Evaluating the Accuracy of 128-Section Multi-Detector Computed Tomography (MDCT) in Detecting Coronary Artery Stenosis

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ABSTRACT

Catheter-Based Coronary Angiography (CCA) and computed tomography coronary angiography (CTCA) are both used in the diagnosis of coronary artery disease (CAD). The current study aims to evaluate the accuracy of CTCA compared to CCA as a gold standard to find an alternative method to CCA in diagnosing CAD. 65 patients with suspected coronary heart disease underwent CCA and CTCA procedures using 128-section computed tomography (MDCT). The CT images were analyzed by three consultant radiologists with more than 10 years of experience. CCA and CTCA reports were compared, and sensitivity, specificity, positive expected value (PPV) and negative expected value (NPV) were analyzed. These values were found for the 'per artery' and 'per patient' criteria. The results showed that the sensitivity, specificity of PPV, and NPV for accuracy measures of 'per patient' analyzes were 96.8%, 97%, 96.8%, and 97%, respectively. For left main coronary artery (LM), left anterior Descending (LAD), Circumflex artery (CX), and Right Coronary Artery (RCA), the results were 100%, 98.40%, 75%, 100%, 90.6%, 97%, 96.6 %, 91.4% and 61.1%, 100%, 100%, 87% and 73.70%, 97.8%, 93.3%, 90%, respectively with p<.001. The study concluded that it is possible to use MDCT as an alternative part of CCA, which can be used to reduce CCA pain, procedure time, and at a lower cost.

CCS CONCEPTS

• **CCA**; • **MDCT**; • **CAD**;

KEYWORDS

Sensitivity, Specificity, CTCA

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1 INTRODUCTION

Cardiac imaging refers to the imaging of the heart using Medical Imaging modalities including: echocardiography, magnetic resonance imaging (MRI), computed tomography (CT), or nuclear medicine (NM) imaging with PET or SPECT. These modalities explained in the theoretical work of [1] and to the applied accomplishments of [2]. Both showed that it is possible to reconstruct a suitably regular real valued function f from the set of all projections for angles of projections. Then, the success of CT motivated researchers for different reconstruction methods to serve other medical imaging modalities such as Emission CT, Ultrasonography, CT, Magnetic Resonance, and others [3]. This Technology is applied not only in medicine, but recent success in many other fields, such as Seismology, Geophysics, Digital Rock Physics, and others [4-5]. In addition, image registration techniques utilize the Radon transform and other transforms. Moreover, The theory of image and projection moments is a powerful tool for pattern recognition and image analysis,[6-12].

Cardiac Imaging is the challenge of 21st century, this is due to the fact that coronary heart diseases may lead to ischemic heart disease, and also it may cause luminal stenosis [13]. For a very long time catheter angiography has been the highest quality level of coronary angiography. However, it may cause risks for patients with coagulation disorders and expanded vessel delicacy and it is contraindicated in a few patients . Thus, there was a need to find a protected and reliable imaging methodology for assessing coronary artery supply routes as timing of contrast media was critical in such procedures. [14–16].

Accordingly, MDCT has been used in aiding the analysis of coronary artery disease, therefore there is a need to evaluate to what extent MDCT can replace CCA for patients with coagulation disorder and vasodilatation. This can be done by evaluating the accuracy of 128 slices MDCT against CCA as suggested in this paper.

Images in MDCT can be obtained by either sequential or helical imaging. In sequential imaging, the ECG tracing begins the CT scan after a specified period of time after the R wave. During helical imaging, the CT and EKG data are captured together at the same time. After CT images are acquired, motion artifacts are reduced to improve image quality even for patients with tachycardia [17, 18] .

Cardiac MDCT imaging can be performed using 32-slice MDCT, 64-slice MDCT, 128-slice MDCT, and 256-slice MDCT [19-20]. Several studies have compared these methods. For example, in [19] the authors agreed that the 256-slice MDCT is more accurate and has a shorter scanning time than the 64-slice MDCT. On the other hand, in [21], the authors evaluated 128-slice MDCT and concluded that it is a good method for detecting coronary artery abnormalities,

and also revealed that it is a good method for patients who avoid invasive angiography such as patients with equivocal stress test results [22].

