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ORIGINAL ARTICLE

Diagnostic Accuracy of 128-Slice Dual Source CT Coronary Angiography with Invasive Catheter Coronary Angiography in a Tertiary Care Teaching Hospital

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ABSTRACT

Background: Coronary artery disease (CAD) morbidity and mortality increasing day by day in India as well as worldwide. Coronary arteries visualization by using invasive catheterization angiography is still using as a front-line diagnostic tool to evaluate the patients with CAD. 128 slice dual source CT improves the cardiac imaging such as high scanning speed, good temporal resolution and low radiation dose.

Objective: To assess the diagnostic accuracy of 128-slice dual source CT cardiac angiography with conventional catheter angiography to find common arteries involved in CAD.

Methods: This is a prospective, comparative, cross sectional study conducted at cardiology OPD. Patients with complaint of chest pain and suspected CAD were evaluated by CT and conventional coronary angiography and results were compared. Serum creatinine and ECG status were analyzed before the angiography. SIEMENS 128-slice Dual Source Flash Definition CT Scanner was used as a CT coronary angiography. Severity distribution of coronary artery disease, artery wise distribution of non-significant, significant lesions and coronary artery dominance pattern were analyzed and compared.

Results: A total of 70 suspected CAD patients were selected and analyzed. American Heart Association (AHA) model of 17-segment was used to assess the coronary arteries. Normal angiograms reported in 15.71% patients and 58.57% had significant disease. A total of 356 lesions were identified from 690 out of 720 segments. Right coronary artery (RCA) is the most common location of significant lesions which contributes 33.5% (n=55/164). Coronary circulation of right-sided dominance was most commonly reported (70.0%). CT angiography showed 96.13% of an overall sensitivity, 96.28% specificity, 89.72% positive predictive value and 98.49% negative predictive value.

Conclusion: 128-slice dual source CT scanner has showed high accuracy and act as non-invasive assessment of coronary arteries in patients with CAD

Keywords: Cardiac angiography, Catheter coronary angiography, CT coronary angiography, 128-slice MDCT, Conventional angiography

INTRODUCTION

Coronary Artery Disease (CAD) is one of the main risk factor for cardiac ischemia and leading cause of death in developed and developing countries like India.(1) The World Health Organization (WHO) and Global Burden of Disease Study revealed that people living with CAD in India had exponential increasing trends in years of life lost (YLLs) and disability-adjusted life years (DALYs).(2) Coronary and peripheral angiography is one of the essential diagnostics list (EDL) for cardiovascular diseases including CAD in India.(3) Cardiovascular deaths before the age of 70 years was 23.0% in Western countries and 52.0% in India.(4) Overall ischemic heart diseases (IHD) prevalence in India is 37 per 1000 population. However, cardiovascular deaths are higher in low and middle income countries like India in comparison with high income countries.(5,6) Due to high cardio-vascular disease burden, India may lose the revenue by spending health care costs in various forms.(7) From the decades,

