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Diagnostic accuracy of 64 slice ct coronary angiography for diagnosing significant coronary artery stenosis

Abstract

Objective: To determine the diagnostic accuracy of 64 slice CT angiography in the detection of significant coronary artery stenosis in patients suspected to have coronary artery disease keeping invasive conventional coronary angiography as gold standard.

Methods: The cross-sectional study was conducted at KRL Hospital, Islamabad and data was obtained during the period of six months from April 2014 to October 2014. All the patient of either gender from the age of 35 to 70years who had H/O angina and without any known CAD were included. CCTA and conventional invasive angiography (CIA) findings were recorded in every patient. Occlusion of >50% in coronary artery considered as positive angiography.

Results: Among 135 patients 82.2% (n=111) of patients were males and 17.8% n=(24) were females. 63.7% (n=86) of patients were CCTA positive and 65.9% (n=89) of patients had disease on CIA. Sensitivity, specificity, PPV, NPV and accuracy were found to be 91.1%, 89.1%, 94.2%, 83.7% and 90.4% respectively.

Conclusion: CCTA with improved spatial resolution and premedication with oral beta-blockade permits detection of coronary artery stenosis with high accuracy. Further large scale studies are needed in our setup to validate this technique in routine clinical practice.

Keywords: CCTA, coronary angiography, calcium scoring

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Introduction

Coronary artery disease (CAD) is one of the main causes of disability and death all over the world.[1] One in 4 middle-aged adults in Pakistan has prevalent CAD. The overall prevalence of CAD (95% CI) is 26.9% (22.3%-32.0%):23.7% (17.8%-30.9%) in men vs 30.0%(23.4-37.5%) in women (P=.12).[2] For several decades, conventional invasive angiography (CIA) has been considered as the well-established gold standard for making the diagnosis of CAD. CIA has a high diagnostic ability to determine the extent, location and severity of coronary obstructive lesions.[1] According to study by Jiangping et al.,[3] conventional coronary angiography has a sensitivity of 91% and specificity of 93 % for detecting coronary artery stenosis of greater than 50%.[3] However, CIA is not a good choice in some cases due to its invasive nature and the risk of complications, i.e. arrhythmia, myocardial infarction, stroke, access site problems. Finally, nearly one third of CIAs were reported to be normal, in many cases CIA is used for diagnostic evaluation only and is not followed by coronary revascularization. Furthermore, there are constraints on the number of CIA that can be undertaken, in terms of the cardiologist's time.[1] Therefore, this invasive procedure is not necessary for all patients. Consequently, these patients could benefit from a non-invasive approach to visualize the coronary arteries. Therefore, an accurate non-invasive alternate evaluation method for diagnosing CAD is highly desirable.[1]

Exercise testing, stress echocardiography and myocardial perfusion with single positron emission CT (SPECT) studies are all well-established non-invasive methods for the investigation of CAD. However, the sensitivity and specificity of these tests for significant CAD are less than ideal. Meta-analysis of the literature pertaining to these non-invasive methods quotes exercise testing as having a sensitivity and specificity of 68% and 77% respectively, stress echocardiography a sensitivity and specificity of 85% and 77% respectively, and myocardial perfusion a sensitivity and specificity of 87% and 64% respectively.[4]

Multi-slice computed tomography angiography (CTA) has been proposed in recent years as an alternative procedure for determining the presence of coronary obstructions. Improved diagnostic value has been seen with different upcoming generations of multi slice CT scanners.[5] With the emergence of subsequent technological improvements that have increased the spatial and temporal resolution of resulting imaging in multi slice CT, the use of invasive coronary angiography in the diagnosis of CAD has been challenged. It is anticipated that these developments will continue to translate into superior image quality and further improvements in the evaluation of CAD. The sensitivity for diagnosing significant coronary stenosis was 84% and the specificity was 91% by a study done by Gerber et al.[6] on multislice CT coronary angiography.[6]

CT coronary angiography is a new emerging non invasive technique for diagnosing significant stenosis in patients of coronary artery disease. This study aims to evaluate the accuracy of 64-row CTA in identifying significant CAD using invasive CCA as the gold standard and to determine if CT coronary angiography can completely

replace conventional invasive angiography for detecting significant stenosis.

