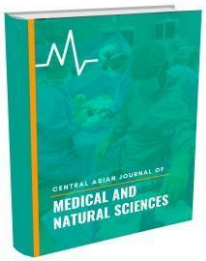

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Article

Multi-Detector CT Coronary Angiography Accuracy in the Evaluation of Significant Coronary Arteries Stenosis versus Invasive Coronary Angiography Procedures.

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Abstract: Background: - Invasive coronary angiography (ICA) is the recognized gold standard for evaluating stenosis in the coronary arteries due to its unparalleled temporal and spatial resolution and the capacity to carry out therapeutic interventions in the same session. The search for a non-invasive alternative has been fueled by the patient's inconvenience and financial concerns, even though the risk of major complications is low. All the patients prepared by assessment of renal function test with aid of nephrourologists as a preliminary test to avoid nephrotoxicity of contrast dye and exclude those with azotemia or impaired renal function. The evaluation of coronary artery disease (CAD) using current multi-detectors computed tomography (MSCT) scanners shows promise; however, some segments cannot be evaluated because of motion artifacts or significant calcification of the arterial wall.

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1. Introduction

Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide, necessitating accurate diagnostic tools for early detection and management. Invasive coronary angiography (ICA) has long been considered the gold standard for evaluating coronary artery stenosis due to its high diagnostic accuracy. However, ICA is an invasive procedure that carries risks, including vascular complications, bleeding, and patient discomfort.

Recent advancements in imaging technology have introduced Multi-Detector CT Coronary Angiography (MDCT-CA) as a promising non-invasive alternative for assessing significant coronary artery stenosis. MDCT-CA provides high-resolution images of coronary arteries, allowing for detailed evaluation of plaque burden and lumen narrowing. With reduced risks and improved patient compliance, MDCT-CA has gained widespread attention in clinical practice.

This study aims to compare the diagnostic accuracy of MDCT-CA with ICA in detecting significant coronary artery stenosis. By evaluating the sensitivity, specificity, and predictive value of MDCT-CA, this research seeks to establish its reliability as a non-invasive imaging modality and its potential to reduce the reliance on invasive procedures in CAD diagnosis and management.

2. Materials and Methods

Retrospective cross-sectional study all the case sheets of the patients who were under went MDCTA and ICA at (MDCTA of radiology department and ICA unit of Iraqi center for cardiac diseases in Ghazi –AL-Hariri Hospital for surgical specialization in Medical city / Baghdad-Iraq) during the period from 1st April 2022 - 1st April 2023 was reviewed. A total of 44 out of 180 case sheets of patients who did MDCT and ICA were randomly selected. All the patients prepared by assessment of renal function test with aid of nephrourologists as a preliminary test to avoid nephrotoxicity of contrast dye and exclude those with azotemia or impaired renal function.

The 64-slice multi-detector CT was performed using a number of scanning factors: 64-channel detectors through the z-axis, electrocardiogram-triggered x-ray tube adjustment, a scanning field of view [25 cm], a gantry -rotation about [0.35 seconds] per-rotation, a matrix-size around [512×512], an average slice-width of [0.625 mm], and lastly a helical pitch about (0.16). A single oral dose of (25 to 50 mg) metoprolol tartrate was administrated [one hour] prior to CT-scan angiography study if the patient HR was [> 65] b/min. Patients were fasted, positioned in supine posture, then given [1.25 - 2.5mg] sub-lingual vasodilators like nitrates derivatives as they were without symptoms prior to scanning. After two localization scans, a low-dose native scan of the heart was performed to identify and score coronary calcium. An {18-gauge catheter} was used to inject bolus dose [80cc] iodixanol into an antecubital vein at a rate of flow about 4 cc/sec, then 50 cc of normal saline after the bolus dose of contrast. Significant coronary artery disease was defined as arteries with (50 percent) luminal diameter loss when bolus monitoring was conducted with a region of interest (ROI) applied into the ascending thoracic aorta. Segments were categorized according to the degree of more affected segment when a section has numerous lesions.

Coronary artery calcium scoring was performed using gated non-contract images acquired prior to CT angiography using the "Agatston method" An ECG triggered, shoot acquisition mode / sequential step was used to detect and quantify calcium, using tube voltages (120kv) tube current (430mA) with slice thickness (2.5mm).

3. Results

The result of current study demonstrated that the chronic stable angina is the first indication for imaging by multi-detectors CT which represent (29.5%) of cases followed by More than one indication (22.7%) and pre-operative assessment represented the lowest percentage (11.4%) of cases as seen in table.1.

