsIngenuity128 slice Netherlands) using standard cardiac CT protocol. Gantryrotation time was 400ms with a half sector acquisition protocol and multi sector reconstruction permitting an effective temporal resolution between50 and 200ms depending on patient heart rate. Data were reconstructed using either a mono- or multi-segmental algorithm depending on patient heart rate automatically and displayed by Philips Extended Brilliance Workspace.

CCA protocol and quantitative coronary analysis: All the n=30 patients underwent conventional coronary angiography 1 — 2days after CTCA using a catheter via radial artery into the ostium of each of the two coronary arteries. A contrast agent (Omnipaque iohexol 350mgIodine/ml) was injected, and a series of images were recorded using DigitalSubtraction Angiography (Philips Allura FD 10). Multiple projections of coronary arteries were acquired and analyzed by an experienced cardiologist. All the available data were analyzed for descriptive statistics with SPSS version 21.

RESULTS:

Total n=30 patients n=22(73.33%) male and n=8(26.67%) female were evaluated. The youngest patient was 38years old and the oldest was 75years old. The mean age of the study group was 55.16 years. The highest numbers of patients were in the age group of 40-60 years.The n=30 CCA and n=30 CTA exams were all performed successfully.

The MDCT scan time varied according to scan volume and heart rate. Average scan time was5 sec. (range 3-7) for the native, and 8 sec. (range7-10) for the contrast-enhanced scan. All patients included in this study were able to hold their breath for the entire scan duration.

Age	Number	Percent
30-40	01	3.33
41-50	11	36.67
51-60	12	40.0
61-70	04	13.33
71-80	02	6.67
Total	30	100

Table 1: Age distribution of the population under study

In the n=30 Patients included in the study, a total of n=450 coronary segments were evaluated with CCA, of these segments n=441 (98%) could be evaluated with CTA. The remaining 9 segments could not be evaluated due to poor image quality. With CCA, then=450 coronary segments included in the study were found to contain a total number of n=138 stenoses among them non-significant stenoses, (<50%vessel diameter involving n=68 segments and n=70 stenoses greater than 50% of the vessel diameter, of these stenoses n=49(70%) was hemodynamic relevant ($\geq$ 70% of vessel lumen).CTA was able to detect=79 of all significant stenoses and n=44(89%) of the stenoses greater than 70% of vessel lumen (Fig. n=8 and n=9) of which n=16were false positives and n=7 were false negatives (seven significant lesions were missed on CT coronary angiography). Among n=30 patients, four patients (13.3 %) had normal angiograms, n=5 (16.6%) had a non-significant disease and n=21 patients (63%, n=18 male and n=3 female) had a significant disease, on CT coronary angiography, which was also proved on invasive angiography. The incidence of

significant coronary detected was highest in the age group of 41-60 years.

Of the 100% stenoses seen in CCA n=3(4.8%) was in the LM, n=16(22.85%) in the RCA, n=38(54%) in the LAD and n=13 (18.57%) in the LCX. The statistical evaluation of the data to determine sensitivity, specificity, positive and negative predictive value for CTA detection of coronary lesions greater than 50% of lumen diameter showed a sensitivity of 0.9 and a specificity of 0.95. Positive and negative predictive values were 0.79 and 0.98 respectively.

In the study, the accuracy of MDCT detection of coronary stenoses greater than 50% diameter of vessel lumen was about 94.78. When raising the threshold for stenosis from 50% to 70% of the vessel lumen, so that only hemodynamic relevant stenoses enter the evaluation, the sensitivity decreases from 88%. The MDCT detection in the patient group with heart rates below 60 beats per minute higher values for sensitivity 93% and specificity 97%were observed, compared to sensitivity 87% and specificity 93%of the patient group with heart rates above 60 beats per minute. The statistical results of coronary CTA of patients with calcium scores above and below 100, an increase in sensitivity from87% for patients with scores below 100 to 0.95 for those patients with scores above 100 can be observed. The specificity rose slightly from 98% to 99%. The positive predictive value for the patient group with calcium scores below 100 was very low 75% compared to the patient group with scores above 100 (90%).