Subjects and methods

The descriptive cross-sectional study was conducted from April to October 2014, at the Department of Radiology KRL Hospital, Islamabad, Pakistan after approval from the institutional ethical committee. Our study comprised patients of either gender with age between 35-70years who had H/O angina and without any known CAD. Sample size of 135 was calculated using World Health Organization sample size calculator with Sensitivity=84%,[6] Precision=10% Prevalence=27% Specificity=91%, p=27%[2] and Precision=8%.

All stable patients (age 35-70years) with suspicion of coronary artery disease having history of angina, stable vital signs with pulse rate less than 60bpm and BP less than 140/90mm Hg and no ST segment elevation on ECG included in the study. Patient who had history of previous bypass surgery or coronary artery stent placement, known allergic reaction to iodinated contrast agents, high baseline heart rate (>70bpm) with contraindication to beta blockade, abnormal renal function (serum creatinine level >1.5mg/dL) inability to hold breath for 15seconds, inability to lie flat and potential pregnancy were excluded. The stable patients presenting in the radiology department OPD of KRL Hospital for CT coronary angiography examination with clinical suspicion of coronary artery disease were included in the study. Informed Consent was taken from each patient. The patients' heart rates were assessed 1hour before scanning. Patients with a pre scan heart rate of higher than 60 beats/min received 50–100mg oral metoprolol 1hour before CCTA. All patients were scanned by Toshiba Aquilion- 64 Slice CT Scan System. The scanning parameters were: scan slice thickness 0.5mmx64, pitch and rotation time as determined by Cardio sure (the apparatus software). After calcium scanning, a bolus of 80-100ml nonionic iodinated contrast medium (Ultravist-300) according to 1ml/kg body weight was given through an antecubital vein by way of an 18-gaugecatheter using a power injector at a flow rate of 4–5ml/s followed by injection of 50–60ml of normal saline Cardiac CT was done by sure start technique with ROI placed on descending aorta at level of pulmonary trunk and trigger at 180HU.

All data sets acquired was reconstructed from the axial, coronal, and sagittal images using a retrospective electrocardiogram gating with the Toshiba Workstation. The data set was reconstructed at 75% of R-R intervals. In cases that motion artifacts resulted in low image quality, additional data sets were reconstructed between 25% and 85% of R-R interval to obtain optimal image quality. The reconstructed images were visually evaluated for estimation of coronary artery narrowing. Axial images, post processing volume-rendered 3D images, the maximum intensity projections, multi planar reconstructions, and linear conformation of the vessels was used to evaluate vessel stenosis. A significant lesion was defined as equal to or more than 50% reduction in lumen diameter. The judgment about the absence/presence of CAD was made after viewing the various images and checking stenosis of main coronary vessels, i.e. left main artery, left anterior descending, circumflex artery, first diagonal, second diagonal, obtuse marginal, right coronary artery and the posterior descending artery.

Routine CIA procedure was performed via the femoral or radial artery. All evaluated vessels were classified as normal vessels, having non-significant disease (luminal irregularities resulting in narrowing (<50%), or as having significant stenosis (luminal narrowing ≥50%). Accordingly, patients were classified as positive for the presence of significant CAD if there was a significant stenosis in any artery. Comparisons was then made between CCTA and CIA.

Results

Comparisons was then made between CCTA and CIA. 82.2% (n=111) of patients were males with the mean age of 53.52years±9.33SD and 17.8% n=(24) were females with mean age of 51.37years±8.65SD. Cumulative mean age was 53.14years±9.22 SD. Demographic results are shown in Table 1.

Results of CT angiography showed that there were 63.7%(n=86) of patients who were positive and 36.3% (n=49) were negative (Table 2). Coronary angiography results showed that 65.9%(n=89) of patients had disease (positives) in coronary arteries and 34.1%(n=46) had not disease in coronary arteries (negatives) as per criteria (Table 3).

Our study results showed that in overall study population 60%(n=81) were true positives, 30.4%(n=41) were true negatives, 3.7%(n=05) were false positives and 5.9%(n=08) were false negatives. For the validation purpose, we calculated five parameters; sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy for our study population. Our study results showed that sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 91.1%, 89.1%, 94.2%, 83.7% and 90.4% respectively. Results are shown in Table 4.