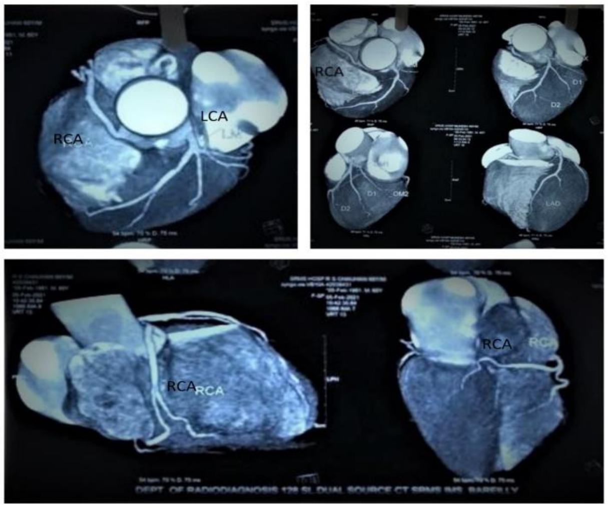
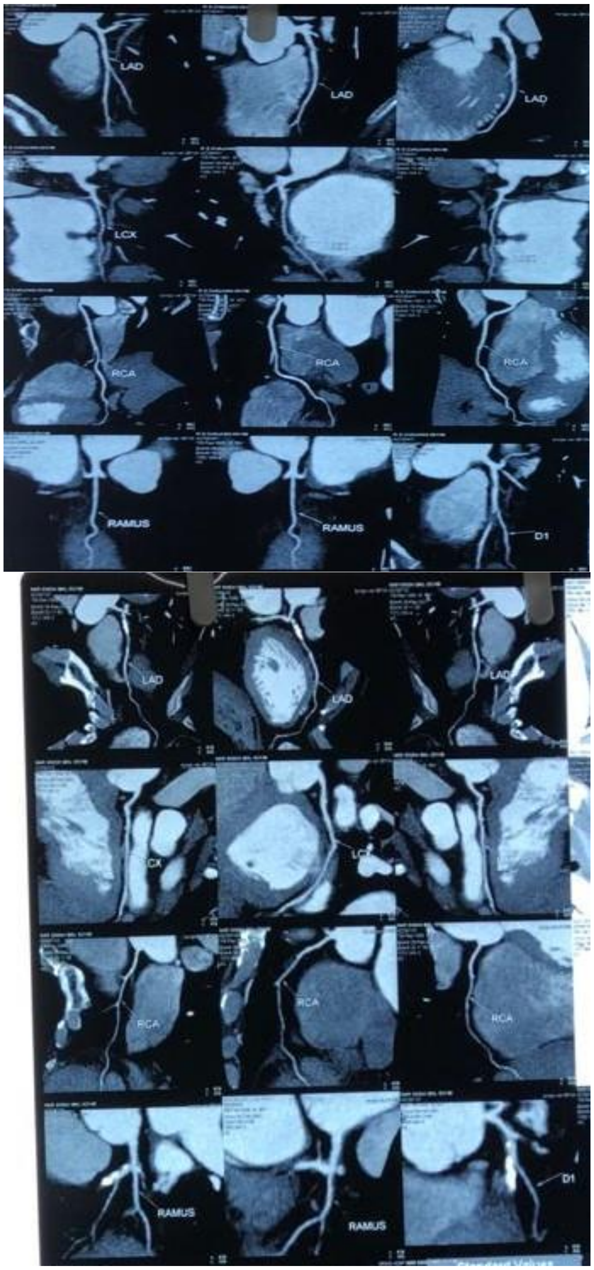


IMAGE 1 AND 2 SHOWING NORMAL DISTRIBUTION OF CARONARY ARTERIES
LAD: LEFT ANTERIOR DESCENDING ARTERY
LCx: LEFT CIRCUMFLEX ARTERY
RCA: RIGHT CORONARY ARTERT
D: DIAGONAL BRANCHES (D1, D2 AND D3)
OM: OBTUSE BRANCH