DISCUSSION:

The n=450 coronary segments included in the study were found to contain a total number of 70 stenoses greater than 50% of the vessel diameter, of these stenoses50 (70%) were hemodynamic relevant ($\geq$ 70%of vessel lumen).CTA was able to detect n=79 of all significant stenoses, and n=55(69%) of the stenoses greater than 70% of the vessel lumen. Among significant stenoses, n=16 were false positives and n=7 were false negatives (seven significant lesions were missed on CT coronary angiography). Raff GL et al., [4] reported sensitivity, specificity, positive predictive value, the negative predictive value of 64-slice CT as 86%, 95%, 66%, and 98%respectively.Nikolaou K et al., [5] reported sensitivity, specificity, positive predictive value, negative predictive values in their study. Values are 82%, 95%, 72% and 97%respectively.Kim J Set al., [6]study per-segment analysis, stated that two low-radiation dose CCTA techniques using 128-slice MDCT yields comparable diagnostic performance for coronary artery disease in symptomatic patients with low heart rates. Sensitivity, specificity, positive predictive value, and negative predictive value were 91/96%, 95/94%,75/73%,and 98/99% for step-and-shoot prospectively. In a similar study A.F. Kopp et al. [7]on n=102 patients who underwent both conventional and MDCT coronary angiography. The results were compared with those of invasive coronary angiography in a blinded fashion. The overall sensitivity for the detection of significant stenoses ($\geq$50%) were 86% (observer 1) and93% (observer 2), specificity 96% (observer 1) and 97% (observer 2), negative predictive value 98% (observer 1) and 99% (observer 2). High-resolution MDCT angiography with retrospective gating permits the non-invasive detection of coronary artery stenoses with high accuracy if image quality is optimized for each of the three major coronary arteries. Our results correlated with this study well although we did not evaluate for different observers. Gorenoi V, et al, [8]A systematic literature search showed that CT coronary angiography with invasive coronary angiography as the reference standard, had a sensitivity of 96 %, specificity of 86 %, a positive likelihood ratio of6.38, and a negative likelihood ratio of 0.06. They proposed that CT coronary angiography scanners with at least 64 slices should be recommended as a test to rule out obstructive coronary stenoses to avoid inappropriate invasive coronary angiography in patients with an intermediate pretest probability of CHD.

One of the causes of artifacts is cardiac motions in our study in the patient group with heart rates below 60 beats per minute, higher values for sensitivity 93% and specificity 97% were observed, compared to sensitivity 87% and specificity 93% of the patient group with heart rates above 60 beats per minute. To avoid motion artifacts, only minimal cardiac motion within the image acquisition time is tolerable. With a given image acquisition time of 200ms, the optimal window for image reconstruction within the diastole of the cardiac cycle is very narrow even at low heart rates. [9]By choosing the right interval for image reconstruction within the cardiac cycle and applying dedicated spiral algorithms, motion artifacts can be reduced significantly. [10]It seems logical that larger coronary lesions are more easily detected in CTA than smaller ones. Calcification of the coronary vessels is a common phenomenon frequently observed in patients with coronary heart disease. [11, 12]Although extensive coronary calcification indicates a high plaque burden, it does not necessarily coincide with coronary stenosis. [13]It has been shown that the presence of calcium within a coronary plaque is a sign of plaque remodeling which indicates coronary disease progression but does not make the plaque more likely to rupture, causing an acute coronary event. The rapid motion of the heart and the relatively small size of the coronary arteries account for the major difficulties associated with coronary angiography.MDCT offers high spatial and temporal resolution and thereby meets the basic requirements for an adequate depiction of the coronary vessels. This study shows a sensitivity of 0.90 and a specificity of 0.95 for stenoses greater than50% of the lumen in coronary segments, suggesting a high potential for the detection of coronary lesions General disadvantages of coronary CTA include intravenous contrast media application and radiation exposure to the patient. The most severe complications associated with contrast media application are renal failure and anaphylactic reactions.

Artery	Non-significant stenosis on CTA	Significant stenosis on CTA >50%	Significant stenosis on CCA >50%	False positive	False Negetive
RCA	20	17	13	4	0
PDA/PLV	00	02	4	0	2
LM	05	02	02	0	0
LAD	15	40	33	7	0
LCX	18	14	9	5	0
Diagonal	01	02	4	0	2
OMs	0	02	05	0	3
Total	59	79	70	16	07

RCA- Right coronary artery, PDA/PLV- Posterior Descending artery, Posterolateral branch, LM-Left main, LCX- Left circumflex, OM-Obtuse marginal

Table 2: Artery wise distribution of lesions detected on CTA and CCA

CONCLUSION:

The present study revealed that a high negative predictive value (98.08%)suggests that 128- Slice MDCT coronary angiography is a good screening modality for evaluation of patients with mild to intermediate-risk factors who might otherwise require invasive angiography. It may be used to evaluate the coronary artery anomalies and in coronary evaluation in patients undergoing major non-cardiac surgery.

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How to cite this article: Kumar S. **Evaluation of Diagnostic Performance of MDCT Coronary Angiography in Comparison with Conventional Coronary Angiography**. Perspectives in Medical Research. 2021;9(3):35-38
DOI: 10.47799/pimr.0903.09

Sources of Support: Nil: , Conflict of Interest: None Declared: