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Radio diagnosis

THE SEGMENTAL EVALUATION OF 128 SLICE CT CORONARY ANGIOGRAPHY AND CONVENTIONAL INVASIVE ANGIOGRAPHY.

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KEYWORDS :

Introduction

The report of World Health Organization (WHO) in 2005, posited that the cardiovascular disease (CVD) caused 17.5 million (30%) of the 58 million deaths that occurred worldwide[1]. While the prevalence and mortality due to CVD is declining in the developed nations[2] the same cannot be held true for developing countries. There has been a 4-fold rise of CVD prevalence in India during the past 40 years. Current estimates from epidemiologic studies from various parts of the country indicate a prevalence of CVD to be between 7% to 13% in urban[3-5] and 2% to 7% in rural [6,7] populations.

Both invasive and non-invasive diagnostic techniques available for evaluation of disease. Electrocardiography(ECG), echocardiography, stress echo, MDCT (multi detector computed tomography coronary angiography (CT Coronary angiography), MRI (Magnetic resonance imaging), Nuclear imaging studies etc. are non-invasive procedure whereas invasive conventional catheter coronary angiography has been accepted as the gold standard technique in evaluation of coronary artery disease owing to excellent spatial and temporal resolution. However, besides being expensive and invasive procedure; conventional catheter coronary angiography carries risk of procedure related complication (like aortic dissection, pseudoaneurysm formation) in 1.7% individuals especially in patients with coagulation disorder and peripheral vascular disease. Therefore need was felt for non-invasive procedure which could reliably verify or exclude functionally or prognostically relevant coronary stenosis. MRI angiogram is recognized to have weaknesses in terms of calcium detection, plaque characterization, imaging of the pulmonary circulation, and direct visualization of the coronary arteries or bypass grafts. Multi slice CT angiography is more sensitive and specific than MR angiography in the detection of significant (>50% diameter) stenosis of the coronary arteries. In addition to coronary artery calcium scoring, CT angiography allows direct evaluation of the coronary arteries and the severity of stenosis and may offer advantage over conventional angiography to quantify and characterize atherosclerotic plaques, provide independent prognostic information for predicting cardiac events and mortality in patients with known or suspected CAD[8-9].

Many studies have been carried out in western countries for evaluating the role of CT coronary angiography as an alternative to catheter coronary angiography. A variety of CT angiography techniques are available for the evaluation of CAD. Cardiac imaging by MDCT was first done on 16-slice MDCT, which then upgraded to 64-slice, however both of these have their limitations especially in terms of heart rate requirements and temporal resolution. Cardiac Imaging is the challenge of 21st century and it is being answered by 128-slice CT as it has good temporal resolution, high scanning speed as well as low radiation dose.

Vanhoenacker et al[10] conducted a study to review the literature on the diagnostic performance of MDCT angiography for assessment of symptomatic coronary artery disease, with conventional coronary angiography as the reference standard. Results of regression analysis indicated that the diagnostic performance significantly improved with the newer generations of multi-detector CT scanners.

The heart is an organ that is subject to displacement from voluntary movement, respiration, and cardiac contraction, all of which need to be neutralized during the data acquisition and image reconstruction[11]. The image reconstruction after data acquisition can result in CT coronary angiography to have blind spots in segmental coronary artery anatomy. However, so far none of the studies have focused on the efficiency per coronary segments of CT coronary angiography compared with catheter coronary angiography. Simultaneously, the non-assessable proportion of segments significantly decreased with the newer generations of multi-detector CT scanners.

Methods

This is a prospective diagnostic cross sectional analytical study. On the basis of current prevalence of coronary artery disease and on the previous available data of sensitivity (96%) and specificity (86%) of the test, a minimum sample size of 72 was found to be appropriate to achieve a precision of 5% with a 95% confidence interval. Sample size was found to be adequate using power of the study 0.8, alpha error to be 0.05 and data from previous studies, sample size was calculated using power and sample size calculator Vs 3.1.2. We have a done total of 75 cases.

