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Original article

Diagnostic accuracy for coronary artery disease by computed tomography angiography as compared to conventional invasive angiography

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Abstract:

- ***Background***: Emerging as a major cause of death and disability in the developing countries is coronary artery disease (CAD). Traditional coronary angiography has traditionally been the preferred diagnostic procedure for CAD. Non-invasive evaluation of coronary artery disease (CAD) using computed tomography (CT) coronary angiography shows promise. This observational study's goal is to assess the relative efficacy of noninvasive multi-section computed tomography (MSCT) coronary angiography vs invasive selective coronary angiography in detecting coronary stenosis.
- ***Method and patient:*** This observational study carried out in the Azadi teaching Hospital/Kirkuk between November 2021 to March 2022. Patients who suspected to have coronary artery disease underwent both CTCA and invasive coronary angiography in different centers in our country comparing and analyzing their results.
- ***Result:*** In total, 92 participants were enrolled in the trial. Patients had a mean age of 57.207.3 years, and men made up the vast majority of those who appeared (67.3 percent). Chest pain was the most common presenting complaint (94 percent). Patients exhibited a prevalence of 84% for HTN, 55% for hyperlipidaemia, 58% for diabetes, and 4% for ischemic heart disease. In addition, 50% of the patients are either current or former smokers. Half of the patients received 64-slice CT scans, nearly half had 128-slice scans, and 3.2% got 256-slice scans. CCTA's sensitivity was 100%, and its specificity was 66.7%. Positive predictive value for CCTA was 98.8 percent (meaning it correctly identified

positive cases in 98.8 percent of patients) and negative predictive value was 100 percent, for a total diagnostic accuracy of 98.9 percent (which mean CCTA can exclude all negative cases and did not miss any case). When looking at individual arteries, the LAD artery was shown to be the most accurate, while the LCX artery was the least accurate (95.6 percent and 78.2 percent respectively). In terms of sensitivity, LAD performed at a 99.1% rate, while LMS performed at a 0% rate (33.3 percent). RCA had the most specificity (95.2 percent), whereas LAD had the lowest (88.8 percent) (40 percent). In order to determine what factors, influence CCTA positivity, we performed a binary logistic regression analysis for positive CCTA (negative as reference) with all variables from the studies. The results showed that IHD, lesions in the LAD artery, lesions in the LCX artery, and CT slice thickness (128 and 256 slices) all have a negative effect on CCTA (p0.05).

- ***Conclusions:*** When compared to traditional angiography, multi-slice computed tomography has demonstrated superior sensitivity and specificity for the identification of coronary artery disease.
- **Keywords:** Coronary artery disease, Computed tomography, coronary angiography, Conventional coronary angiography.

INTRODUCTION

Emerging as a major cause of death and disability in the developing countries is coronary artery disease (CAD). Traditional coronary angiography has traditionally been the preferred diagnostic procedure for CAD [(1)]. In the context of catheter-based or surgical treatments, it offers superb resolution for seeing the coronary arteries. Mortality is a very rare complication of this procedure, but it relates to a number of other problems, both cardiac and otherwise [(2)].

Noninvasive evaluation of coronary artery disease (CAD) using computed tomography (CT) coronary angiography shows promise [(3)]. coronary artery disease is evaluated, and both qualitative and quantitative data on the presence and extent of non-obstructive atherosclerotic plaque in the arterial wall are provided. This suggests that CT angiography-based disease evaluation may yield more useful information for patients than does standard angiography. High diagnostic accuracy of CT coronary angiography has resulted from the development of multi-slice computed tomography (MSCT) technology, such as 64-slice, 128-slice, 256-slice, and now 320-slice MSCT [(4)].

With a negative predictive value constantly exceeding 90%, it has been shown to reliably exclude patients who have severe CAD, whereby coronary luminal stenosis is defined as 50%. Therefore, the purpose of this study is to compare the diagnostic yield and accuracy of coronary CT angiography (CCTA) with invasive coronary angiography (ICA) in patients referred for invasive coronary angiography due to clinical concern for coronary artery disease (CAD). [(5, 6).]

CAD, or coronary artery disease: Atherosclerosis's pathophysiology is still poorly understood. Atherosclerosis likely has a complex pathophysiology due to the interaction of environmental and genetic variables. Some 'new' risk factors and as-yet-unrecognized factors may be as important as the 'traditional' ones as HTN, dyslipidemia, DM, and smoking. The high rate of CAD in Iraq may be a result of any one of these variables acting alone or in various combinations within a genetically susceptible population [1,7,8]. Standard invasive angiography (CIA) has been the gold standard for verifying the diagnosis of CAD for several decades. As part of coronary angiography, a catheter is inserted into an artery in the groin, arm, or shoulder and guided to the heart. Digital X-ray images are taken as iodinated contrast dye is injected directly into the coronary arteries [9 – 11].

Figure 1. Atherosclerosis of the Coronary Arteries. Coronary angiogram and cardiac catheterization demonstrating significant left anterior descending (LAD) stenosis in the left panel. As can be seen in the right panel, a stent was placed in the left anterior descending coronary artery to treat this lesion [13]

The diagnostic accuracy of invasive coronary angiography has various drawbacks. Visual estimations of stenosis severity are common, but they have their limitations due to inter-observer variability that can vary from 30 to 60 percent. As the stenosis areas are reported as a percentage of luminal diameter in comparison with surrounding normal coronary segments, and, in diffuse disease, no such segments are detected, the presence of diffuse disease may also contribute to underestimating of stenosis [12-14].

The fractional flow reserve computed tomography (FFRCT) approach has recently emerged as a non-invasive method for assessing the severity of epicardial coronary narrowing and the physiological consequences of this narrowing [15,16].

To get around the drawbacks of CIA, multi-slice computed tomography angiography (CTA) has been recommended in recent years as an alternative method of diagnosing coronary blockages. Recent advances in technology with many detectors have greatly enhanced spatial and temporal resolutions of pictures, making CTA the focus of doctors' attention [17] This

observational study's goal is to assess the relative efficacy of noninvasive multi-section computed tomography (MSCT) coronary angiography vs invasive selective coronary angiography in detecting coronary stenosis [22], This observational study's goal is to assess the relative efficacy of noninvasive multi-section computed tomography (MSCT) coronary angiography vs invasive selective coronary angiography in detecting coronary stenosis [18-21].

PATIENT and METHOD

This research was conducted from November 2021 to March 2022 at the Azadi Teaching Hospital in Kirkuk. All patients who fulfilled the following inclusion criteria were included in the study: Patient must be 18 years or older. Suspect angina related to coronary heart disease because of chest pain. Individuals who are at a moderate risk for developing coronary artery disease but not at a high risk. Criteria for exclusion: Those who are unable or unwilling to undergo CTCA. People who have developed an episode of acute coronary syndrome (up to 100 days previously). A glomerular filtration rate of 30 ml/min or below indicates chronic kidney disease. Patients who are pregnant women. Systemic comorbidity individuals, such as those with severe COPD, who cannot hold their breath while imaging. Direct questionnaire interviews are conducted with each respondent to acquire the following data: In the first section, you'll be asked questions about your demographics and your health. Give your full name, date of birth, gender, job title, and a brief introduction. Examining the presence of many disorders: ischemic heart disease, diabetes, high cholesterol, high blood pressure, high blood sugar, high body mass index, and a normal electrocardiogram all point to a healthy lifestyle.

Part 2 involves comparing and analyzing the outcomes of CTCA and invasive coronary angiography in patients who gave their informed consent for both procedures. Multiple observers, each of whom was uninformed of the multi-slice CT results, classified coronary lesions as either single-vessel, double-vessel, or triple-vessel disease. To be compared with invasive angiography, lesions of any size are included. According to the degree to which an artery has been blocked, lesions are categorized.

The majority of our patients' CTCA and CIA were performed in the city of Kirkuk in northern Iraq, and the interval between their tests ranged from a few weeks to three months. Regarding the ethical considerations, Approval was taken from Internal Medicine Scientific Committee of Iraqi Board, an agreement for research was taken from hospitals' authorities, written informed consent was taken from each patient. The statistical package for social sciences (SPSS) software version 23 had been used for data entry and analysis. In the descriptive statistics for socio-demographic characteristics, the means, standard deviations, min, max values were used for continuous data. Numbers and percentage values were used for countable data. In analyzing the

differences between the groups, chi square and T test were used. Binary logistic analysis was used to evaluate the possible factors associated with positive CCTA. P<0.05 was used as the threshold for statistical significance.

RESULTS

There were 92 patients included in this study.

Demographic characteristics: The mean age of patients was 57.2 ± 7.3 years (range 44 – 75 years).

Table 1. Descriptive statistics of age

	Mean	SD	Minimum	Maximum
Age	57.2	7.3	44	75

Majority of presented patients were males (67.3%) (Figure 3.1).

