Section: Radiology

Original Research Article

EVALUATION OF DIAGNOSTIC PERFORMANCE OF MDCTCORONARY ANGIOGRAPHY IN COMPARISON WITH CONVENTIONAL CORONARY ANGIOGRAPHY

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Abstract

Background: To evaluate the diagnostic performance of 128 slice multidetector computed tomography angiography (MDCTA) for the detection of stenotic coronary lesions by comparing the results of MDCTA with conventional coronary angiography (CCA). **Materials and Methods:** This is a prospective comparative study in thirty patients who scheduled for invasive coronary angiography, 22 (72%) male and 08 (28%) female. Inclusion criteria of the study was all Age groups who were scheduled for CCA. Exclusion Criteria of the study was patients with renal insufficiency (creatinine> 2.5 mg/dl), Unstable angina, acute MI, and Known allergy to contrast media, pregnant woman. The influence of interfering factors like heart rate, coronary calcification, lesion size, and motion pattern of each separate coronary artery by analyzing results of the study. **Result:** A total of 450 coronary segments (segment 1 to 15 were evaluated with conventional coronary angiography. Of these segments 441 (98%) could be evaluated with MDCT angiography. The remaining 09 segments could not be adequately depicted due to image artifacts.The statistical analysis to determine 128 slice MDCT coronary angiography performance for the detection of coronary lesions greater 50% of vessel diameter in coronary segments yielded high values for sensitivity (0.90) and specificity (0.95). Positive and negative predictive values were 0.79 and 0.98 respectively. **Conclusion:** The present study has 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 also in coronary evaluation in patients undergoing major non- cardiac surgery.

INTRODUCTION

Coronary heart disease (CHD)Is epidemic in India and 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 the 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. WHO report 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 is the gold standard technique for diagnosis of CAD, due to its superior spatial and temporal resolution.For a number of 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. Furthermore, CCA offers the option of treatment through PTCA and stent implantation. 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

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hemorrhage at the site of catheter insertion to coronary rupture may occur. Although severe complications are rare, the risk involved with CCA usually requires a short hospitalization of the patient.[4]

These drawbacks of CCA must be considered when defining the indication for the procedure, limiting the procedure to high risk patients and patients who already show symptoms of CAD.[5]

Multi-detector computed tomography coronary angiography (MDCTA) is currently considered as 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 but this has to be determined. Nevertheless, the available equipment suffers from several limitations comparedwith CCA. The diagnostic accuracy of MDCTA has improved after introduction of newer generations of scanners with high temporal and spatial resolution.[6,7]

MATERIALS AND METHODS

This is a prospective comparative Meta analytic study done at Department of Radio diagnosis Kakatiya Medical college, Warangal, Telangana State, India. All patients attending the cardiology OPD with complaint of chest pain and suspected of having CAD, who were scheduled for conventional coronary angiography. Study was conducted over a period of fifteen months (Jan 2022 to April 2023) on 30patients with clinically suspected coronary artery disease. They were evaluated with 128 Slice CT Scanner (GE Revolution act) and conventional coronary angiography.

Inclusion Criteria

All Age groups in patients who were scheduled for CCA.

Exclusion Criteria

Renal insufficiency (creatinine> 2.5 mg/dl), unstable angina, acute MI, known allergy to contrast media, pregnant woman

The study protocol was approved by the hospitals ethics committee and all patients gave informed consent. Initially the CTA examination was performed and the reconstructed images were evaluated by an on staff radiologist. The scheduled CCA examination took place. 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 was 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

Patient consent was taken. Risks and benefits of the procedure were explained to the patient clearly. Patientswere asked not to consume coffee or tea 24 hours prior to studyand fast for 6hoursprior to study. Patientswere also asked to avoid metformin 1day prior to study. Detailed patient historywas 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 (Philips Inguenity128 slice Netherlands) using standard cardiac CT protocol. Gantry rotation time was 400ms with a half sector acquisition protocol and multi-sector reconstruction permitting an effective temporal resolution between 50 and 200ms depending on patient heart rate. Patient positioning was supine with leg towards the gantry. Initially Calcium scoring was performed by scanning the patient from the bifurcation of the trachea to the diaphragm.