Table 1 Demographic profile of the study population

	Number (percentage)	Mean age±SD(years)
Male	111(82.2%)	53.52±9.33
Females	24(17.8%)	51.37±8.65
Total	135(100%)	53.14±9.22

Table 2 CCTA results

	Frequency	Percent	Valid percent	Cumulative Percent
Positive	86	63.7	63.7	63.7
Negative	49	36.3	36.3	100.0
Total	135	100.0	100.0	

Table 3 Coronary angiography results

	Frequency	Percent	Valid percent	Cumulative percent
Positive	89	65.9	65.9	65.9
Negative	46	34.1	34.1	100.0
Total	135	100.0	100.0	

Table 4 Cross-tabulation of CCTA and angiography results

	Coronary angiography		
CCTA	**Positive**	**Negative**	**Total**
Positive	81(True positives)	5(False positives)	86
Negative	8(False negatives)	41(True negatives)	49
Total	89	46	135

Discussion

Coronary computed tomography angiography (CCTA) has been proposed in recent years as an alternative procedure for determining the presence of coronary obstructions. Improved diagnostic value has been seen with the emergence of subsequent technological improvements that have increased the spatial and temporal resolution of resulting imaging in multi slice CT, the use of invasive coronary

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angiography in the diagnosis of CAD has been challenged. A reliable noninvasive imaging method for significant coronary artery stenosis would have enormous implications related to cost of diagnosis and enhanced patient safety. Main aim of the study was to determine the diagnostic accuracy of 64 slice CT angiography in the detection of significant coronary artery stenosis in patients suspected to have coronary artery disease keeping invasive conventional coronary angiography as gold standard. A total of 135patients of either gender with age between (age 35-70years) with suspicion of coronary artery disease having history of angina, stable vital signs with pulse rate less than 60bpm and BP less than 140/90mm Hg and no ST segment elevation on ECG presenting in radiology OPD for CT coronary angiography evaluation were included in the study. CCTA and CIA findings were recorded in every patient. Occlusion of >50% in coronary artery considered as positive angiography. 82.2% (n=111) of patients were males and 17.8% n=(24) were females. 63.7 %(n=86) of patients were CTA positive and 65.9% (n=89) of patients had disease on CIA. Sensitivity, specificity, PPV, NPV and accuracy were found to be 91.1%, 89.1%, 94.2%, 83.7% and 90.4% respectively.

Our results are similar with the already published data on the subject. Stein PD et al.[7] in their systematic review assessed the accuracy of 64-slice CT coronary angiography for the diagnosis of coronary artery disease. They identified all published trials in all languages that used 64-slice CT to diagnose coronary artery disease. Results of 64-slice CT coronary angiography were compared with invasive coronary angiography or intravascular ultrasound. They found that sensitivity of 64-slice CT for significant (>or=50%) stenosis, based on pooled data from all studies, was >or=90% in patient-based evaluations, named vessels, segments, and coronary artery bypass grafts, except the left circumflex (sensitivity 88%), distal segments (80%), and stents (88%). Specificity was 88% in patient-based evaluations, and>or=90% at individual sites. Positive predictive values for patient-based evaluations, left main coronary artery, and coronary artery bypass grafts ranged from 91% to 93%, but elsewhere ranged from 69% to 84%. Negative predictive values were 96% to 100%. Positive likelihood ratios for patient-based evaluations were 8.0 and, at specific sites, were>or=9.7. Negative likelihood ratios, except for distal segments, were <0.1. They concluded that negative 64-slice CT reliably excluded significant coronary disease. However, the data suggest that stenosis shown on 64-slice CT require confirmation. Combining the results of 64-slice CT with a pre-CT clinical probability assessment would strengthen the diagnosis. Due to the risk of radiation-induced cancer, patients should be selected carefully for this test, and scan protocols should be optimized to minimize risk.

Sheikh M et al.[8] in his prospective study aimed to assess the accuracy of 64-multidetector-row computed tomography coronary angiography (CTA) in the diagnosis of coronary artery disease (CAD). Ninety-two patients suspected of having CAD underwent CTA using a 64-slice CT scanner before a scheduled, conventional coronary angiogram (CCA). Blinded assessment of CTA to detect CAD was performed. The accuracy of CTA in detecting significant stenosis (>or=50%) was compared to CCA. Their results showed that for patient-based analysis, CTA had a sensitivity of 95%, a specificity of 96%, a positive predictive value of 98% and a negative predictive value of 90%. For the whole vessel, the sensitivity of CTA was 60-100%, for all vessels and the specificity was 82-100%. Pooled sensitivity was 92% and pooled specificity was 98%. For the segments, the sensitivity of CTA was 64% or above for all vessels except for the distal left anterior descending artery (40%), mid circumflex artery (50%) and posterior descending artery (60%); the pooled sensitivity was 79%. The specificity for the segments was 82-100% for all vessels and pooled specificity was 94%. They concluded that the sensitivity and specificity for patient-based analysis and for the main coronary vessels were high whereas for the segments, the sensitivity was moderately good, but the specificity was high, confirming that a negative CTA is useful to rule out significant CAD. They recommended for a coordinated classification system between radiologists and cardiologists is required to eliminate errors in segment classification.

