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Original Research Article

Accuracy of 128-slice multi-detector computed tomography in the detection of stenosis at different cut-off values in corresponding target areas on conventional angiogram

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ABSTRACT

Background: Coronary artery disease (CAD) is a common medical condition. Over the years, assessment methods for CAD have evolved, with non-invasive techniques gaining prominence. Multi-detector computed tomography (MDCT) coronary angiography has emerged as an alternative to conventional invasive coronary angiography (ICA). This study aimed to evaluate the diagnostic accuracy of 128-slice MDCT in detecting stenosis at various thresholds and compare its efficacy with traditional coronary angiography.
Methods: This cross-sectional study was conducted at the radiology and imaging department of combined military hospital (CMH) in Dhaka from August 2021 to July 2022. Forty-three patients were selected through purposive sampling. Computed tomographic angiography was performed using a 128-slice MDCT scanner. Data analysis was conducted using SPSS, with statistical significance set at $p<0.05$. Sensitivity, specificity, diagnostic accuracy, negative predictive value (NPV), and positive predictive value (PPV) were calculated for each patient and segment. Sensitivity and specificity were assessed for stenosis exceeding 75% and 50%.
Result: For diagnosing stenosis less than 50%, the sensitivity, specificity, PPV, NPV, and accuracy were 83.9%, 95.6%, 61.0%, 98.6%, and 94.7%, respectively. For stenosis greater than 50%, they were 84.2%, 99.3%, 86.5%, 99.1%, and 98.5%. For stenosis exceeding 75%, the values were 100.0%, 99.9%, 97.0%, 100.0%, and 99.9%.
Conclusions: 128-slice CT provides a reliable non-invasive method to assess hemodynamically significant CAD with high diagnostic accuracy. The study findings suggest that at the artery level, MDCT demonstrates high level of accuracy in identifying significant obstructive CAD.

Keywords: MDCT, CAD, Coronary angiography, Stenosis

INTRODUCTION

Coronary artery disease (CAD) is a significant health risk. Prompt and accurate diagnosis is crucial, as it allows for early treatment, which can improve patient outcomes and potentially reduce healthcare costs.[1]

Non-invasive methods for assessing CAD are becoming more attractive as technology progresses rapidly. MDCT coronary angiography is gaining recognition as a viable alternative to conventional coronary angiography (CCA). MDCTA avoids the invasive method with quick image acquisition and reduced risk of complications.[2,3]

The diagnostic accuracy of MDCTA has improved with the advent of newer generations of scanners boasting enhanced temporal and spatial resolution.[4] Many studies have explored the precision of evolving generations of MDCTA across diverse patient groups, using CCA as the gold standard reference. Numerous systematic reviews and meta-analyses have compiled results from research utilizing earlier scanner iterations.[5-10] Patients experiencing recurrent ischemic symptoms following coronary artery bypass grafting (CABG) are at a higher risk of encountering stenosed or significantly narrowed grafts within five years post-surgery. Consequently, the assessment of structure of coronary artery, ventricular activity and disease condition plays a pivotal role in clinical decisions and efficient treatment plans.[10]

Selective coronary angiography has traditionally been the preferred method for evaluation vessel condition. However, this procedure carries risks, including arterial cannulation site trauma leading to pseudoaneurysm formation (1.2%), arrhythmia (1%), CVA (0.3%), MI (0.2%), artery dissection and nephropathy. These complications, along with the need for hospitalization in specialized cardiac units, limit the use of coronary angiography, especially for patients who are suspected of having graft-related issues.[11]

The advent of 128-slice CT represents a significant advancement in non-invasive angiography, offering improved capabilities in visualizing coronary arteries. Despite achieving noteworthy results in detecting high-grade coronary stenosis, this technology still has some limitations, including challenges with image clarity in the presence of calcifications or arrhythmias, and a need for advanced operator expertise. These factors can impact its reliability and restrict its application in certain clinical scenarios.[12,14]

Moreover, existing documentation highlights that motion artifacts in scans, primarily attributable to limited temporal resolution, can usually be mitigated only when patients maintain heart rates below 65 beats per minute.[13,15] This limitation may explain why most existing studies focus exclusively on detecting high-grade stenosis, leaving gaps in the assessment of lesser degrees of narrowing. As of now, no effort has been made to quantify stenosis using CT scans, even though accurately determining the severity of a lesion is crucial for clinical decision-making. The therapeutic approach for a 50% stenosis can differ markedly from that for a 90% stenosis. 128-slice CT, with its capacity of 128 slices per rotation and ability to cover entire heart volume in 8-9 seconds, holds considerable promise for elevating image quality. This advancement potentially allows for more accurate assessment of coronary stenosis. Objective of this study was to evaluate the diagnostic precision of a 128-slice CT scanner, characterized by an isotropic voxel resolution of 0.4×0.4×0.4 mm, in the identification and quantification of coronary artery atherosclerosis. This assessment involved comparing its efficacy of invasive angiography.

