

To Study Coronary Artery Stenosis on CT in Comparison with Catheter Angiography

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DOI: <http://dx.doi.org/10.21276/ijcmsr.2019.4.3.27>

How to cite this article: Aastha Pruthi, Anand M Rahalkar, Manali Rahalkar. To study coronary artery stenosis on CT in comparison with catheter angiography. International Journal of Contemporary Medicine Surgery and Radiology. 2019;4(3):C118-C123.

A B S T R A C T

Introduction: Coronary artery disease is a significant cause of morbidity and mortality in present day scenario. The aim of this study is to assess coronary artery stenosis on computed tomography and compare the results with standard conventional catheter angiography. The objectives of the study were to detect specificity and sensitivity of computed tomography angiogram to detect stenosis.

Material and methods: This was a prospective study including 50 patients from Sassoon general hospital who underwent computed tomography coronary angiogram as well as catheter angiography. After following ethical guidelines and taking informed consent, both the procedures were performed on separate days. Post processed images of computed tomography coronary angiograms were compared with conventional angiograms for degree of stenosis in each coronary artery. Additional information of artery dominance, type of plaques, bridging and anomalies was obtained.

Results: In this study, one of the methods-conventional angiography- is the gold standard to detect coronary stenosis. So sensitivity, specificity positive and negative predictive values of computed tomography angiograms to detect coronary artery stenosis were calculated. Sensitivity, specificity, positive and negative predictive value of computed tomography were 94.5%, 95.2%, 87.5% and 95.5%.

Conclusion: Computed tomography angiograms can be used as a screening test especially in patients with low to intermediate risk of coronary heart disease.

Keywords: Coronary, Stenosis, Computed Tomography, Catheter Angiography

INTRODUCTION

Coronary artery disease (CAD) has high prevalence. In the urban population, it is 7.9% to 11% above 20 years and 14.3% above 40 years of age.^{1,2,3} CAD is the cause of death in 25.1% in urban population.⁴ Diagnosing and treating cardiovascular ailments has become important.

Conventional invasive coronary angiography currently remains the standard for the evaluation of CAD.⁵ The overall complication rate of conventional invasive coronary angiography is around 1.8% with mortality rate 0.1% but may be up to 0.55% in high-risk populations.^{6,7} Different risk stratification scores are in use like Framingham Risk Score and European Systematic Coronary Risk Evaluation.^{8,9} Such scores provide some prediction of who will have CAD and who will not. However, they have been found to perform poorly.

Role of computed tomography (CT) of coronary arteries was previously very limited due to longer scan times, slow gantry rotations and continuous pulsations. Recently Multiple detector/ Multislice CT have decreased scan times to few seconds using iso-volumetric image acquisitions and faster

computing speeds. 128 slice CT can be used for diagnosis in wide range of heart rates. CT coronary angiography (CTCA) can also be applied for assessment of coronary artery anatomy, its variants/anomalies and other non-coronary artery cardiac indications.

Study aimed to assess the role of coronary artery stenosis on CT coronary angiography in comparison with catheter angiography (CA) *with the objectives* to assess anatomy, dominance, presence and characterisation of plaques in coronary artery on computed tomography coronary angiography and to assess coronary artery stenosis in each of the artery as visualised on CT coronary angiography on comparison with catheter angiography and to detect specificity and sensitivity of CTCA.

MATERIAL AND METHODS

This was a prospective study done from June 2012 to June 2014 in Sassoon general hospital. Sample size is 50 patients.

Inclusion criteria: Patients coming for routine screening and getting CT coronary angiography (CTCA) and conventional angiography (CA) both.

Exclusion criteria: patient not undergoing both the scans. Patient undergoing only calcium scores. Any symptomatic patients.

Scanning Protocol: After taking approval from institute ethics committee and informed consent, they were evaluated for CTCA finding. Subjects were scanned on Siemens 128 slice scanner. Patients having irregular heart rhythm or high heart rate were given beta blockers. For CT calcium score, plain scan was acquired at 120 Kv, 100 mAs, 3mm slice thickness, 64 x 0.6mm collimation, field of view (FOV) of 200. Scan data was acquired in cranio-caudal direction. Matrix size of 512 x 512. All subjects with calcium score of >400 were advised catheter angiography. Patients having poor breath hold after beta blockers were excluded from the study. For CTCA, 80-100ml of non-ionic contrast-Iohexol (350mg/ml) was injected at rate of 4.5 to 5.5ml/sec. Auto-trigger technique was used with trigger kept on descending aorta, with threshold at 100 HU. Images were acquired during whole cardiac cycle. Scanning parameters employed during scanning were – 120 Kv, 100mAs, 1mm slice thickness, FOV of 200 and 64x0.6 collimation. Retrospective ECG-gated reconstructions were done at various R-R time intervals. B46f Heart-view sharp kernel and 1mm slice thickness was used for reconstruction. Images were viewed in a cardiac window with window level at 200 HU and window width of 600HU.

The acquired data sets were evaluated in axial sections and also using various post-processing methods like multi-planar reconstruction (MPR), curved MPR, maximum intensity projection (MIP), surface shaded display (SSD) and volume rendering technique (VRT). Coronary circulation was evaluated for dominance. Then, individual coronary artery was also assessed for presence of any variation or anomalies. The involvement of vessel by calcified or soft (non-calcified) atherosclerotic plaques were categorized into no vessel diseased, single vessel diseased and multiple (i.e. more than one vessel) vessel diseased. The significant stenosis was defined as >50-70% of luminal narrowing of coronary artery lumen. Catheter correlation was obtained in all subjects for comparison.

Catheter angiography (CA): Severe anaemia, uncontrolled hypertension, ventricular fibrillation, renal failure and congestive cardiac failure were contraindications. Serum creatinine was done in all patients. Contrast used was Iohexol-nonionic, water soluble and low osmolar-up to 50 ml.

Approach – Via Femoral artery with diagnostic catheter (jetking).

Angiograms: Right anterior oblique caudal, AP, Cranial, LAO cranial, LAO caudal are the views for right side. LAO caudal and AP are views taken for the left side. One AP view for renals is also taken.

Additional evaluation of intracoronary pressure, pre and post stenosis is assessed. Distal flow /collateralization can also be visualized. If stent placement is to be done in the same setting, exact length and gauge of stent can be assessed. Post-stent placement revascularization can be documented.

RESULTS

Only 3 patients were under 45 years, rest all were above 45 years. 80%were males. Right dominant circulation was observed in 40 subjects (80%). Left dominant circulation was seen in 7 subjects (14%) and co-dominant circulation in 3 subjects (6%).

Calcium Score: Out of 50 subjects, 24 subjects (48%) had calcium score less than 80. 14 of these (58% of these) had non-significant stenosis and 10 (41% of these) had significant stenosis. 26 (52%) subjects had calcium score more than 80. 9 of these (34.6% of these) had non-significant stenosis and 17(65.4% of these) had significant stenosis. Three subjects having multiple vessels with significant stenosis had calcium score more than 80, and one case had calcium score less than 80 as shown in table 1.

Plaque: Highest number of plaques were found in LAD followed by RCA and circumflex. Type of plaque are reported as calcified, non-calcified/soft or mixed plaques. Calcified being highest in prevalence, followed by mixed and soft plaque in each coronary artery. Figure 1a and 1b shows mixed plaque in LAD. Figure 2a and 2b show mid RCA

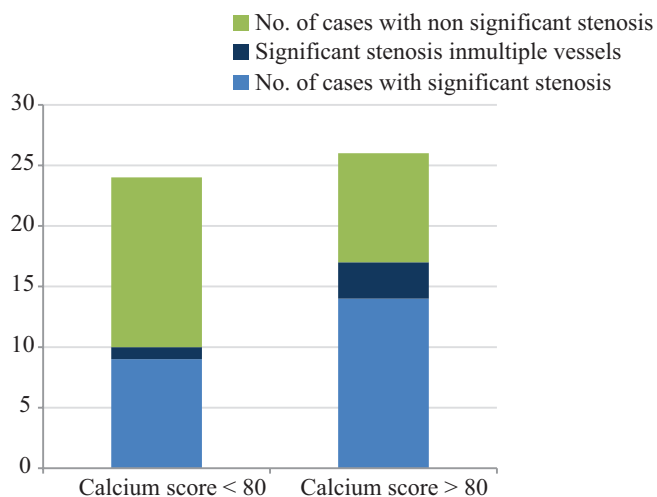


Table-1: This histogram shows more prevalence of significant stenosis among higher calcium