Table.1 patients' distribution by multidetector CT scan coronary arteries angiography indication

	No.	%
Chronic stable angina	13	29.5
More than one indication	10	22.7
Prior GABAG	9	20.5
TMT results	7	15.9
Preoperative assessment	5	11.4
Total	44	100.0

Table.2 finding of arterial stenosis (≥50%) by MDCT and ICA for LMT artery

			LMT(ICA)		
			Positive	Negative	Total
LMT (MDCT)	Positive	Count	15	2	17
		% within LMT(ICA)	71.4%	8.7%	38.6%
	Negative	Count	6	21	27
		% within LMT(ICA)	28.6%	91.3%	61.4%
Total		Count	21	23	44
		% within LMT(ICA)	100.0%	100.0%	100.0%

Sensitivity=71.4%, specificity=91.3%, PPV=88.2%, NPV=77.7% and accuracy=81.8%

The results showed that the sensitivity of MDCT for LAD vessel was 80%, i.e. the ability of the test to detect 80% of individuals have stenotic lesion appropriately, whilst the specificity about (44.4%) which means MDCT can evaluate 44.4% of individuals who are free of the disease correctly. The positive predictive value was (84.8%) that means 84.8% of individuals with +ve MDCT are more vulnerable to develop stenotic coronary artery diseases, whilst the negative predicative value was (36.3%), that means about 36.3% of patients with -ve findings are more liable to be free of disease. calculated accuracy of the test was 72.7% as seen in table 3 .

Table 3 Finding of arterial stenosis (≥50%) by MDCT and ICA for LAD artery

			LAD(ICA)		
			Positive	Negative	Total
LAD(MDCT)	Positive	Count	28	5	33
		% within LAD(ICA)	80.0%	55.6%	75.0%
	Negative	Count	7	4	11
		% within LAD(ICA)	20.0%	44.4%	25.0%
Total		Count	35	9	44
		% within LAD(ICA)	100.0%	100.0%	100.0%

Sensitivity=80%, specificity=44.4%, PPV=84.8%, NPV=36.3% and accuracy=72.7%

The finding revealed that the sensitivity of MDCT for LCX vessel was 57.1%, i.e. The test properly detected 57.1% of diseased individuals, but its specificity was 86.7, implying that the MDCT correctly detected 86.7% of disease free individuals. Positive predictive value was (66.6%), indicating that 66.6% of patients with +ve MDCT results are liable to develop stenotic coronary artery diseases, whereas negative predictive value about (81.2%), indicating that 81.2% of those with -ve findings are further liable to be disease-free. calculated accuracy of the test was 77.2% as seen in table 4 .

Table 4 Finding of arterial stenosis (≥50%) by MDCT and ICA for LCX artery

			LCX(CIA)		
			Positive	Negative	Total
LCX(MDCT)	Positive	Count	8	4	12
		% within LCX(ICA)	57.1%	13.3%	27.3%
	Negative	Count	6	26	32
		% within LCX(ICA)	42.9%	86.7%	72.7%

Total	Count	14	30	44
	% within LCX(ICA)	100.0%	100.0%	100.0%

Of current study demonstrated that the sensitivity of MDCT for RCA vessel was 75.9%, i.e. the ability of the test to diagnose 75.9% of the patients properly, whereas the specificity about 60% that mean the MDCT can detect 60% of individuals who are disease free properly. The positive predictive value (78.5%) means 78.5% of patient with +ve MDCT are liable to have stenotic coronary artery diseases; whilst negative predicative value about (56.2%), means that 56.2% of individuals with -ve findings are more liable to be free of disease . calculated accuracy of the test was 47.7% as seen in table 8.

Table.8 finding of arterial stenosis (≥50%) by MDCT and ICA for RCA artery

			RCA(ICA)		
			Positive	Negative	Total
RCA(MDCT)	Positive	Count	22	6	28
		% within RCA(ICA)	75.9%	40.0%	63.6%
	Negative	Count	7	9	16
		% within RCA(ICA)	24.1%	60.0%	36.4%
Total		Count	29	15	44
		% within RCA(ICA)	100.0%	100.0%	100.0%

Sensitivity=75.9%, specificity=60%, PPV=78.5%, NPV=56.2% and accuracy=47.7%

The mean value of sensitivity, specificity, PPV, NPV and accuracy which obtained from the findings of all primary vessels was 71.1, 71.0, 79.5,62 and 69.8% respectively as seen in table 5.

Table 5 sensitivity, specificity and accuracy by multi-detector CT for primary vessels.