METHODS

The cross-sectional study was carried out at the department of radiology and imaging in CMH, Dhaka, from August 2021 to July 2022. Patients with suspected CAD, who perform their CCA were considered as the study population. A total of 43 patients were selected as study subjects as per inclusion and exclusion criteria. Patients who are indicated and completed their coronary angiogram of both sexes were over the age of 18 included. But the patients with CABG or stent implantation in the past, atrial fibrillation, sinus syndrome or AV block greater than 1st degree, systolic blood pressure below 100 mm of Hg, contraindicated for beta blockers, obstructive pulmonary disease and severe peripheral vascular disease, renal disease or other conditions that might increase the risk of contrast nephropathy, hypothyroidism (thyrotropin level <0.44 mIU/L), and allergy to iodine-containing contrast material were excluded. Purposive sampling technique was followed in this study.

The study protocol included the oral administration of 50 mg of metoprolol 60 min before the scheduled CT scan in patients with heart rates >70 beats/min. However, in the presence of contraindications for a beta blocker or an unsatisfactory lowering of the heart rate, the scan was performed even at higher heart rates. Computed tomographic angiography was performed by a 128-slice MDCT scanner (128-slice Siemens Somatom Sensation machine). A bolus of 1.2 ml/kg ml of 31 contrast agents (Topamiro 370 mg/ml, omnipaque 350 mg/m) will be injected intravenously (4.5 ml-6 ml/sec). When the signal in the ascending aorta reached a predefined threshold of 120-150 HU, the scan was started automatically and the entire volume of the heart was acquired during one breath hold in 6 to 10 seconds with simultaneous recording of the electrocardiographic trace. For the statistical analysis, one Microsoft Windows-based software product was used (SPSS 11.5 for Windows, SPPS Incorporation, Chicago, IL, USA). For all statistical tests, a significance level of $p<0.05$ 34 was considered a statistically significant result. Continuous variables were presented as mean±SD. Sensitivity, specificity, diagnostic accuracy, NPV, and PPV were calculated per patient and segment. Sensitivity and specificity were calculated for stenosis >75%, and stenosis >50%. After analysis, the data were presented in tables. Ethical clearance was obtained from the ethical committee of CMH, Dhaka. Informed written consent was taken from the participants.

RESULTS

The age of patients in the present study. Out of all patients, 25.6% were within the 30-45 years age group, 48.8% were within the 46-60 years age group and 25.6% were more than 60 years (Table 1).

Table 1: Age of the patients, (n=43).

Age (in years)	N	Percentages (%)
30-45	11	25.6
46-60	21	48.8
≥61	11	25.6
Mean age±SD=53.28±11.15		

Out of 43 patients 31(72.1%) were male and 12 (27.9%) were female (Table 2).

Table 2: Distribution of patients by gender, (n=43).

Gender	N	Percentages (%)
Male	31	72.1
Female	12	27.9
Total	43	100.0

After ICA evaluation 14.6% of arteries were non-detectable, 68.1% were normal, 7.7% had stenosis <50%, 5.2% had >50% and 4.4% had >75% (Table 3).

Table 3: Invasive coronary artery angiographic evaluation of coronary arteries, (n=43).

Coronary arteries	N	Percentages (%)
ND	107	14.6
Normal	498	68.1
<50%	56	7.7
>50%	38	5.2
>75%	32	4.4
Total	731	100.0

In terms of <50% stenosis sensitivity, specificity, PPV, NPV, and accuracy was 83.9%, 95.6%, 61.0%, 98.6%, and 94.7% respectively (Table 4).

Table 4: Accuracy of 128-slice MDCT in the detection of stenosis <50% in corresponding target areas on the conventional angiogram, (n=43).

Evaluation	Percentages (%)	95% CI
Sensitivity	83.9	73.9-90.9
Specificity	95.6	94.7-96.1
PPV	61.0	53.8-66.1
NPV	98.6	97.8-99.2
Accuracy	94.7	93.1-95.7

Concerning >50% stenosis sensitivity, specificity, PPV, NPV, and accuracy were 84.2%, 99.3%, 86.5%, 99.1%, and 98.5% respectively (Table 5).

Table 5: Accuracy of 128-slice MDCT in the detection of stenosis >50% in corresponding target areas on the conventional angiogram, (n=43).

Evaluation	Percentages (%)	95% CI
Sensitivity	84.2	73.9-90.4
Specificity	99.3	98.7-99.4
PPV	86.5	75.9-92.9
NPV	99.1	98.6-99.5
Accuracy	98.5	97.4-99.1

In the case of >75% stenosis sensitivity, specificity, PPV, NPV, and accuracy were 100.0%, 99.9%, 97.0%, 100.0%, and 99.9% respectively (Table 6).

Table 6: Accuracy of 128-slice MDCT in the detection of stenosis >75% in corresponding target areas on the conventional angiogram, (n=43).

