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Mohammed Abd El Gowad
1Radio diagnosis department, Faculty of Medicine, Al-Azhar University, Egypt,
mohammed.dr2121@gmail.com

Mohamed Abd El Moaty
Radio diagnosis department, Faculty of Medicine, Al-Azhar University, Egypt,
fouadmohamed889@yahoo.com

Mohamed Ibraheem
Radio diagnosis department, Faculty of Medicine, Al-Azhar University, Egypt,
mohamedibraheem300@yahoo.com

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Diagnostic aspects of multi-detector CT in detection of coronary arteries stenotic lesions diseases versus interventional Diagnostic Angiography

Mohammed Abd El Fattah Abd El Gowad [1]*M.B.B.Ch; Mohamed Fouad [1]MD and Mohamed Abd Elfattah Talaat [1]MD.

**Corresponding Author:*

Mohammed Abd El Fattah Abd El Gowad

mohammed.dr2121@gmail.com

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[1]Radiodiagnosis Department, Faculty of Medicine, Al-Azhar University, Cairo , Egypt.

ABSTRACT

Background: Invasive coronary angiography (ICA) is anatomical evaluation of coronary artery disease is considered gold standard.
Aim of The Work: To compare the diagnostic characteristics of non-invasive computed Tomography (CT) coronary angiography to invasive coronary angiography in diagnosis of coronary artery stenosis and their economic benefits.
Patients and Methods: This study was descriptive Observational study, thirty studied cases included in research. Patients are undergone ECG gated MDCT coronary angiography in CT unit in Radiology Department of National Heart Institute NHI was analyzed from PACS (Syngovia acquisition system) and we was included patients for detection of coronary stenotic lesions compared to outcomes of invasive coronary Angiography attached with patients including CABG patients.
Results: the value of Sensitivity was (091.7percent), specificity (080.00percent), Positive predictive value (PVP) is 50.0 percent, negative predictive value (PVN) is 97.8%, & accuracy is 90.6 percent which means that CT angiography is a good screening tool for detection of degree of coronary arteries stenosis.
Conclusion: this study revealed that CT angiography provided high sensitivity & negative predictive values in examination of coronary arteries, so it is good screening instrument for detection of degree of coronary arteries stenosis. However, moderate and severe coronary calcifications may interfere with diagnostic accuracy of the coronary artery.

Keywords: *Invasive coronary angiography; coronary calcifications; non-invasive computed Tomography; coronary artery stenosis.*

INTRODUCTION

The gold standard for anatomical assessment of coronary artery disease is invasive coronary angiography (ICA). New progress in non-invasive coronary computed tomographic angiography (CCTA) technology, & allow for anatomical examination of coronary arteries without the need for invasive treatments. As the use of CCTA for clinical & research purposes grows.[1]

it's critical to know link between parameters produced from CCTA as well as those derived from ICA. Prior research has only looked at small groups of studied case. [2]

FFR is an invasive physiologic indicator used to determine presence of ischemia-producing coronary stenosis. [3]

Ischemic disease IHD, also known as Coronary Artery Disease CAD, is at the top of the list of the world's most dangerous diseases. It is caused by a buildup of fatty deposits on the artery wall, which is frequently ascribed to lifestyle choices or other high-risk illnesses such as high blood pressure or diabetes. It is responsible for approximately millions of fatalities each year. Studied case's arteries narrow, preventing blood & oxygen flow to the heart & potentially leading to a catastrophic heart attack, making this illness lethal. As a result, several modalities must be used to evaluate CAD, one of which is Coronary CT angiography. Moreover to be Coronary CT angiography has emerged like gold _standard for identification of coronary artery anomalies as noninvasive in addition to conventional invasive coronary angiography for monitoring coronary artery disease.[4]

Number of slices that can be captured simultaneously by raising number of detector rows has improved performance of cardiac CTA. The scan duration decreases as number of slices that may be captured simultaneously increases. Reconstruction artefacts are greatly reduced, & spatial resolution is improved. A 4-slice detector CT was used for the initial cardiac CT imaging.[5]

Researchers wanted to see how non-invasive computed Tomography (CT) coronary angiography

compared to invasive coronary angiography in terms of diagnosing coronary artery stenosis & how much it cost.