Parameter	Sensitivity	Specificity	PPV	NPV	Likelihood ratio	Accuracy
LMT	71.4	91.3	88.2%	77.7%	9	81.8%
LAD	80	44.4	84.8%	36.3	2	72.7%
LCX	75.1	88.7	66.6%	81.2	8	77.2%
RCA	75.9	60	78.5%	56.2	5	47.7%
Mean from all vessels	71.1	71.0	79.5%	62.%	6	69.8%

4. Discussion

Because the cardiovascular related diseases are the leading cause of mortality, the necessity to accurate detection and cost-effective care of coronary artery disease is becoming increasingly important. Although coronary angiography is the gold standard for detecting coronary artery disease, it has significant drawbacks, including invasiveness, cost, complications risk, and the requirement special facility as well as skilled-operator in response to these constraints, multiple non-invasive approaches have been developed and

are now available. Functional and anatomical imaging is two types of imaging. Anatomical imaging allows direct sight of the coronary artery tree, whereas functional imaging analyses hemodynamic changes. These tests are useful for identifying regions of ischemia and predicting myocardium reversibility, but they come with considerable dangers due to the use of pharmacologic stress producing perfusion abnormalities. Furthermore, direct viewing of the coronary arteries is not possible. (9) A 64-multi-detectors CT imaging makes a significant improvement in accuracy of diagnosis, so the recent generation of 64-multi-detectors CT-scan machine allowing more rapid contrast media injection and decrease iodinated-contrast media dosage needed; in addition they decreasing the amount of artifacts due to improper breath-holding and cardiac rate changes. Individual meta-analysis studies of 64-multi-detectors CT-scan showed a (96% sensitivity) and (73 % specificity) (10). Though the non-valuable number of coronary vessels segments has been decreased with the utilization of sixty four-multidetector coronary CTA in comparison to previous generation multi-detectors CT-cans, critics have claimed that excluding non-valuable segments falsely raises the diagnostic value in coronary CT angiography. (11)

Present study revealed about [71.4% sensitivity], and about of [71.0 % specificity], (79.5%) positive predictive value, (62%) negative predictive value for primary vessels. This finding regarding sensitivity and NPV was lower than what was reported by meta-analysis study (12) which was conducted at (2008) where a sensitivity of 99% and NPV of 100% was reported, in addition false +ve conclusions are reported particularly in patients with high calcium score. Our finding with regards to sensitivity and also lower than what was reported by (13) where they concluded that the pooled sensitivity and specificity about (97.7%) and specificity was (91.0%) on a patient level, while on a segmental level as fellow, for proximal segments was (94.2% , 94.1%) respectively, and for distal segments was (84.8% ,96.9%) respectively. A study carried out by Miller JM et al. (14) to assess the accuracy of 64-slice multi-detectors CT found out the subsequent locating concerning the sensitivity, specificity, PPV, and NPV; (85%, 90%, 91%, and 83%), respectively and that they concluded that despite the fact that multi-detectors CT cannot be used as an alternative for invasive coronary angiography, it is able to assist manual clinician selections as to whether or not a affected person desires in addition invasive studies. Schuijf et al (15) were linked the performance of multi-detectors CT to the segments which were included in the evaluation of accuracy of the test, where they concluded that 64 MD-CT is a feasible noninvasive test with (95%) for both [specificity and sensitivity] for segments that were interpretable, but when un-interpretable segments were included, the (specificity and sensitivity) decreased to [82% and81%] respectively. Depending on the results of meta-analysis, the authors Stein PD et al (16) They concluded that the detection accuracy achieved with 64 slices was higher than with 16 slices, and the results of this meta-analysis proved that the sensitivity of 64 slice CT-scan (~98%) was significantly superior to that of 16 slices. 64 slice multi-detector CT-scans have a higher number of slices/gantry rotation and faster speed gantry {330 ms/rev for 16-slice versus 375 ms/rev for 64-slice}, making CT scans (approximately 95%) the preferred choice for patient-based analyses. , image quality is superior to previous versions, with a 64-slice multi-detector CT scan that improves imaging challenges and helps detect coronary artery disease, even when coronary arteries have high calcium concentrations. Raff et al. (17) (18) It was also shown that greater heart rate and BMI, as well as the breathing related artifact, were linked to poor quality image. Manghat NE et al (19) stated; the vast coronary calcium obscures the lumen and might appreciably restrict evaluation of segments or maybe whole arteries with the aid of using coronary CT angiography, this approach can be of restrained software in sufferers with a excessive probability of giant coronary arteries calcified plaques, consisting of the aged or in these have calcium scores more than (1,000). Morin RL et al (20) attributed the limitation to the presence of heavy calcifications, arrhythmias and the blooming artifacts Caused by pacing wires, in addition they stated that the radiation

remains a concern, but a limited one, as the ECG-controlled tube current modulation allows significant dose reductions.