Table a)	CA	Negative
CTCA	Positive	
RCA		
Positive	9	0
Negative	1	40
Table b)	CA	
CTCA	Positive	Negative
LAD		
Positive	19	2
Negative	0	29
Table c)	CA	
CTCA		
CX		
Positive	6	0
Negative	1	43

Table-2: Depicts in toto results of the study.

	CATHETER ANGIO	CT ANGIO
Contrast inj	Intraacoronary	Intravenous/periphery
Contrast enhancement	Selective coronary	Complete vascular
Image acquisition	Projection	Cross section(3D)
Acquisition rate	20 projections per heart cycle	1 data set in 20 heart cycles
Radiation exposure	3-10mSv	5-13 mSv
Examination time	>1 Hr	1-2 hr
In hospital time	<1 day	1-2 hr
Spatial resolution	0.1 x0.1x infinite mm	0.7 x0.7x0.7mm
Temporal resolution	<50 ms	50-200ms
Advantages	1. Lesion quantification more accurate 2. coronary flow, additional diagnostics (IVUS, Pressure measurements) 3. Intervention in the same setting possible	1. Minimally invasive 2. Cardiac anatomy evaluated 3. Plaque imaging 4. Calcium score can be calculated
Disadvantages	Complications and discomfort related to arterial puncture and coronary intubation	Sensitive to arrhythmia, calcified vessels, poor breath hold

Table-3: Comparison of CTCA and CA

Authors	Right dominance	Left dominance	Co dominance
Bezbaruah NK(2003)	76%	20%	4%
Kalpana R (2003)	89%	11%	-
Present study	84%	14%	2%

Table-4: Distribution of dominance in different study.

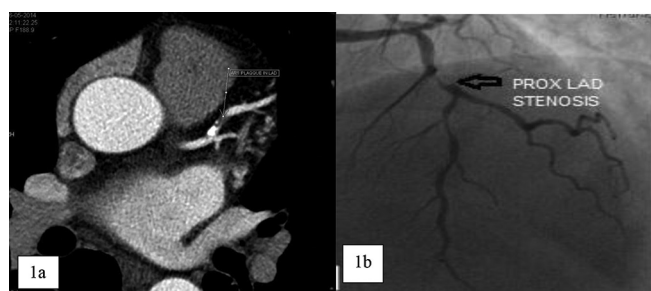


Figure-1a): shows a mixed plaque in LAD causing significant stenosis. **1b)** confirms the findings on CA

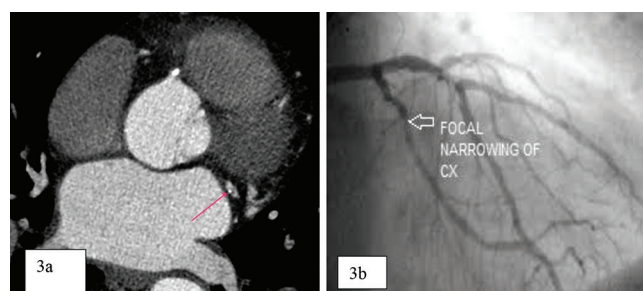


Figure-3a and 3b: Non significant focal narrowing in circumflex artery seen on CTCA and CA.