PATIENTS AND METHODS

This study was descriptive Observational study, thirty studied cases are in research. Patients are undergone ECG gated MDCT coronary angiography in CT unit in Radiology Department of National Heart Institute NHI was analyzed from PACS (Syngovia acquisition system) and we was included patients for detection of coronary stenotic lesions compared to outcomes of invasive coronary Angiography attached with studied cases including CABG patients.

Research was authorized by the Institute's Ethics Committee, & studied cases gave their informed consent.

CT angiography should be chosen in conjunction with studying modalities like stress myocardial perfusion pictures or cardiac ultrasound outcomes, so that information obtained aids in management decisions rather than simply adding another layer of testing.

Inclusion criteria: Patients with coronary heart diseases symptoms or have history of CABG with their attached invasive coronary Angiography reports.

Exclusion criteria: Patients with impaired renal function Patients that have allergy to contrast, cardiac Arrhythmias as patients with atrial fibrillation (unless when rate-controlled) or other severe arrhythmias, ejection fraction less than thirty percent, pregnant women, BMI greater than forty (except when third generation Dual-Source CT (DSCT) 120 kv tube voltage is used) and calcium score 1000 or more.

Methods: Patient preparation: Reassurance of the patient, shaving of the chest hair, respiratory training, Subjects were advised to fast for four-six hours prior to assessment, not to stop taking any medications, & to have their heart rate checked before the test. If heart rate is less than seventy beats each 60 seconds, an examination is performed. Individuals with heart rates more than seventy beats per minute were given a cardio-selective beta-blocker; 50/100 mg of Metoprolol, Bisprolol, & Atenolol orally 60 minutes before trial to achieve a low heart rate, assuming there were no contraindications to B-blockers. Test was moved to a different location if heart rate remained above seventy beats each 60 seconds. Temporary coronary vasodilator (or coronary antispasmodic) for coronary spasm as Sublingual Nitrates (Dinitra). To assess sufferers' ability to hold their breath for an extended period of time, they were requested to execute deep inspiration and hold their breath without pressing (i.e., Valsalva maneuver). During the trial, case's compliance was monitored, as well as the ECG for any significant differences.

Contrast Material: A 120 ml bolus of water soluble non-ionic contrast (Omnipaque 300 mg Daiichi pharmaceutical, Tokyo, Japan) was injected through an 18 gauge cannula into upper limb vein (right antecubital vein in all cases to reduce left sided artefacts) at flow rate of 5 to 5.5 ml/sec. To keep proper opacification of the coronary vessels as well as the grafts a programmable dual head power injector pump (Med Rad; USA) was used to inject roughly 45 cc of saline at a flow rate of 5ml/sec to wash off contrast material from the SVC and right side of the heart, which could create artefacts (Med Rad; USA).

Reconstruction: During middle to end diastolic phase, 45-75 percent of R-R interval, the information are reconstructed (with slice thickness of 0.625mm & 0.4mm increments). If the picture quality in this test datasets isn't up to par, photographs were selected for additional analysis. All of the information gathered is sent to a second computer workstation. Based on the vessel shape and the quality of the MDCT data sets, various post-processing techniques are employed to analyse origin & course of the coronary arteries, such as maximum-intensity projection (MIP), curved multiplanar reconstruction (CPR), and volume rendering (VR). The music is played at a rate of 75 beats each 60 seconds. Pipe time is padded to enable the reconstruction to adapt to minor heart rate fluctuations. Padding in sizes ranging from Forty to eighty msc is available.

Statistical analysis: SPSS 26.0 for Windows was used to gather, tabulate, & analyse all of the results (SPSS Inc., Chicago, IL, USA). The mean, SD, & (range) were used to convey quantifiable information, while absolute & relative frequencies were used to represent qualitative information (percentage). The Chi square (X2) test was done to see if there was a link between the qualitative factors. To assess the validity, 95 percent confidence intervals were determined for sensitivity, specificity, true positive rate (PVP), accuracy (PVN), & accuracy. A accuracy is calculated by the area under the ROC curve. A perfect test has an area of one.