The Calcium score was then generated automatically by the software, according to the algorithm introduced by Agatstonetal.8Later a region of interest at the origin of the descending aorta was marked topermit subsequent use of automated contrast bolus tracking. Iodinated contrast media (Omnipaque 350 mg/ml) was injected via18Gauge cannula in antecubital vein, preferably on right side. Contrast volume and rate of injection varied with patient weight from 75 to 90 ml and 5.0 to 6.0 ml/second respectively. The contrast injection was immediately followed bya40 ml saline “chaser bolus” at a rate of 5 ml/second. Scanning was automatically triggered when contrast media in the pre-defined area of the descending aorta reached a density of 160 Hounsfield units. A single automated breath-hold command was given and helical scan acquisition commenced 3 seconds thereafter to minimise respiratory related fluctuation in heart rate. Overall scan time was between 7and 10seconds depending oncardiac size

Post processing and reconstruction

Data was reconstructed using either a mono- or multi-segmental algorithm depending on patient heart rate automatically and displayed by Philips Extended Brilliance Workspace. Retrospective ECG gating permitted reconstruction of images at 45%, 50%, 60%, 75% and 80% of the transferred data to a dedicated Image analysis workstation.[9,10]

CCA protocol and quantitative coronary analysis

All 30 patients underwent conventional coronary angiography 1 - 2 days after CTCA using catheter via radial artery into the ostium of each of the two coronary arteries. A contrast agent (Omnipaque Iohexol 350mg Iodine/ml) was injected and a series of images were recorded using Digital Subtraction Angiography (Philips Allura FD 10). Multiple

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projections of coronary arteries were acquired and analyzed by experienced cardiologist.

Data Evaluation and Statistics

The analysis of the data is based on the comparison of each single coronary segment seen in CTA with conventional coronary angiography representing the gold standard. For this purpose each coronary segment is classified as either Positive = Stenosis or negative = no stenosis. The stenosed segments are divided into 3 categories according to the extent of lumen narrowing (high grade stenosis: >70% of vessel lumen, significant stenosis 50 - 70% of vessel lumen, wall irregularity (non-significant stenosis) :<50% of vessel lumen). Each coronary segment is thus categorized with both conventional and CT angiography, making it possible to define the CTA results for each segment as either true positive, false positive, true negative or false negative. Separate evaluations for high grade and intermediate stenosis can be performed.

15 segments of coronary tree analyzed with both CCA and MDCT –CA and results were compared with CTA.

Separate statistical evaluations were performed for Lesions > 70% and >50% of the coronary lumen, Lesions within each of the separate coronary arteries (LAD, RCA and\LCX), Studies performed at heart rates above and below 60 beats/min and Studies with calcium scores above and below 100 Agatston.

RESULTS

Total 30 patients including male and female (22male and 8female) were evaluated. The highest numbers of patients were in the age group of 40-60 years. The 30 CCA and 30 CTA exams were all performed successfully.

In the 30 Patients included in the study a total of 450 coronary segments were evaluated with CCA, of these segments 441 (98%) could be evaluated with CTA. The remaining 9 segments could not be evaluated due to poor image quality.

With CCA, The 450 coronary segments included in the study were found to contain a total number of 138 stenoses among them non-significant stenosis, (<50%vessel diameter involving 68 segments and 70 stenosis greater 50% of the vessel diameter, of this stenosis 49 (70%) were hemodynamic relevant (≥ 70% of vessel lumen).

CTA was able to detect 79 of all significant stenosis and 44(89%) of the stenosis greater than 70% of vessel lumen of which 16 were false positives and 7 were false negatives (seven significant lesions were missed on CT coronary angiography).

Among 30 patients, four patients (13.3 %) had normal angiograms, 5 (16.6%) had non-significant disease and 21 patients (63%, 18 male and 3 female) had significant disease, on CT coronary angiography, which was also proved on invasive angiography. The incidence of significant coronary detected was highest in age group of 41-60 years.

Table 1: MDCT Scan parameters used for Ca scoring and contrast study

Parameter	Ca scoring	MDCT angiography
Contrast agent	None	75ml; 350 mg /ml; 5 ml/sec
Collimation	40x0.625	64x0.625 mm
Gantry rotation time	400 ms	400 ms
Kv	120	140
mA	55	800
Slice width	2.5mm	0.9 mm

Table 2: Distribution of the severity of coronary artery disease

Results	Number of patients
Normal	04
No significant stenosis	05
Significant stenosis	21
Total	30

Majority of patients (12/30, 40%) had calcium score of zero. Only three patients had a calcium score of more than 400. The mean CT coronary calcium score was 84.13Agatston units

Table 3: Artery wise distribution of lesions detected on CTCA and CCA

Artery	Non sig ST on CTA	sig ST on CTA >50%	sig ST on CCA>50%	False positive	False neg
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	05	0
Diagonal	01	02	4	0	2
OMs	0	02	05	0	3
Total	59	79	70	16	07

Of the 100%stenoses seen in CCA 3(4.8%) was located in the LM, 16(22.85%) in the RCA, 38(54%) in the LAD and 13 (18.57%) in the LCX. The statistical evaluation of the data to determine sensitivity, specificity, positive

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and negative predictive value for CTA detection of coronary lesions greater 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.