Catheter Angiography is used as a conventional and gold standard diagnostic test to study the coronary blood vessels. But it has own limitations in people with coagulation disorders may lead to increased vessel fragility.(8) It is also contraindicated in some patients.(9,10) Hence, there is a need of screening modality which is highly safe, reliable and affordable to evaluate the coronary arteries in CAD and other ischemic heart diseases.(11) This is one of the challenges in recent past and being solved by 128 slice dual source CT with its better temporal resolution, minimal dose of radiation and good scanning speed. Multi detector computed tomography (MDCT) is widely accepted and introduced in clinical practice to assisting in the diagnosis of coronary heart disease.(12,13) Initially 16-slice MDCT was used for cardiac imaging then increased to 64-slice, both these variations has drawbacks of heart rate requirements and temporal resolution. MDCT analyses helps to identify the several parameters such as individual coronary arteries and their branches, left and right ventricular functions, myocardial perfusion and calcium score.(14) To obtain two sets of images in a selected anatomical region, two X-ray tubes with simultaneous 80 and 140 kVp are used as a dual energy mode in a 2 x128-slice dual source CT. Both tubes generally work at same kV (120 kVp) as spiral and adaptive mode for coronary applications. Angular offset of 90 degrees and cover 180 degrees alternatively mounted on the rotating gantry of both X-ray tubes with 0.6 mm collimation. Temporal resolution is good (75 milliseconds) with 0.28 second single gantry rotation. Hence, we can achieve z-direction 48 mm of total coverage in a single rotation.(15,16). As compared to intracardiac catheter examination, Siemens dual source CT scanner dose values are lied far below. It takes only 250 milliseconds to scan the entire heart which is less than half a heartbeat. Therefore, the present study aimed to assess the diagnostic accuracy of 128-slice dual source CT cardiac angiography in comparison with conventional catheter cardiac angiography to find common arteries involved in coronary vascular disease.

MATERIALS AND METHODS

This a prospective, comparative study conducted at Department of Radiodiagnosis Rohilkhand medical college and hospital between Jan 2018 and August 2020. The present study was approved by Institutional ethics committee and Review board. Witten informed consent was taken from all study participants before recruiting into the study. Study was carried out in accordance with declaration of Helsinki. Subjects were selected and recruited at cardiac OPD of either gender with mild to moderate risk of suspected CAD. All study participants were recruited based on the clinical symptoms, ECG and TMT observations. All patients were checked for serum creatinine before the angiography. Suspected or established acute coronary syndrome, atrial fibrillation or conditions which directly or indirectly affect the coronary arteries were excluded from the study. One or two days before the examination of conventional angiography, every patient has been initiated cardiac CT examination. Hence, 128-slice CT coronary angiography and conventional invasive coronary angiography results were assessed and compared in people with suspected CAD. CT coronary angiography was done on SIEMENS made 128-slice dual source flash definition. Patients whose heart rate <85bpm, a prospective ECG gating was performed with a fluctuation of less than 10bpm and heart rate of >90bpm, retrospective ECG gating was performed. Iodinated non-ionic 370 mg/mL I.V used as a contract medium. Test bolus technique was used to calculate the desired dose for each patient. For this, 10mL test bolus of contrast was injected then 20mL of normal saline chaser was injected, peak enhancement time at ascending aorta was estimated. Injector flow rate (5mL/sec) was multiplied by peak enhancement time to calculate the required amount of contract needed for each patient. The average amount of contrast given to the patient was set as 70mL with maximum amount of 110mL.(17) To study the coronary arteries, scan boundaries were set at the level of carina to the hemi diaphragms level. Maximal intensity projections, multiplanar reconstruction, curved reconstructions and volumes rendering advanced offline post processing techniques were performed for better anatomy visualization and disease progression evaluation. Agatston-Janowitz method was used to calculate the calcium score in patients with CT coronary angiography. Systolic, diastolic and ejection fraction for cardiac cycle (0 to 100%) were generated by system after each scan. For post processing, the obtained data was moved to Syngovia workstation. American Heart Association (AHA) model of 17-segment was used to assess the coronary arteries which includes [– RCA proximal (1); mid (2); distal (3); PDA (4a); PLV (4b); LM (5); LAD proximal (6); mid (7); distal (8); D1 (9); D2 (10); LCX proximal (11); OM1 (12); LCX mid (13); OM2 (14); LCX distal (15); RI (16)]. Stenosis of 50% or more diameter was considered as significant disease of the coronary arteries whereas less than 50% stenosis considered as non-significant disease.(18) To evaluate the diagnostic tests ischemia, the best cut-point for defining significant angiographic disease was 75% or greater coronary luminal stenosis.(19). Discrete, tubular and diffuse lesions are defined as its length is less than 10 mm, 10-20 mm and more than 20 mm respectively.(20)