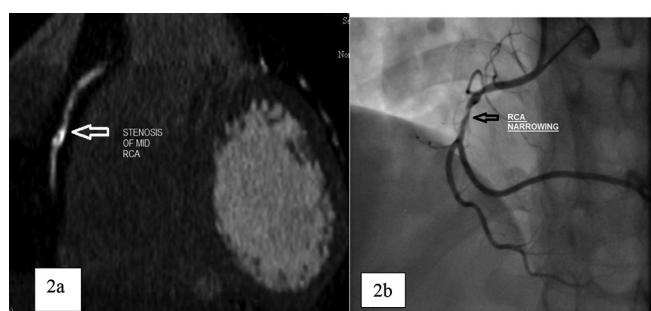


Figure-2a and 2b: shows stenosis in mid RCA on CTCA and CA.

stenosis. Figure 3a and 3b show focal calcified plaque.

Stenosis: Each coronary artery proximal, mid and distal segments were evaluated. Significant stenosis by definition was taken as 50-70% narrowing. Rest all cases were taken as non-significant narrowing. For LAD Sensitivity was 100%, Specificity 96.6, positive predictive value 95% and negative predictive value 100%. For RCA Sensitivity 88.8%, specificity 95.1% positive predictive value 80%, negative predictive value

97.5%. For circumflex artery sensitivity=87.5%, specificity 95.2% positive predictive value 79% and negative predictive value 97.5%. This is shown in Table 2.

Intoto sensitivity: 94.5% Intoto specificity 95.5% Intoto positive predictive value 87.5% Intoto negative predictive value 95.5% (Table 2).

Subjects with significant stenotic lesions in LAD, RCA and circumflex were 19, 10 and 7 respectively and those with non-significant stenotic lesions were 31, 40 and 43 respectively. Left main coronary artery was normal in all cases except 1.

Variants: Bridging of the coronary arteries was better appreciated on CTCA, with 10 subjects showing bridging. 9 of these where bridging of LAD. One of it was focal bridging of right coronary artery. Variation in origins of coronary arteries was seen in 1 case with right coronary artery taking origin from left coronary sinus. A case of ectasia of LAD artery with luminal expansion by more than 1.5 times. Type III LAD (beyond apex into posterior interventricular groove) was seen in 10 subjects out of 50.

DISCUSSION

CAD causes the largest healthcare burden to society. To decrease the morbidity and mortality of patients having coronary artery disease, it is necessary to diagnose and manage CAD at an earlier stage. The Framingham Heart Study is the origin of the term 'risk factor'. These can be modifiable and non-modifiable factors. Modifiable factors can be lifestyle and environmental factors. Non-modifiable factors are age, sex, hereditary factors i.e. family history of coronary artery disease.

Age: Framingham's study suggests increased risk over age 45 years in men and over age 55 years in women. In our study too, these findings hold true. Almost all of the subjects having significant CAD belong to an age group more than 45 years. Those below the age of 45 years have predominantly non-significant coronary artery stenosis.

Gender: Overall men are more prone to atherosclerosis than women²⁷ probably due to protective role of estrogen. Post-menopausal women have nearly the same risk as males of similar age group. In our study too there were 14% females and 86% males. Among these too, more percentage of males had significant coronary stenosis as compared to females.

With advancements in CT technology we now use CTCA for evaluation of coronary arteries. This can be done as an out-patient procedure without any special preparation, except for those routinely required prior to any other CT study with contrast. The ease and minimum invasive nature makes it an attractive tool for clinical application. Lesser complication rates as compared to conventional catheter angiography and simultaneous assessment of coronary artery calcium score (Modified Agatston score) also favor use of CT angiography of coronary arteries.

MSCT coronary angiograms are different from conventional angiograms as shown in the table. Conventional angiograms are projections of a vessel that has been enhanced with high concentration of contrast material. During injection of contrast, multiple images of this vessel are acquired throughout a number of cycles. In MSCT angiography, the cross-sectional images of the coronary arteries are reconstructed during single phase of a number of consecutive heart cycles.

Dominance: The term right or left "Coronary Dominance" was used to show which coronary artery supplies the heart's diaphragmatic surface, based on the origin of the posterior interventricular artery (PIVA). Origin of the PIVA from the RCA was termed 'right dominance'; from the circumflex artery was called 'left dominance'. Origin from both the RCA and the circumflex artery was known as co-dominant pattern.