RESULTS

Variable	N	%
Age (years)		
Mean± SD	55.35±14.2	
Range	(34-74)	
Gender		
• **Man**	22.00	73.30
• **woman**	8.00	26.70
Smoking habit:		
• **Smoker**	15	50.0
• **Non smoker**	15	50.0

Comorbidities		
• **HTN**	15	50.0
• **Diabetes**	21	70.0
• **Dyslipidemia**	8	26.7
• **Hereditary**	2	6.7

Table 1: study group's fundamental qualities (n=30)

This table demonstrated that mean year old of tested group was 55.53±14.2 ranging from 34 to 74 years. Most of cases (73.3%) were males, (50.0%) were smokers, and Most of cases (70.0%) were diabetic. About (50.0%) of cases had HTN and (26.7%) had dyslipidemia. Table (1)

Variable	N	%
Typical chest pain	15	50.0
Atypical chest pain	15	50.0
Dyspnea	5	16.7
Epigastric pain	5	16.7
Vomiting	6	20.0

Table 2: Frequency distribution of clinical manifestations of the studied group (n=30)

This table shows that all patients had chest pain (50.0% typical and 50.0% atypical chest pain). About (16.7%) suffered from dyspnea and Epigastric pain. Table (2)

Variable	N	%
Acute marginal artery1(AM1)	1	1.9
Left anterior descending	23	43.4
Left circumflex artery	8	15.1
Right coronary artery	10	18.9
Left main trunk	3	5.7
Obtuse marginal 1(OM1)	1	1.9
Ramus	7	13.1

Table 3: Frequency distribution of the affected vessels (n=53)

By evaluation of the studied patients, it was found that there are about 53 vessel affected. This table shows that about (43.4%) of cases had affection of left anterior descending artery while (18.9%) of cases had Right coronary artery & (15.1%) left circumflex artery. Table (3)

Variable	N	%
Degree of stenosis		
Mean ±SD	67.52±17.52	
Range	(30-100)	
Stenosis grade		
Mild stenosis	8	15.1
Moderate stenosis	27	50.9
Severe stenosis	18	34.0
Stenosis category		
Insignificant<50	8	15.1
Significant≥ 50	45	84.9

Table 4: Frequency distribution of the degree of stenosis of the affected vessels by CT angiography (n=53)

Regarding Provisional CT angiography diagnosis, this table shows that: (15.1%) had mild stenosis, (50.9%) moderate stenosis, (34.0%) severe stenosis with (84.9%) had significant stenosis (≥ 50). Table (4)

Variable	N	%
Degree of stenosis		
Mean ±SD	66.3 ±18.42	
Range	(20-100)	
Stenosis grade		
Mild stenosis	5	9.4
Moderate stenosis	31	58.5
Severe stenosis	17	32.1
Stenosis category		
Insignificant<50	5	9.4
Significant≥ 50	48	90.6

Table 5: Frequency distribution of the degree of stenosis of affected vessels by catheter (n=53)

Regarding Provisional catheter angiography diagnosis, this table shows that: (9.4%) had mild stenosis, (58.5%) moderate stenosis, (32.1%) severe stenosis with (90.6%) had significant stenosis (≥ 50). Table (5)

Variable	Catheter			X^2	P value
	Mild (n=5)	Moderate (n=31)	Severe (n=17)		
Mild stenosis (n=8)	4 (80.0)	4 (19.9)	0	48.8	<0.001**
Moderate stenosis (n=27)	1 (20.0)	24 (77.4)	2 (11.8)		
Severe stenosis (n=18)	0 (0.0)	3 (9.7)	15 (83.3)		

Table 6: Relation between CT angiography and catheter angiography is used to diagnose stenosis in coronary arteries. (n=53)

As in table (8), there was important association between stenosis marks detected by CT and catheter with catheter reported 17 severe cases from which CT detected 15 cases and 5 mild cases detected by catheter from which 4 cases were reported by CT angiography. Table (6)

CT angiography		Catheter angiography				
		Insignificant (n=5)		Positive (n=48)		
Insignificant (n=8)		4		4		
significant (n=45)		1		44		
AUC	95 percentCI	The Sensitivity	The Specificity	The PPV	The NPV	The Accuracy
0.858	0.647-1.0	91.7%	80.0%	50.0%	97.8%	90.6%