This paper focuses on evaluating the accuracy of 128-slice MDCT compared with CCA for Palestinian patients in order to improve diagnostic performance in detecting obstructive coronary artery disease. The main objectives of our work are summarized as follows:

- Conducting a literature review related to 128-MDCT and CCA in CAD detection.
- Evaluating the accuracy of 128-section MDCT in CAD detection for patients with compliant of chest pain and suspected artery stenosis using sensitivity, specificity, PPV and NPV measures.
- Investigate to what extent 128-section MDCT could replace CCA in CAD detection.

2 METHODS AND DETAIKED STEPS

2.1 Data collection

65 patients suspected of having coronary heart disease had the following symptoms (chest pain, abnormal stress test, multiple cardiovascular risk factors including diabetes (DM). These patients presented to Istishari Arab Hospital a medium-sized private hospital between In 2017 and 2022 due to suspected coronary heart disease. Ethical approval was obtained from the Research Ethics Committee of Al-Quds University for the required data.

65 participants (55 males and 10 females) were evaluated. The average age is 56.2 years. The youngest patient was 27 years old and the oldest was 82 years old.

A 128-slice Philips single source Ingenuity computed tomography device was used in this study. The scanning parameters are shown in Table 1. Dose modulation was attained with electrocardiographic gating for a maximum gantry delivery between 40% and 80% during the R-R interval. A bolus of 70-80 ml of contrast madia (Omnipaque™ (iohexol) 350 mg/ml) was administered intravenously at 5 ml/sec, followed by 20 ml of saline injected at the same infusion rate. The scan was initiated according to the bolus-tracking technique. Image data sets were analyzed using multi-planar reconstruction on retro-processing workstations (CardioQ3 package, Advantage Workstation version 4.2, GE Healthcare, Milwaukee, WI). A calcium score was performed using the Agatston-Janowitz method in all cases. Oral/ intravenous Beta-blockers were used wherever required. After the scan, the system generates the best systolic, diastolic, and 0 to 100% of the cardiac cycle for ejection fraction. This data was transferred to the Syngovia workstation for Post Processing.

Regarding the devices used for creating CCA, two devices are used: Philips Allura Centron and Philips Allura Clarity.

Table 1: Protocol parameters in the hospital

Protocol parameter	Value
Scan mode	Helical
Thickness	0.8 mm
kVp	120
Gap	0.4
mAs	55
Rotation time	0.4 second
Does modulation	On
Collimation	Auto
Pitch	0.200
DLP	56.2mGy*cm
CTDIvol	3.7mGy

2.2 Data Analysis

All 128-slice MDCT images were analyzed by four consultant radiologists with more than 10 years of experience and blinded to the results of the CCA examination.

All participants underwent CCA testing according to normal and standard techniques. The images were evaluated by experienced cardiologists who blinded to 128-MDCT images.

Simple descriptive statistics such as number, maximum, minimum, percentages and means were used to provide a summary about the study population. Statistical analysis was performed using Microsoft Excel ad SPSS software packages.

In addition, the CCA was used as the standard reference (the gold standard) to assess the diagnostic accuracy of 128 MDCT slides based on four statistical measures were calculated using SPSS version 28.0.1.1.including sensitivity, specificity, NPV and PPV.

Diagnostic performance was assessed on a per-patient and per-artery basis. For the analysis of per-patient, a true positive was defined as a single positive result (>=50% stenosis of the lumen diameter) on both the CTCA report and the CCA report regardless of site.

For per-artery analysis, results were classified as normal or abnormal for each of the following: left main coronary artery (LM), Circumflex artery (CX), left anterior descending artery (LAD), and right coronary artery (RCA). True positivity is defined as an 'abnormal' result on both the CTCA report and the CCA report.