Table 4: Sensitivity, specificity, positive and negative predictive value for MDCT

	Sensitivity	Specificity	PPV	NPV
sig ST on CTA>50%	0.9	0.95	0.79	0.98
sig ST on CTA>70%	0.88	0.97	0.8	0.98
RCA	0.88	0.96	0.78	0.98
LAD	0.94	0.93	0.83	0.98
LCX	0.78	0.96	0.68	0.97
HR <60/min	0.93	0.97	0.87	0.98
HR >60/min	0.87	0.93	0.75	0.97
CA score <100	0.87	0.95	0.75	0.97
CA score >100	0.95	0.97	0.9	0.98

Detection of coronary stenosis greater than 50%, >70% diameter of vessel lumen. Separate evaluation for each coronary artery, patients with HR >60/min, <60/min AND CA score >100, < 100 Agatston units were evaluated. n-number, pts-patients, seg-segments, sten-stenoses.\PPV-Positive predictive value, NPV=Negative predictive value.

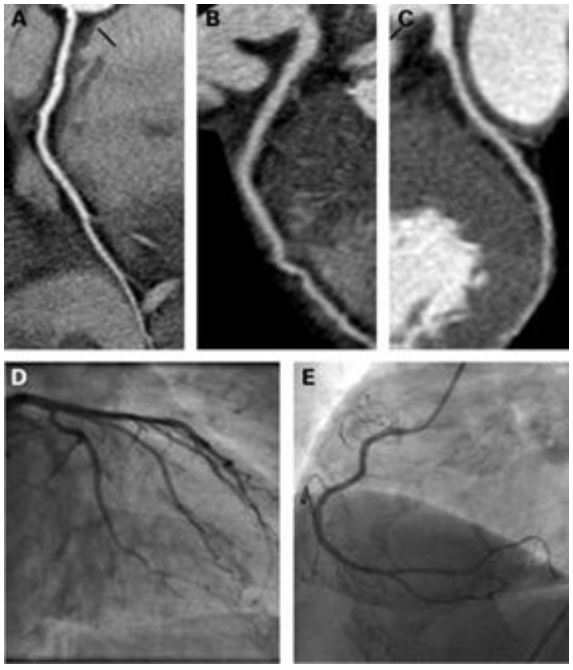

Figure 1: A, B, C, D, E Curved multi planar reconstruction images demonstrate diagnostic image quality of the right coronary artery (A); left anterior descending coronary artery (B) and left circumflex artery (C). No plaque, stenoses were present in CTA confirmed by CCA (D&E)

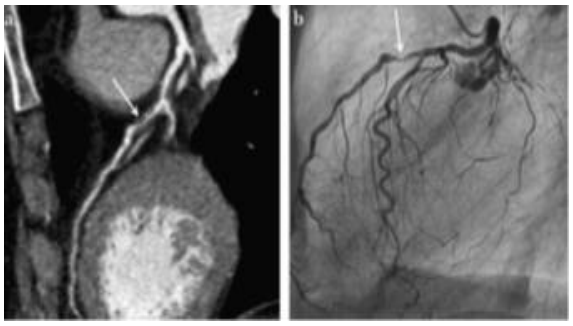

Figure 2: a, b: Curved multi planar reconstruction image showing significant stenosis involving mid segment of LAD which was confirmed by CCA.

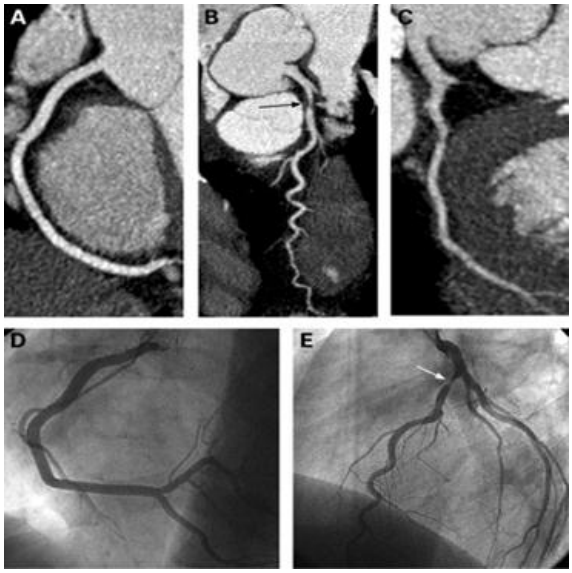

Figure 3: Curved multiplanar reconstructions of the RCA (A); LAD (B) and LCX artery (C) demonstrate a high-grade stenosis caused by a non-calcified plaque in the proximal left anterior descending artery (arrow). No significant stenoses of the RCA and the LCX artery were found. CCA of the right (D) and left (E) coronary artery confirms the stenosis in the proximal LAD (arrow) and absence of stenosis in right coronary and left circumflex artery.