Table 7: Validity of CT angiography in detection of coronary artery stenosis versus catheter as a gold standard

This table shows that the value of Sensitivity was (91.7%), specificity (80.0%), predictive value for positive (PVP) (50.0%), predictive value for negative (PVN) = (97.8%), & (90.6%) accuracy which means that CT angiography is a good screening instrument for detection of degree of coronary arteries stenosis. Table (7)

	Coronary stenosis		kappa	P
Items	CT	Catheter		
Insignificant	8	5	0.565	<0.001*
Significant	45	48		

Table 8: Kappa agreement between CT angiography vs. catheter for detecting coronary artery stenosis

This table shows good agree between CT angiography & catheter in recognition of coronary artery stenosis as kappa coefficient was 0.565. Table (8)

Case Presentation

Case 1

Man with aging fifty admitted for suspected CA, diabetic and hypertensive, findings illustrated below:

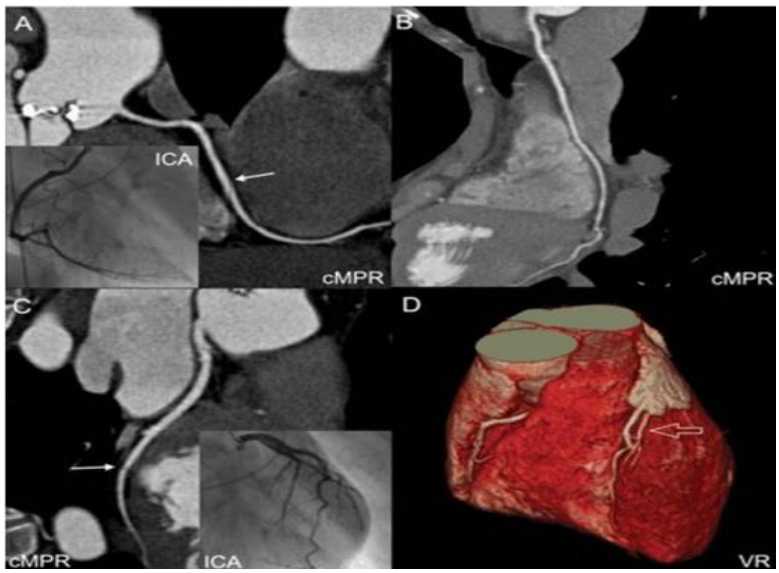

Fig. 1: Curved multi-planar reform movements (cMPR) of the RCA (A), LAD (B), & LCX (C) show no stenosis in normal coronary arteries with 64-slice CT coronary angiography & ICA. In the mid-RCA & distal LCX, there are some minor motion artefacts (arrows). By not interfering with artery visualisation, the VR picture (D) defines 3D course of coronary arteries while also presenting venous opacification (open arrow). Right (Inlay in A) & left coronary arteries are normal in the ICA (Inlay in C).

Case 2

67 aged male presented with typical chest pain. Both 64- MDCT and CCA were done and they both modalities revealed same findings illustrated below:

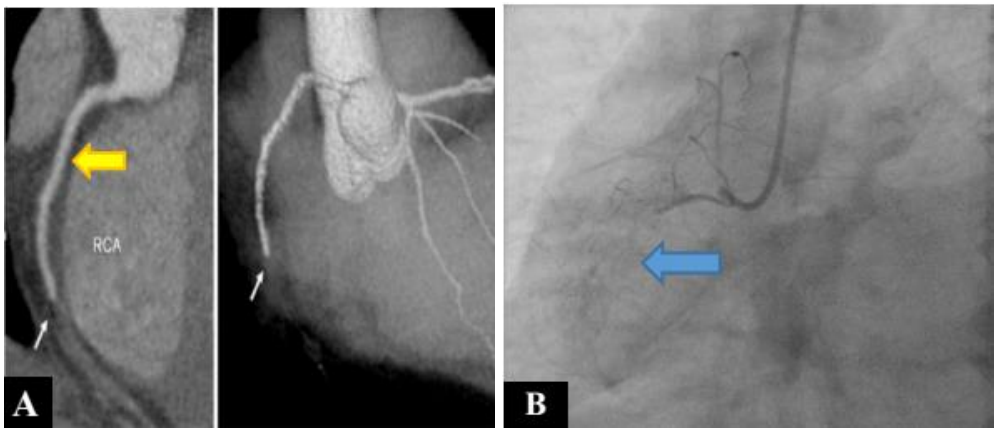

Fig. 2: On the left (A) On the MPR & 3D-MIP photos (small arrow), CTCA pictures indicate occlusion of the mid RCA near the junction with the distal RCA, with full cutoff at the stump of the occlusion & no visibility of artery distal to the occlusion. On the right (B), as shown in the ICA the same finding has been identified (blue blocked arrow).