Evaluation	Percentage (%)	95% CI
Sensitivity	100.0	93.2-100.0
Specificity	99.9	99.5-99.9
PPV	97.0	90.4-97.0
NPV	100.0	99.7-100.0
Accuracy	99.9	99.3-99.9

DISCUSSION

In this study, the mean age of the patients was 53.28 years, with 72.1% being male and 27.9% female. To manage heart rates before the CT scan, 50 mg of oral metoprolol was given 60 minutes prior to the procedure for patients with heart rates within 60-70 beats per minute, while a higher dose of 100 mg was used for those with heart rates exceeding 70. To gain broader acceptance as a clinical tool for assessing suspected coronary artery stenosis, CT coronary angiography must comprehensively visualize all coronary arteries significant for treatment planning, ensuring that no segments are omitted from analysis.[13]

Our research indicates that, compared to ICA, MDCT demonstrates a high level of discriminative power in detecting coronary artery stenosis. Specifically, the study showed that 68.1% of coronary arteries were normal, while 17.3% exhibited stenosis at varying levels, including 7.7% with stenosis less than 50%, 5.2% with stenosis greater than 50%, and 4.4% with stenosis exceeding 75%. MDCT's accuracy extends to identifying coronary artery stenosis based on commonly accepted thresholds: less than 50%, greater than 50%, and 75% lumen patency. For stenosis less than 50%, MDCT showed a sensitivity of 83.9%, a specificity of 95.6%, a PPV of 61.0%, an NPV of 98.6%, and an accuracy of 94.7%. When evaluating stenosis greater than 50%, the sensitivity was 84.2%, the specificity 99.3%, the PPV 86.5%, the NPV 99.1%, and the accuracy 98.5%. For stenosis exceeding 75%, the sensitivity was 100%, the specificity 99.9%, the PPV 97.0%, the NPV 100%, and the accuracy 99.9%. An abnormal 128-slice CT angiography (CTA) serves as a predictor of coronary stenosis at less than 50% (positive predictive value, or PPV, of 70.0%) and as a strong predictor at greater than 50% (PPV of 88.6%) and 75% (PPV of 83.8%). With such predictive capabilities, patients diagnosed with obstructive CAD by CT angiograms might not require further evaluation, thereby potentially reducing the need for invasive procedures.[18,19]

Although current CTA technologies are limited in temporal resolution, impacting their capability to accommodate normal heart rates at rest, this limitation can be alleviated through heart rate reduction strategies. The use of beta-blockers, which increase diastole and extend phases of low cardiac and coronary motion, can aid in facilitating imaging without artifact, effectively addressing this limitation.[18,19] Two main strategies have surfaced to enhance the temporal resolution of CT scans. The first strategy involves adjusting the gantry's rotation speed, where reconstructing a single CT frame requires a 180-degree gantry rotation, and therefore, temporal resolution improves as gantry rotation times are reduced.[20] The second strategy, as illustrated in our study, involves compressing the reconstruction window within a single heart cycle by segmenting the acquisition of image data across multiple heartbeats. This adaptive multicycle reconstruction approach combines data from consecutive cardiac cycles to achieve an average temporal resolution of approximately 140 milliseconds.[19,21]

Motion artifacts continue to pose a significant limitation for accurately assessing coronary segments. Recent studies have highlighted this issue, particularly affecting the reliability of CT coronary angiography in visualizing all coronary segments.[22,23] To address motion artifacts, this study administered 50 mg of oral metoprolol to patients with pulse rates of 60-70 beats per minute and 100 mg to those with heart rates above 70, one hour before the CT scan. By selecting various reconstruction intervals relative to the cardiac cycle, it became feasible to diminish motion artifacts in the majority of affected vessels. This was achieved by individually choosing the phase with minimal vessel motion for each segment. Despite the challenge of motion artifacts and their association with decreased image quality at higher heart rates, our study found that careful administration of beta-blockers and selection of appropriate reconstruction intervals allowed for effective artifact reduction. Consequently, no significant coronary lesions were missed due to severe cardiac motion.

Limitations

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community. Furthermore, we did not conduct quantitative coronary angiography, and stenoses were assessed semi-quantitatively using both ICA and MDCT. Currently, we utilize 128-slice MDCT, which has been found to result in an effective radiation dose ranging from 6 to 13 mSv. This exceeds the radiation exposure of a conventional coronary angiogram, which typically ranges from 3 to 5 mSv without a left ventriculogram. To mitigate radiation exposure effectively, we employ prospective ECG tube current modulation. The method requires the injection of an iodinated contrast agent

CONCLUSION

With 128-slice CT technology, a non-invasive evaluation of hemodynamically significant CAD is achievable with high diagnostic accuracy. Our findings indicate that MDCT demonstrates reasonably high accuracy in detecting significant obstructive CAD when evaluated at the artery level.

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