Almost all authors have reported higher percentages of right dominance. Our study findings coincide with Indian as well as international study results in prevalence of dominance. It is important to know clinically about the dominance of artery, e.g. stenosis of circumflex needs to be treated more aggressively in a left dominant heart and vice versa is true for right dominant circulation.

Calcium Score: The prognostic value of coronary calcium

has been studied in many studies. These studies indicate that calcium scoring can be used as a risk factor, i.e. a high calcium score is associated with a relatively high risk of adverse coronary events. Absence of calcium is associated with a low likelihood of advanced coronary disease and a very less likelihood of advanced coronary atherosclerosis. Greenland and Gaziano²⁸ proved in their study that a calcium score less than 80 significantly reduced the risk of occurrence of coronary event in the next 10 years i.e. have a lesser tendency to be associated with significant stenotic lesions. Our study also gives a larger portion of patients with significant stenosis belonging to calcium scores more than 80. However, scores less than 80 don't rule out the presence of significant stenosis.

PLAQUE: LAD shows the highest prevalence of plaques, followed by RCA and circumflex. Left main artery shows the lowest incidence of atherosclerosis in our study. This corroborates with the findings of the above-mentioned study, which also labels LAD, especially proximal and mid segments as most vulnerable to plaques. These can be calcified, non-calcified/soft or mixed depending on morphology. The sensitivity of plaque detection depends on the percentage of calcium in the plaque. Calcified plaques are found to be more stable and less prone to rupture. A study by Leber et al¹¹ found that among asymptomatic patients, calcified plaques are the highest in prevalence. Our study too, shows similar findings. Among all the plaques detected on CT coronary angiography, calcified plaques showed the highest predominance in all the arteries (55-70%). Whereas, soft plaques show more association in patients with angina pectoris and myocardial infarction as suggested by Mollet et al.¹⁵

Artery Stenosis: CT coronary angiography results showed a slight overestimation of significant stenosis on CTCA giving a slightly lower positive predictive value. Optimal breath hold, regular heart rate artifacts due to motion and calcifications are many factors responsible for this. In our case, 2 false positive cases were due to excess calcium in the plaques. These are known facts described in Accuracy Trial by Budoff et al.²² As compared to Herzog C, Peter L. Zwerner,¹⁴ et al who did a study titled "Significant Coronary Artery Stenosis: Comparison on Per-Patient and Per-Vessel or Per-Segment Basis at 64-Section CT Angiography", found that on a per-segment basis, up to 90% of all segments could be clearly evaluated. Stenoses of 50% or greater were detected with sensitivity, and specificity, respectively, of 89% and 91.5% on a per-vessel basis. Dewey et al also studied a total of 30 patients, CT coronary and conventional angiography both were performed, which, together with quantitative analysis, served as the reference standard. Our findings match well with the conclusions of the above-mentioned studies. Most of the plaques detected were not causing significant stenosis. This was expected, as our study included only asymptomatic patients.

Variants: Highly variable observations are reported regarding myocardial bridging, ranging from 1.5 to 1.6% in catheter angiography study to 18 to 30% in CT coronary angiographic studies. It is well appreciated by CT coronary angiography. Catheter angiography is less sensitive. Anomalous origin of RCA is a benign anomaly in which right coronary artery

taking origin from left aortic sinus. It is appreciated well on both CT and catheter angiography.

Ectasia is dilatation of arterial lumen by 1.5 times or more than the original. It was appreciated both on CT and catheter angiography.

CONCLUSION

Catheter angiography remains the gold standard for diagnosis of significant stenosis, as diagnosis and treatment can be done in the same setting. In all, CTCA demonstrates good negative predictive value. Also sensitivity, specificity and positive predictive value are such that it can be used as a good screening test in subjects with low to intermediate likelihood of coronary artery disease. And those depicting normal coronaries can avoid the hassles of catheter angiography and the costs associated. Characterisation of plaque and detection of anomalies is an additional technically useful information for any intervention later on. In case of malignant anomalies, preventive measures can be advised.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 13-07-2019; **Accepted:** 07-08-2019; **Published online:** 04-09-2019