DISCUSSION

In the presence of CAD, ICA shows the luminal diameter, stenosis rate, and luminal irregularity with high resolution. An important advantage of ICA is that it facilitates the use of interventional procedures, like balloon & stent placement in the stenotic region under emergency or elective conditions based on clinical outcomes from examination of studied case

Lumen stenosis is usually determined by the proportion of a stenotic segment to the normal segment proximal to the stenosis. In the presence of diffuse atherosclerotic CAD, if there is no normal arterial segment, ICA may underestimate the stenosis rate.

A 4-slice detector CT was used for the initial cardiac Computed tomography. With a sixteen-slice detector CT, scanning times were lowered from forty seconds to twenty seconds. Scanning times were decreased to ten-second breath-hold with the introduction of sixty four-slice detector CT. Scanners of today's generation can complete full volumetric acquisition with only one heart cycle (R-R interval) and/or without breath holding.

The purpose of this research was to compare diagnostic characteristics of non-invasive computed tomography (CT) coronary angiography versus invasive coronary angiography in diagnosis of coronary artery stenosis.

Patients undergone ECG gated MDCT coronary angiography in CT unit in Radiology Department of National Heart Institute NHI were analyzed from PACS (Syngovia acquisition system) and were included for detection of coronary stenotic lesions compared to outcomes of invasive coronary Angiography attached with patients including CABG patients.

Data is collected & transferred to a different computer workstation. Different post-processing techniques, like maximum-intensity projection (MIP), curved multiplanar reconstruction (CPR), & volume rendering (VR), were used to analyse genesis & course of the coronary arteries, based on vessel morphology & the quality of MDCT data sets. A maximum heart rate of seventy five beats per minute was employed.

In research, age of the studied group was 55.53±14.2 ranging from 34 to 74 years. Most of cases (73.3%) were males, (50.0%) were smokers, and most of cases (70.0%) were diabetic. About (50.0%) of cases had HTN and (26.7%) had dyslipidemia, and this was in line with Sahin et al.[6] that aimed to investigate accuracy of multi-detector computed tomography (MDCT) coronary angiography via comparing with the invasive coronary angiography (ICA), the study consisted of 63 patients, 42 male (42.6%) and 21 female (33.3%), aged 35 to 75 years.

Also it was in agreement with Mohammadzadeh et al.[7] study that aimed goal of research was to evaluate deal of cardiac CTP photos with CT angiography results in a single dual energy computed tomography (DECT) acquisition in a collective of studied cases suspected of having ischemic heart disease. There were thirty studied cases in total, with an average year old of 53.8 12.9 years (35–78). There were 18 men among studied cases (60 percent).

Coinciding to our results, Mohammadzadeh et al.[8] study that aimed the average year old of studied cases was 58 aging (ranged 43-78 in age), & 63.8 percent of them were males, according to a study comparing MSCT-CA to traditional invasive coronary angiography for diagnosis of severe stenoses in coronary arteries. Hypertension was present in half of studied cases, & hyperlipidemia and diabetes mellitus were present in less than one-third of studied cases.

In our study, all patients had chest pain (50.0% typical and 50.0% atypical chest pain), about (16.7%) suffered from dyspnea and epigastric pain, and it was in agreement with Mohammadzadeh et al.[7] study that documented In ninteen studed cases (63.3%), stable angina was present, while in 5 individuals, unstable

angina & unusual chest pain were present (percent 16.7).

By evaluation of our studied cases, we found that there were about 53 vessel affected, about (43.4%) of cases had affection of left anterior descending artery while (18.9%) of cases had right coronary artery & (15.1%) left circumflex artery.