INCLUSION CRITERIA:-

All patients that underwent the CT coronary and conventional catheter coronary angiography at our institute between July 2015 to September 2016, irrespective of their indication for the either procedure.

EXCLUSION CRITERIA:-

The patients who presented with acute chest pain and underwent none or only one of the two modalities of coronary angiography - catheter or computed tomography.

METHODOLOGY

CT CORONARY ANGIOGRAPHY:

All patients included in the study were scanned by 128 slice CT scanner (Siemens 128 slice CT scanner Somatom Definition AS+ following the institutional protocol. Images were reconstructed with ECG gating to obtain optimal, motion-free image quality. Data sets were reconstructed immediately after the scan following a stepwise pattern. Initially, a single data set was reconstructed during the mid- to end-diastolic phase. Image quality was assessed on a per segment level. Multiphasic reconstructions (i.e., automatic reconstruction of multiple phases of the RR interval) was performed. If necessary, multiple data sets of a single patient were used separately to obtain optimal image quality of all available coronary segments. All acquired set of data images obtained were transferred to an offline Syngovia Work Station for detail evaluation. All scans were analysed independently, and were visually scored for the presence or absence of significant stenosis. Exclusion of motion artifacts were done by

correlating the results with those for the same coronary segment in another phase. Maximum-intensity projections and multiplanar reconstructions (curved) were used to identify coronary lesions and to classify lesions as significant or non-significant. Maximum intensity projections (MIP) also provide a good anatomical overview, however they were used for stenosis detection in the absence of any calcifications, as the blooming effect of coronary calcifications is significantly enhanced using this post-processing technique. Multiplanar reconstructions (MPR) or curved multiplanar reconstructions (cMPR) were used to evaluate the presence of significant coronary stenosis. A mean luminal narrowing of 50% or more is to be considered as a significant stenosis in case of left main coronary artery and mean luminal narrowing of 70% or more in case of any other coronary artery.

Calcium scores of all patients were calculated with dedicated software and expressed as Agatston scores. A cut off value of 400 was used to see the association of calcium score with significant coronary artery disease.

Angiographic scan parameters included the following: number of slices per rotation, 128; individual detector width, 0.6 mm; rotation time, 330 ms; table feed, 3.8 mm per rotation; tube voltage, 120 kV; tube current, 800 mA; effective temporal resolution 150 ms and prospective x-ray tube modulation, none. Coronary angiographic images were reconstructed with following parameters FOV 180–200 (mm), slice thickness 0.5–0.75 mm reconstruction increment 0.3–0.5 mm, Kernel B25f smooth for non calcified lesions, while a sharper kernel B 46f for calcium plaques and R-R interval of 0–90% at 10% increments and/or minimal cardiac motion phases.

Calcium scoring parameters (similar unless indicated) were a tube current of 150 mA and prospective x-ray tube modulation. The mean radiation exposure for CT coronary angiography with this scan protocol was calculated as 12.8 and 15.7 mSv (for men and women, respectively) The radiation exposure of calcium scoring (including prospective x-ray tube modulation) was calculated as 1.3 and 1.7 mSv (for men and women, respectively).

CONVENTIONALANGIOGRAPHY:

All patients after the CT angiography were taken up for conventional angiography as per institutional protocol, which were done on Philips Allura Xper FD 10 (Fig 3.2) by a cardiologist (single observer) unaware of the multi slice CT results. He evaluated coronary segments using a 17-segment modified AHA classification[15] (right coronary artery: 1, proximal; 2, mid; 3, distal; 4, posterior descending; 16, posterolateral; left main coronary artery: 5, left anterior descending coronary artery (LAD); 6, proximal; 7, mid; 8, distal; 9, first diagonal; 10, second diagonal; circumflex coronary artery: 11, proximal; 12, first marginal; 13, mid; 14, second marginal; 15, distal; and 17, intermediate branch. A mean luminal narrowing of 50% or more is to be considered as a significant stenosis in case of left main coronary artery and mean luminal narrowing of 70% or more in case of any other coronary artery. Validated quantitative coronary angiography software was used.