In order to measure the accuracy of the 128-slice MDCT, the statistical measures shown in Table 2 including "Sensitivity", "Specificity", "PPV" and "NPV" are used in data analyzing in order to extract the calculations and final statistical results.

3 RESULTS

A total of 65 patients including (55 males and 10 females) were considered in the study. The youngest patient was 27 years old and the oldest was 82 years old. The mean age of the study population was 56.2 years.

Many patients (15/65 = 23%) had a score of zero calcium. Twelve patients had a calcium score of over 400 with the highest value being 2983. The mean coronary artery calcium score on CT was 345.1 Agatston units.

3.1 Evaluating the accuracy of 128-section MDCT in significant CAD detection

Accuracy measures for the detection of significant CAD disease was evaluated on per-patient analysis and on per-artery analysis as detailed below.

Table 2: Sensitivity, specificity, PPV and NPV

	Disease	
	Yes	No
Positive test result in the image	True Positive (TP)	False Positive (FP)
Negative test result in the image	False Negative (FN)	True Negative (TN)
Sensitivity=TP/(TP+FN)		
Specificity=TN/(TN+FP)		
Positive Predicted Value(PPV)=TP/(TP+FP)		
Negative Predicted Value(NPV)=TN/(FN+TN)		

Table 3: Accurecy measures for patient-based analysis

Accuracy measure	Value
Sensitivity	96.8%
Specificity	97%
PPV	96.8%
NPV	97%

3.1.1 Accuracy measures for per-patient analysis. Table 3 shows the accuracy measures for for per-patient analysis ; In 31 patients, 128-MDCT correctly identified the presence of CAD (true positive), and the 128-MDCT correctly identified the absence of CAD in 32 patients (true negative). However, 128 MDCT result revealed no CAD in one patient, while in fact according to CCA result he had CAD (false negative). Moreover, the MDCT 128 result revealed the presence of CAD in one patient, while in fact according to the CCA result; He did not have CAD (false positive).

Accordingly, the sensitivity value was 96.8% (31 / (31 + 1)), specificity was 97% (32 / (32 + 1)), and the positive predictive value (PPV) was 96.8% (31 / (31 + 1)) and The negative predictive value (NPV) was 97% (32 / (32 + 1)).

One popular limitation of CTCA is heavy calcification of vessel walls leading to overestimation of the stenosis degree in the lesion due to calcium blooming and blurring of the vessel lume . This may be the main reason for false negative or false positive in some cases, in addition to the low quality or obesity of the produced CT images.

However, in most patients CT correctly identified the absence or existence of CAD disease in comparison to CCA.

3.1.2 Accuracy measures for artery-based analysis. This section describes in details accuracy measures for the Left Main Coronary Artery (LM), Left Anterior Descending (LAD), Circumflex artery (CX), Right Coronary Artery (RCA).

As shown in Table 4, 128-section MDCT for LM had an overall sensitivity of 100%, specificity of 98.4%, a positive predictive value of 75% and a negative predictive value of 100% with CCA as the gold standard. The high sensitivity value indicates that the 128-slice MDCT was able to correctly identify individuals with disease in LM, that is, true positives. Low specification and positive predictive value indicate that the 128-slice MDCT was less able to correctly identify individuals without disease in LM, i.e., true negative.

Regarding Left Anterior Descending (LAD) Coronary Artery, it has high specificity and positive predictive values (97%, 96.6) respectively. 97% Specificity means that 128-section MDCT was capable to give negative test results for 32 people of 33 people who don't have the disease in LAD. While the result of measuring PPV means that all people who have positive test results truly had the disease in LAD with 96.6% probability. Sensitivity and NPV measures are nearly the same. As shown in table 4.2, 90.6% of patients got positive test results and they truly had CAD disease in LAD. While 91.4% of patients got negative test results and they truly had not the CAD disease in LAD.

As for CX Coronary Artery, it has high specificity and positive predictive values (100%), which mean that 128-section MDCT was capable to give negative test results for all people who don't have the disease in CX. Sensitivity and NPV measures are 61.1%, 87% respectively. Sensitivity result means that more than half of patients got positive test results and they truly had CAD disease in CX according to the gold standard (angiography). While NPV means that 87% of people got negative test results and they truly had no CAD disease in CX.