IMAGES 3 AND 4 SHOWING CARONARY ARTERIES IN 128 SLICE MDCT
LAD: LEFT ANTERIOR DESCENDING ARTERY
LCx: LEFT CIRCUMFLEX ARTERY
RCA: RIGHT CORONARY ARTERT
D: DIAGONAL BRANCHES
OM: OBTUSE BRANCH

RESULTS

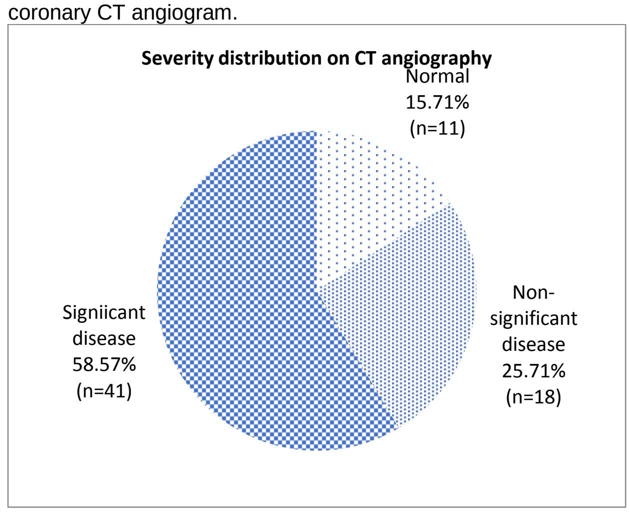
In this prospective, comparative, cross sectional study, we have evaluated 70 patients including both genders (42 male, 28 female). Baseline demographic details were showed in Table 1. Mean age of the study participates was 50.24 years with standard deviation of 7.73. A total of 51.4% of participants were in the age group of 51-60 years.

Table 1: Baseline demographics of study participants

Category	Value (N=70)
Gender, n (%)	
Male	42 (60)
Female	28 (40)
Age in years, mean ± SD	50.24±7.73
Range	40-70
Age distribution, n (%)	
40-50	18 (25.7)
51-60	36 (51.4)
61-70	16 (22.8)

Severity distribution of coronary artery disease on coronary CT angiogram was showed in Figure 1. A total of 15.71% patient angiograms were normal, 25.71% had non-significant disease and 58.57% of patients had significant disease on CT angiography, which was further proven in invasive coronary angiogram. Calcium score was zero for 65 patients (92.8%). Five patients had a calcium score higher than 400. All normal CT coronary angiogram patients (n=11, 16.9%), 16/65 patients in non-significant disease group (24.6%) and 38/65 patients in significant disease group (58.4%) had a calcium score of zero.

Figure 1: Severity distribution of coronary artery disease on coronary CT angiogram.



A total of 720 segments were found, in which 690 segments were evaluated and 356 lesions were identified and considered for comparison on both CT and invasive coronary angiography. Artery wise distribution of non-significant and significant lesions on CT coronary angiography in patients with suspected CAD was shown in Table 2. CT coronary angiography has missed eleven significant lesions; all these lesions were found to be involved in branch arteries. Right coronary artery (RCA) contributes 33.5% (n=55) of all significant lesions and most common location followed by left anterior descending artery (LAD) accounts 20.1% (n=33) and left circumflex artery (LCX) 16.4% (n=27) (image 9). CT coronary angiography not missed any significant lesion in these arteries. Most of the non-significant lesions are discrete in nature (length is less than 10 mm). A total of 86 (44.7%) of non-significant lesions were located in LAD followed by RCA 37 (19.2%) and LCX 33 (17.1%).