STATISTICALANALYSIS:

The diagnostic performance of CT coronary angiography for the detection of significant lesions in coronary arteries with conventional angiography as the standard of reference is presented as sensitivity, specificity, positive and negative predictive values with the corresponding exact 95% CIs. Comparison between CT coronary angiography and conventional angiography was performed on 2 levels: segment by segment, vessel by vessel (no or any disease per vessel). For Vessel-based evaluation, four major vessels were considered; Left main coronary artery(LM), Left anterior descending artery(LAD), Left circumflex artery(LCx.) & Right coronary artery(RCA). We also looked for any association (if any) between coronary calcium score and significant coronary artery stenosis. CT coronary calcium scoring was done for each patient and they were divided in two categories; patients having score > 400 and patients having score < 400. Presence or absence of significant coronary artery stenosis was determined in patients of both the categories. Association between the Coronary calcium score and significant coronary artery stenosis detected on Catheter coronary angiography will be determined by using chi square test. A P value < 0.05 will be considered significant. Data was expressed as percentage and mean +/- standard deviation. Linearity of data was checked by Kolmogorove Smirnov analysis. Sensitivity, specificity positive predictive value and negative predictive value was calculated using standard formulae. SPSS vs 17 for windows, IBM inc,Ny and Microsoft Excel 2007, Microsoft Pvt. Ltd. was used for statistical evaluation.

Observation

The 17-segment modified AHA classification[15] has the following segments:

- Right coronary artery (RCA): 1, proximal; 2, mid; 3, distal; 4, posterior descending; 16, posterolateral;
- Left main coronary artery (LM): 5
- Left anterior descending coronary artery (LAD); 6, proximal; 7, mid; 8, distal; 9, first diagonal; 10, second diagonal;
- Left circumflex coronary artery (Lcx): 11, proximal; 12, first marginal; 13, mid; 14, second marginal; 15, distal; and 17, intermediate branch.

The segments 4, 9, 10, 12, 14, 16, and 17 were excluded from analysis for their high variability in anatomy.

Table 1:

Coronary Artery Segment	Non Assessable by CTCAG (out of 75)	Sensitivity (in percent)	Specificity (in percent)	Positive Predictive Value (in percent)	Negative Predictive Value (in percent)	Accuracy (in percent)
1 Proximal RCA	2	92.90	100	100	98.4	98.67
2 Mid RCA	2	75.00	94.90	92.30	93.30	90.66
3 Distal RCA	7	85.70	86.80	75.00	98.30	86.70
6 Proximal LAD		97.00	95.20	94.10	97.60	96.00
7 Mid LAD		100	92.60	84.00	100	94.67
8 Distal LAD		75.00	85.90	75.00	98.40	58.00
11 Proximal LCx		80.00	98.50	88.90	97.00	96.00
13 Mid LCx		100	95.80	60	100	96
14 Second OM						
15 Distal LCx		100	87.30	66.70	100	88.00

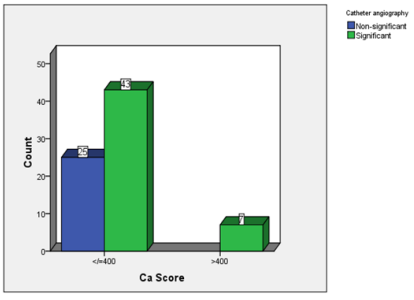
The total of 724 segments were analysed and compared. There was significant lesion correlation seen in 106 out of 117 significantly diseased segments (90.06%), while 11 out of 117 significant lesions were missed by CT coronary angiography (false negative).