Sahin et al.[6] study demonstrated that by using MDCT, stenosis was detected in 215 segments at various levels, of which 37 were evaluated as normal in ICA (false-positive result). A total of 712 segments were evaluated as normal (true-negative result) using MDCT coronary angiography and ICA. Eighteen segments were reported to be normal in MDCT coronary angiography but had stenosis according to ICA (false-negative result).

In research, there was important association among stenosis grades detected by CT and catheter, with catheter reported 17 severe cases, from which CT detected 15 cases and 5 mild cases detected by catheter, from which 4 cases were reported by CT angiography, also there was good correlation between stenosis grades detected by CT and catheter with ICC 0.771 (0.634-0.861) and Corbach α 0.871), but none of the previous studies found such relationship.

In the current study, we found that the sensitivity of CT angiography in detection of stenosis was 91.7%, specificity was 80.0%, PVP was 50.0%, PVN was 97.8%, and its accuracy was 90.6%, which means that CT angiography is good screening instument for detection of degree of coronary arteries stenosis.

Sahin et al.[6] study when compared the MDCA results with those of ICA in detecting ≥ 50% stenosis, found that it had 90.8% sensitivity, ninty five percent specificity, 82.7percent positive predictive value, & 97.5percent negative predictive value, & this coincided to our results, except for PPV which was higher than ours.

In another study conducted with 104 patients using 256-slice MDCT, the patient-based analysis showed 98.8% sensitivity, 50% specificity, 92.4% positive predictive value, & 87.5% negative predictive value for the detection of ≥ 50% stenosis.[9]

Budoff et al.[10] investigated diagnostic accuracy of sixty four-slice MDCT coronary angiography based on 50% and 70% threshold values. Their patient-based analysis on the data revealed 95% sensitivity, 83% specificity, 64% positive predictive value, & 99% negative predictive value for detection of ≥ 50% stenosis. Similarly in order to detect of ≥ 70% stenosis, sensitivity, specificity, positive & negative predictive values were reported as 94%, 83%, 48%, and 99%, respectively.

Bordeleau et al.[11] When optimally visualised segments were evaluated, sensitivity, specificity, & positive predictive value for diagnosing more than fifty percent luminal stenosis were eighty, hundred, & hundred percent, respectively, when compared to CCA.

Anders et al.[12] found that Twelve CT angiography could detect bypass occlusion with hundred percent sensitivity & ninty eight percent specificity in a trial.

Alexander et al.[13] evaluated 798 segments in 64 patients using 64-slice MDCT. According to their segment-based analysis, compared to ICA, MDCT had a sensitivity & specificity of eighty percent & ninty seven percent, respectively, for detecting seventy five percent stenosis, which was consistent with our findings.

Aviram et al.[14] sensitivity & specificity were eighty six, ninty eight, eighty thee, & ninty eight percent, respectively.

Another study with sixty four-slice scanners (seven tests in 444 individuals) found that they were more accurate, with stated sensitivity & specificity of ninty eight percent & ninty three percent, respectively. [15]

Many studies investigating the accuracy of MDCT coronary angiography have reported high false-positive results and low positive predictive values. Among the factors that increase false positives are technical problems and motion artefacts that degrade image quality.

In the current study, we found good agreement between CT angiography & catheter in detection of coronary artery stenosis as kappa coefficient was 0.565

Multi- slice CT angiography offers unique ability to detect plaques & irregularities in the walls. These plaques may not be visible on catheter angiography due to compensatory enlargement of the coronary arteries (unless intravascular ultrasound is used). Plaque rupture, not stenosis, is thought to be most significant reason of myocardial infarction. Until now, these individuals have been false positives only in terms of stenosis detection; they have been true positives in terms of early detection of CAD, necessitating preventative interventions. [16]

Further advancements in temporal &, in particular, spatial resolution improved image quality & usability of MDCT for coronary imaging, albeit at expense of increased radiation dose.

CONCLUSION

This study revealed that CT angiography provided high sensitivity & negative predictive values in examination of coronary arteries, so it is good screening thing for detection of degree of coronary arteries stenosis. However, moderate and severe coronary calcifications may interfere with diagnostic accuracy of coronary artery.

Conflict of interest : none

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