IMAGE 5 AND 6 SHOWING NON-SIGNIFICANT LESIONS IN LAD

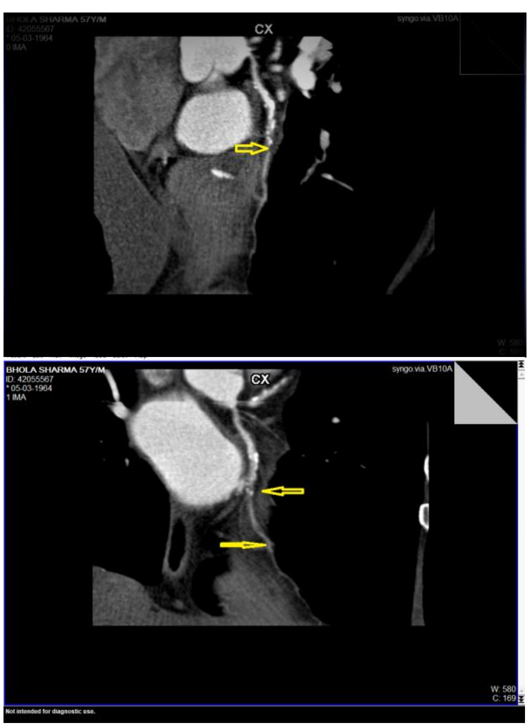


Image 7 and 8 Showing Lesions (Non-Significant)

Image 9 Showing Significant Lesion In Lcx

image 7 showing lesion in rac and image 8 showing lesion in lcx (both are non-significant)

Table 2: Artery wise distribution of non-significant and significant lesions on CT coronary angiography in patients with suspected CAD

Sl.No	Artery	Total number of non-significant lesions	Total number of significant lesions
1	RCA	37	55
2	PDA/PLV	5	0
3	LM	7	17
4	LAD	86	33
5	LCX	33	27
6	Diagonals	11	8
7	OMs	9	15
8	RI	4	9
	Total	192	164

RCA = Right coronary artery; PDA/PLV = Posterior descending artery/ posterior left ventricular; LM = Left main coronary artery; LAD = Left anterior descending artery; LCX = Left circumflex artery; OM = Obtuse marginal; RI = Ramus intermedius

Coronary artery dominance pattern on CT angiography was shown in Table 3. Coronary circulation of right-sided dominance was most commonly seen (70.0%) compared to left side (21.4%). A total of 6 (8.5%) patients were showed co-dominant pattern on CT angiography. CT angiography of 128-Slice dual source reported 96.13% of an overall sensitivity, 96.28% specificity, 89.72% positive predictive value and 98.49% negative predictive value compared to invasive catheter angiography.

Table 3: Coronary artery dominance pattern on CT angiography

Sl.no	Dominance	Number of patients	Percentage
1	Right	49	70.00
2	Left	15	21.43
3	Co dominant	6	8.57

DISCUSSION

Diagnostic accuracy between invasive and MDCT coronary angiography was compared by many authors in their studies. Raff GL et al, conducted a study in 2005 and reported that multislice computed tomography (MSCT) coronary angiography using a 64-slice scanner showed sensitivity, specificity, positive and negative predictive value were 86%, 95%, 66% and 98% respectively.(21) Another study conducted by Nikolaou K et al.,(22) in 2006 and reported that 64-MDCT systems had showed 82%, 95%, 72% and 97% respectively. A study conducted by Mühlenbruch G et al, in 2007 and reported that 64-slice MDCT showed 87%, 95%, 75% and 98% respectively. Madhok R et al,(15) conducted a similar study in 2014 and reported that 128- Slice dual source CT angiography had reported 95.26%, 95.12%, 88.46% and 98.08% respectively. The present study results showed greater values in all diagnostic accuracy parameters (96.13%, 96.28%, 89.72% and 98.49%) as compared to earlier studies.

Diameters of small blood vessel, less opacification, tortuous nature or motion blur are possible reasons for false negative cases. CT coronary angiography has missed eleven significant lesions. All these missed significant lesions were mainly located in the branch arteries. Accordance of per-segment level was good between CT and invasive coronary angiography and irrespective of vessel diameter, all coronary segments were assessed. Leschka S et al,(23) study excluded the patients with vessels diameter of < 1.5 mm, whereas all coronary segments were evaluated irrespective of vessel diameter in the present study.