As shown in Table 4, the highest accuracy measures in Right Coronary Artery are specificity and positive predictive values. 97.8% Specificity means that 128-section MDCT was capable to give negative test results for most patients who don't have the disease in RCA. While the result of measuring PPV means that the majority of patients (93.3%) who have positive test results truly had the disease in RCA.

Table 4: Accurecy measures for artery-based analysis

ArteryMeasure	LM	LAD	CX	RCA
Sensitivity	100%	90.6%	61.1%	73.70%
Specificity	98.40%	97%	100%	97.8%
PPV	75%	96.6%	100%	93.3%
NPV	100%	91.4%	87%	90%

Table 5: Comparing accuracy measures among different researches

Research	Study population size	Sensitivity	Specificity	PPV	NPV
Narumol Chaosuwannakit , Songsak Kiatchoosakun [55]	42	100%	93%	87%	100%
Madhok, R., & Aggarwal, A. [56]	40	95.26%	95.12%	88.46%	98.08%
This research	65	96.8%	97%	96.8%	97%

Based on the above-mentioned results, researchers concluded that 128-slice MDCT is best suitable for detecting the existence (True positives) of CAD disease in LM. While it is best used for identifying people who don't have the disease in CX.

To what extent can 128-section MDCT replace CCA in CAD detection?

In this research, we found that the sensitivity, specificity, positive predictive, and negative predictive values in per-patient analysis are 96.8%, 97%, 96.8% and 97% respectively. These results demonstrate the excellent accuracy of 128 MDCT in CAD detection. Only one patient out of 65 people with CAD was missed because of poor opacification or motion blur. Other reasons may produce false negative results such as tortuous course; the patient had a small vessel size.

The high overall accuracy measures represented by sensitivity, specificity, PPV, and NPV means that the 128-section MDCT can replace invasive CCA for patients who cannot afford invasive procedures or have coagulation disorders and dilated vessels. However, it will not replace the CCA as a reference tool but can be considered as a reliable alternative.

3.2 Comparing study results with previous studies

This research used a larger study population size than other studies as shown in Table 4.3, which provides a smaller margin of error and increases validity.

Accuracy measures for per-patient are shown in Table 5. Accuracy measures in each are clearly high. High sensitivity and specificity values (>90%) indicate the excellent ability of CTCA by 128 MDCT to detect true positivity (patients had positive test results and already had CAD) and true negative (patients had negative test results and did not actually had any disease).

The PPV in this research (96.8%) was higher than in others (87%, 88.46%). This means that all participants with positive test results in this study actually had the disease, with a probability of 96.8%.

4 CONCLUSION

This paper significantly evaluated the accuracy of the 128-section MDCT in detecting CAD compared to CCA. In order to achieve this goal, a comprehensive review of the literature on MDCT 128 and CCA was conducted. To assess the accuracy of the 128-section MDCT in CAD detection, data were collected include CCA and CTCA from 128-section MDCT reports of 65 patients with suspected CAD. The collected data were analyzed on per-patient base and per-artery base and compared. CCA reports were used as the gold standard to determine whether or not patients had CAD. A spreadsheet summarizing all results was created using Excel and SPSS in order to summarize the results and perform statistical calculations including sensitivity, specificity, PPV and NPV.

The results of per-patient analysis showed that 128-slice MDCT was excellent in detecting the existence of CAD. The study showed high overall accuracy measures represented by sensitivity 96.8%, specificity 97%, PPV 96.8%, and NPV 97% which mean that 128-section MDCT could replace invasive CCA particularly for patients who can't undergo surgeries or have coagulation disorders, and expanded vessel.

In addition, based on per-artery based analysis, the study concluded that 128-slice MDCT is best suitable for detecting the existence (True positives) of CAD disease in LM. While it is best used for identifying patients who don't have the disease in CX (True negatives).

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