Table 2: Comparison of CT angiography with Catheter angiography for diagnosis of significant stenosis in vessels assessed

Coronary Artery Vessel	Correlated with Catheter Angiography as significant lesion	Correlated with Catheter Angiography as Non -significant lesion	Sensitivity (in percent)	Specificity (in percent)	Positive Predictive Value (in percent)	Negative Predictive Value (in percent)	Accuracy (in percent)	Relationship with Catheter Angiography
RCA	48/50	25/25	92.60	100.00	100.00	96.00	97.33	<0.0001
LMCA	70/71	4/4	80.00	100.00	100.00	98.60	96.67	<0.0001
LAD	39/40	32/35	97.00	92.90	91.40	97.50	94.67	<0.0001
LCx	60/60	12/15	100.00	95.20	80.00	100.00	96.00	<0.0001
overall	217/221	73/79	94.80	97.30	92.40	98.20	96.60	

We evaluated total of 300 vessels out of which 77 (25.6% 77/300) had significant stenosis (true positive), of this 73 (94.8%) were correctly identified by the CT coronary angiography where as 4 (5.2%) lesions were missed and were labelled non-significant (false negative) on CT. Rest of the 223 (74.4% 256/300) lesions were non- significant (true negative) and 217(97.3%) of them were correctly detected on CT angiography and 6 (2.7%) were incorrectly detected as significant (false positive). Frequency of involvement of the four major vessels are as follows LAD 42.8% (33/77), RCA 35% (27/77), LCx 15.6% (12/77) and LMCA 6.5% (5/77). Overall vessel based **sensitivity, specificity, positive predictive value and negative predictive value of CT coronary angiography is 94.8%, 97.3%, 92.4%, 98.2% with diagnostic accuracy of 96.6%**. The overall individual accuracy for the LM, LAD, RCA, and LCX was 98.6%,94.6%, 97.3% and 96% respectively. LAD was most commonly vessel involved in our study population and LMCA was least commonly involved.

Table 3: Association of Catheter angiographic findings with calcium score



			Catheter angiography		Total	P value
			Non-significant	Significant		
Ca Score	<=400	Count	25	43	68	0.049
		% within Catheter angiography	100.0%	86.0%	90.7%	
	>400	Count	0	7	7	
		% within Catheter angiography	.0%	14.0%	9.3%	
Total		Count	25	50	75	
% within Catheter angiography			100.0%	100.0%	100.0%	

Association of Catheter angiographic findings with calcium score was analysed using Fischer's exact test. Significant association was found between these two variable with p value of 0.04.

Coronary calcium scoring was done in each individual using Agatston score and subjects were divided into two groups those having score of </= 400 and those having score of >400. There were 50 out of total of 75 subjects who were found to have significant coronary artery disease. Amongst these 50 patients, only 7 (14%) had a calcium score >400, while 43 (86%) had a calcium score <= 400, despite significant coronary artery disease. All the 25 subjects with non-significant coronary artery disease had a calcium score well below 400. Though, a calcium score of zero was seen in 29 subjects, only 9 (31%) And normal coronary angiogram, 4 (13.8%) had non-significant coronary artery disease and 16 (55%) had significant coronary artery disease.
Results

The CT coronary angiography could not analyse 11 segments in right coronary artery out of 75 in comparison to catheter angiography, suggesting certain blind spots exist over and above the segments at posterior descending and posterolateral arteries, first and second diagonal, first and second obtuse marginal arteries and ramus intermedius artery.

The segmental analysis suggests that the accuracy decreases from proximal to distal in each vessel. The accuracy for RCA from proximal to distal segments (proximal 98.67%, mid 90.66%, and distal 86.70%), for LAD (proximal 96.0%, mid 94.67%, and distal 58.0%) and LCx (proximal 96%%, mid 96.0%, and distal 88.0%)

The CT coronary angiography had 90.06% correlation for significant lesion for 724 segments as compared to conventional gold standard of catheter coronary angiography. Out of 300 vessels, 94.8% were true positive, 74.4% were true negative.

The CT coronary calcium scoring in the study revealed that 86% of cases with significant coronary artery lesion had a coronary calcium score of less than 400, suggesting inadequacy of reliability on insignificant or zero coronary calcium score to rule out significant coronary disease.

Conclusions

This study concludes that the 128 slice CT coronary angiography has made significant leap in detection of coronary artery disease and that there are still areas where it trails behind the conventional catheter angiography. Even the 128 slice CT coronary imaging has blind spots over and above the traditional ones. A guiding principle concluded from this study is that the accuracy decreases from proximal to distal in each vessel. An insignificant or zero coronary calcium score can not be relied to rule out significant coronary disease.

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