Few coronary branch vessels were showed high accuracy might be due to small vessel size. To find out the significant lesions in coronary arteries, 128-slice MDCT coronary angiography had high potential to achieve. Study results also strongly showed the evidence and in accordance to the earlier claim. In the present study, how calcium score variation in a subgroup of patients were assessed and compared the 128- slice MDCT coronary angiography diagnostic accuracy. For better explanation, patients were grouped into 2 with those <100 coronary calcium score and ≥ 100 Agatston units. A total of 51 patients had less than 100 calcium score, in that 98.74%, 87.31%, 99.16% and 93.38% showed specificity, positive predictive value, negative predictive value and sensitivity respectively. More than 100 coronary calcium score was reported by 19 patients. A total of 38.5% of false positive segments were due to more than 100 coronary calcium score. So, in these patients, 97.10%, 78.20% 89.28% and 91.00% had sensitivity, specificity, positive and negative predictive values respectively. Calcium score ≤ 100 Agatston units had better accuracy.

Patients should be avoided with high coronary calcium score, as it causes extensive arterial wall calcification which impairs vessel assessment, CT coronary angiography. Overstimulation due to coronary calcium may enhance lesions on the CT scan. Patients with high calcium scores decreases the specificity of diagnostic procedure as it obscures the coronary lumen due to severe coronary calcification can lead to lesion severity by overestimation. Brodoefel H et al,(24) conducted a study in 2008 and also reported that greater than 400 Agatston score drastically and significantly decrease the image quality. However, higher calcium score significantly increase the total number of non-diagnostic segments. The diagnostic tool of CT angiography not only visualize the lumen of the specified coronary arteries, but it can visualize the innumerable several planes includes walls of the coronary walls, myocardium, heart chambers and neighbouring structures of heart.

Van Ooijen et al.,(25) found the visualization issues in their study, using of volume rendering reconstruction (VR), multiplanar reformation or reconstruction (MPR) and maximum intensity projection (MIP) may achieve optimal or sub-optimal results to detect stenosis and plaques. Volume rendering technique (VRT) is the best and well accepted technique to find out the abnormal or atypical anatomical evaluation because VRT more elegantly provides 3-dimentional relationships as well as better coronary artery anatomical course.

Although CT coronary angiography has its own advantages, the most common limitations are high heart rate, sensitivity to arrhythmia and calcification of vessel wall. Spatial and temporal resolution of 128-slice MDCT coronary angiography has been significantly increased compared to earlier MDCT systems. For accurate and reliable diagnosis or exclusion of patients with significant CAD or known and suspected CAD stratification of patients in clinical practice, this tool may hold the great promise. MDCTs are now playing a major role and opened up new frontiers for assessment of coronary arteries, heart, grafts and stenosis. Quick and accurate screening can be done with less radiation dose.

CONCLUSIONS

Study results strongly recommend that 128- slice MDCT coronary angiography is an accurate and reliable diagnostic tool for the evaluation of coronary arteries with equivocal stress test results as the present study showed the high negative predictive value (98.49%) otherwise patients may require invasive catheter angiography. High resolution scanners of coronary CT angiography definitely help for rapid screening of patients with chest pain as well as patients with equivocal stress test evaluation at emergency centres. Implementation of 128- slice MDCT coronary angiography in clinical practice successfully evaluates and detects the coronary artery anomalies, evaluation of coronary arteries who are undergoing non-cardiac surgeries and early screening of atherosclerosis in patients with mild to moderate risk. Potentiality has been reported of latest MDCT scanners in several studies and act as a first-line tool for non-invasive evaluation of suspected graft, vessel stenosis or occlusion in patients with coronary artery disease.

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