Miller JM et al.[9] conducted a multicenter study to examine the accuracy of 64-row, 0.5-mm multidetector CT angiography as compared with conventional coronary angiography in patients with suspected coronary artery disease. Nine centers enrolled patients who underwent calcium scoring and multidetector CT angiography before conventional coronary angiography. In 291 patients with calcium scores of 600 or less, segments 1.5 mm or more in diameter were analyzed by means of CT and conventional angiography at independent core laboratories. Stenosis of 50% or more were considered obstructive. The area under the receiver-operating-characteristic curve (AUC) was used to evaluate diagnostic accuracy relative to that of conventional angiography and subsequent revascularization status, whereas disease severity was assessed with the use of the modified Duke Coronary Artery Disease Index. They found that a total of 56% of patients had obstructive coronary artery disease. The patient-based diagnostic accuracy of quantitative CT angiography for detecting or ruling out stenosis of 50% or more according to conventional angiography revealed an AUC of 0.93 (95% confidence interval [CI], 0.90 to 0.96), with a sensitivity of 85%(95% CI, 79 to 90), a specificity of 90% (95% CI, 83 to 94), a positive predictive value of 91%(95% CI, 86 to 95), and a negative predictive value of 83%(95% CI, 75 to 89). CT angiography was similar to conventional angiography in its ability to identify patients who subsequently underwent revascularization: the AUC was 0.84(95% CI, 0.79 to 0.88) for multidetector CT angiography and 0.82(95% CI, 0.77 to 0.86) for conventional angiography. A per-vessel analysis of 866 vessels yielded an AUC of 0.91(95% CI, 0.88 to 0.93). Disease severity ascertained by CT and conventional angiography was well correlated (r=0.81; 95% CI, 0.76 to 0.84). Two patients had important reactions to contrast medium after CT angiography. They concluded that Multidetector CT angiography accurately identifies the presence and severity of obstructive coronary artery disease and subsequent revascularization in symptomatic patients.

Tsang JC et al.[10] compared the diagnostic accuracy of coronary CTA between men and women without known CAD with the use of invasive coronary angiography (ICA) as the reference standard. They prospectively evaluated 230 (136men and 94women; mean±age, 57±10years) subjects with chest pain at 16 sites who were clinically referred for ICA. ICAs were evaluated for coronary stenosis according to quantitative coronary angiography. All Subjects underwent both CTA and ICA. For a patient-based model for stenosis >50%, sensitivity, specificity, positive and negative predictive values in men versus women were 96%, 78%, 69%, 100% and 90%, 88%, 47%, 99%, respectively. Subgroup analyses were performed for age and lifestyle risk factors. For stenosis >50% in patients <55years, specificity in men versus women was 88% versus 95%, whereas for patients >55years, specificity in men versus women was 68% versus 82% (P<0.05). they concluded that coronary CTA found comparable diagnostic accuracy for women in comparison with men for the

detection of obstructive coronary stenosis at both thresholds of 50% and 70%.

In summary, the introduction of the latest computed tomography (CT) technology allows comprehensive evaluation of various aspects of CAD, including the coronary calcium score, coronary artery stenosis, bypass patency, and myocardial function. Other applications, such as plaque characterization, first-pass perfusion imaging, and viability imaging using delayed contrast enhancement, are still under development and may demonstrate clinical utility in the future. Further improvements in CT hardware and imaging protocols are expected that may result in improved coronary artery imaging, new applications, and a significant reduction of radiation dose. Further large scale comparative studies with conventional criteria are needed in our setup for its validity and its application in clinical practice.

Conclusion

Coronary CTA with improved spatial resolution and premedication with oral beta-blockade permits detection of coronary artery stenosis with high accuracy. Our study results showed sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 91.1%, 89.1%, 94.2%, 83.7% and 90.4% respectively Further large scale studies are needed in our setup to validate this technique in routine clinical practice.

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Conflict of interest

There is no any conflict of interest to disclose.

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