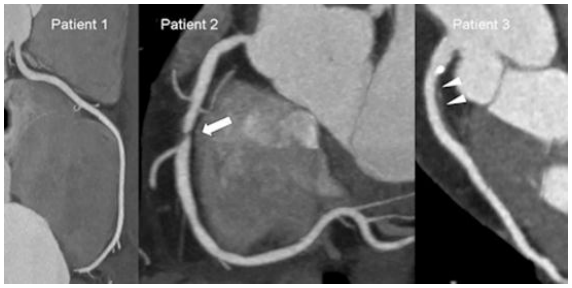

Figure 4: Contrast enhanced multi-row CT coronary angiography Multi-planar reconstruction studies showing normal coronary arteries in patient 1,soft plaque in RCA(arrows)in patient 2 and soft atheromatous plaque and calcifications in patient 3.

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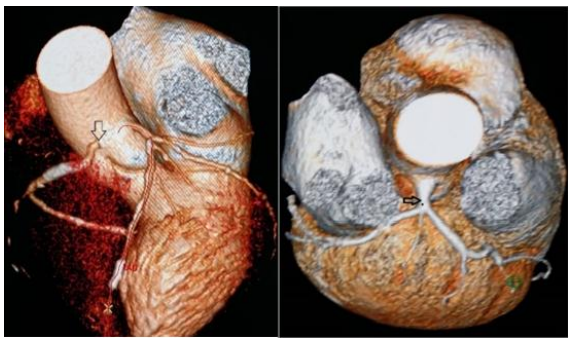

Figure 5: (A). Volume rendering image showing anomalous origin of RCA from left coronary sinus; (B).Trifurcation of left main coronary artery

Among thirty patients included in the study, congenital anomalies detected in two patients where Right coronary artery arise from left aortic sinus seen in one patient and trifurcation of left main coronary artery seen in another patient.

DISCUSSION

Among 30 patients included in the present study, A total of 450 coronary segments (segment 1 to 15) were evaluated with conventional coronary angiography. Of these segments 441 (98%) could be evaluated with MDCT angiography. The remaining 09 segments could not be adequately depicted due to image artifacts. With CCA, The 450 coronary segments included in the study were found to contain a total number of 70 stenoses greater 50% of the vessel diameter, of this stenosis 50 (70%) were hemodynamic relevant (≥ 70% of vessel lumen). CTA was able to detect79 of all significant stenosis, and 55(69%) of the stenosis greater than 70% of vessel lumen. Among significant stenoses,16 were false positives and 7 were false negatives (seven significant lesions were missed on CT coronary angiography).

The present study with128- Slice MDCT angiography had an overall sensitivity of 90.00%, specificity of 95.12%, and positive predictive value of 79%and negative predictive value of 98.08% with invasive catheter angiography as the gold standard. Among 30 patients included in the present study, four patients (13.3 %) had normal angiograms, 5 (16.6%) had non-significant disease and 21 patients (63%, 18 male and 3 female) had significant disease, on CT coronary angiography, which was also proved on invasive angiography. The incidence of significant coronary artery stenosis detected was highest in age group of 41-60 years.

To determine the influence of lesion size, a separate statistical evaluation including only stenosis greater than 70% of the vessel lumen was performed and compared to the evaluation including all stenosis (lumen narrowing > 50% diameter).

Sensitivity, specificity, positive and negative predictive value for MDCT detection of coronary stenosis> 50% diameter of vessel lumen, and >70%diameter of vessel lumen are 90%/88%, 95%/97%, 79%/80%and98%/98%respectively.

The higher specificity observed for high grade stenosis reflects the lower number of false positive segments in this group. It can be concluded that most false positive findings were read as low grade stenosis.

CTA showed slightly higher values for sensitivity and specificity (0.89 and 0.92) for patients with heart rates below 60/min, compared to values of 0.88 and 0.88 for patients with higher heart rates. More motion artefacts seen in patient with high heart rate.[11-13]

The separate evaluation of the data for each coronary branch yielded the highest sensitivity (0.95) for detection of coronary lesions within the LAD compared to the RCA and LCX. LAD experiences less rapid motion than the RCA sensitivity of 0.88 and the LCX 0.78 during the diastole phase of the cardiac cycle.[14-16] High specificity observed for patients with Agatston score more than 100 units compared to less than 100 units. Among thirty patients included in the study, congenital anomalies detected in two patients where Right coronary artery arise from left aortic sinus seen in one patient and trifurcation of left main coronary artery seen in another patient.

CONCLUSION

The present study has 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 also in coronary evaluation in patients undergoing major non- cardiac surgery.

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