In general, it acceptable that the distal segment accuracy is lower than accuracy of the more proximal segment. This is due to reduced blood flowing in a small diameter decrease the contrast/noise ratio and complicates the interpretation of peripheral lesions(22) . Namgung et. al (22) reported contradictory results, that distal segments having higher about [95 %] sensitivity than proximal segments sensitivity about [89 %].

Authors Hamon M et al (9) attributed the difficulty of evaluation of coronary arteries at higher heart rate to limitation of temporal resolution of MDCT-scans, where they stated, prominent coronary arteries motion artifacts occurring during irregular heart rate or rapid heartbeat can complicate assessment of specific coronary artery segments due to the limitation in resolution of MDCT-scans and has been the subject of most studies reported that they generally excluded these non-evaluable coronary arteries segments from definitive accuracy analysis. Although the number of coronary artery segments classified as non-evaluable was reduced with the use of CCTA with a 64-slice multi-detector compared with older-generation MDCT scanners, reviewers ruled out non-evaluable segments. It claims that this falsely improves the diagnostic power of coronary CT angiography. The authors Abdulla J et al (23) demonstrated there was an association between the performance of multi-detectors CT and the diameter of vessels where they sated, the diagnostic accuracy of coronary CT angiography commonly documented in the context when vessels about (1.5 - 2.0 mm) in diameters and the inclusion of vessels less than (2 mm) in diameter unfavorably affected coronary CT angiography accuracy.

Ferencik M et al and Pugliese F (24, 25) reported that due to the coronary artery image quality is inversely related to the patient heart rate, beta-blockers for coronary arteries multi-detectors CT-scans are extensively employed to decrease heart rate, preferably to lower than [60-65 beat/min]. Despite these articles, it was subsequently shown the effect of heart rate on imaging quality is minimal, it affecting mostly the imaging of the left circumflex coronary artery. The regulating effect of blockers was the key factor of higher picture quality in patients taking beta-blockers against those who did not taking beta-blockers (26). some authors employ vasodilator drugs to increase the size of the coronary arteries. Nitroglycerin use has been shown to improve proximal-segments coronary arteries widths by (12-21%). although; an extra-benefit in terms of diagnostic accuracy is not yet obvious. (24).

It should be noted that coronary CT angiography accuracy of diagnosis estimated in the majority of previous studies in individuals who have a high incidence of stenotic coronary arteries diseases. Due to the prevalence of disease can have a direct impact on diagnostic test performance and features, successful use of coronary CT angiography in these individuals with intermediate disease prevalence need efficacy assessment in this population (6)

The Discriminatory power of coronary arteries CT angiographic imaging study to become aware of sufferers with obstructive coronary stenosis above 50 % must be appeared as "excessive diagnostic evidence", to become aware of sufferers without coronary stenosis as "persuasive diagnostic evidence". The discriminatory energy of each kinds of coronary angiography to become aware of sufferers without or with functionally applicable coronary stenosis must be appeared as "susceptible diagnostic evidence". It may be assumed that sufferers with an excessive pretest possibility of CHD will want invasive coronary angiography and sufferers with a low pretest possibility of CHD will now no longer want next revascularization. So, coronary arteries CT angiography can be utilized earlier than appearing invasive procedures coronary angiography in these sufferers from an intermediate pretest possibility of Chronic Heart Disease. coronary arteries CT angiography has been shown to be more cost-effective for determining or excluding obstructive coronary stenosis at a pre-test chance of CHD about (50%) or less, and invasive coronary angiography at a pretest possibility of CHD about (70%) or more. The utilization

of any type of coronary angiography study to detect or rule out functionally relevant coronary stenosis must be regarded as somewhat costly (26). Last study in Kirkuk city by Youash, F. T., & Khalaf, M. A. et al found that CCTA has a sensitivity of 100% and a specificity of 66.7% (2)

Limitations of the study

There is some missing information in the medical reports of the patients regarding the findings about secondary vessels.

5. Conclusion

1. 64-multi-detectors CT provide medium performance in detecting or exclude coronary artery stenosis (≥50).

2. The following clear technical constraints have been cited as the cause of false (+ve) and false (-ve) coronary artery analyses for 64-multi-detectors CT scans: [image artifacts' due to calcium deposits, movement artifact, and obese individuals].

3. Avoiding multi-detectors CT coronary angiography artifacts could be achieved by following steps:

a. Patient preparation use B-blockers to reduce the HR in cases with a heart rate more than (65 beat/min).

b. Prepare the contrast media for injection and give the patient instructions about how to hold their breath.

c. Take care with timing for injection of contrast-media, as well as use an appropriate dosage and injection-speed.

List of abbreviations:-

CT: computed tomography

MDCT: Multi-Detector Computed Tomography

LAD: Left Anterior Descending

LCX: Left Circumflex

ROI: Region Of Interest

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