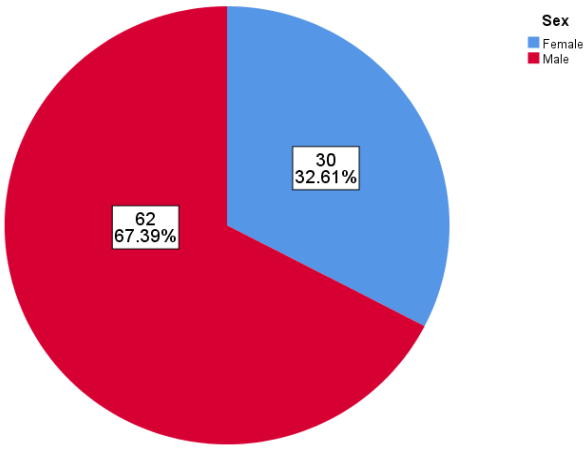

Figure 1. Gender distribution across patients

The majority of patients were presented with chest pain (94%). There were 85%, 55%, 58%, and 4% of patients had HTN, hyperlipidemia, DM, and IHD respectively. Also, 50% of patients are currently smokers or ex-smokers (Table 2).

Table 2. Demographic characteristics of patients

		Count	N %
Chest Pain	No	5	5.4%
	Yes	87	94.6%
Dyspnea	No	45	48.9%

	Yes	47	51.1%
Palpitation	No	54	58.7%
	Yes	38	41.3%
Occupation	Employee	23	25.0%
	Free worker	30	32.6%
	Housewife	27	29.3%
	Retired	10	10.9%
	Teacher	2	2.2%
HTN	No	13	14.1%
	Yes	79	85.9%
Hyperlipidemia	No	41	44.6%
	Yes	51	55.4%
DM	No	38	41.3%
	Yes	54	58.7%
IHD	No	88	95.7%
	Yes	4	4.3%
Smoking	Yes	34	37%
	Ex smoke	12	13.0%
	No	46	50.0%

Regarding vital signs and BMI, the descriptive statistics are given in below table 3.

Table 3. Descriptive statistics of vital signs and BMI

	Mean	SD	Minimum	Maximum
SBP	138	13	110	170
DBP	82	11	60	100
HR	78	8	56	105
RR	14	1	10	16
BMI	27	3	23	36

Regarding the ECG changes, majority of patients presented with ST segment changes (75%) (Figure 2).

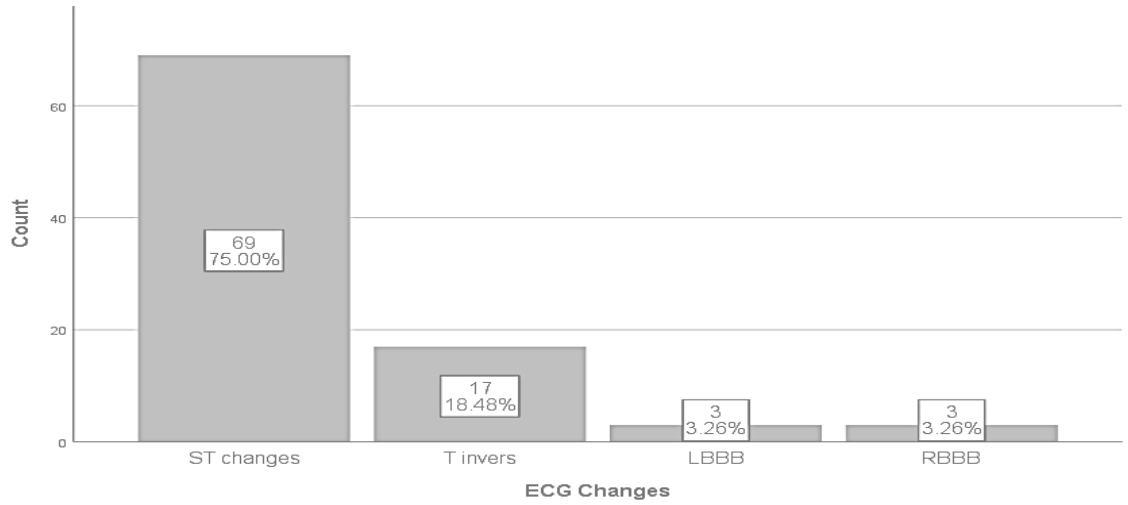

Figure 2. ECG changes across patients

Coronary CT angiography (CCTA): There were 50% of patients had 64-slice CT, 46.7% of patients had 128-slice CT, and 3.2% patients had 256-slice CT (Figure 3).

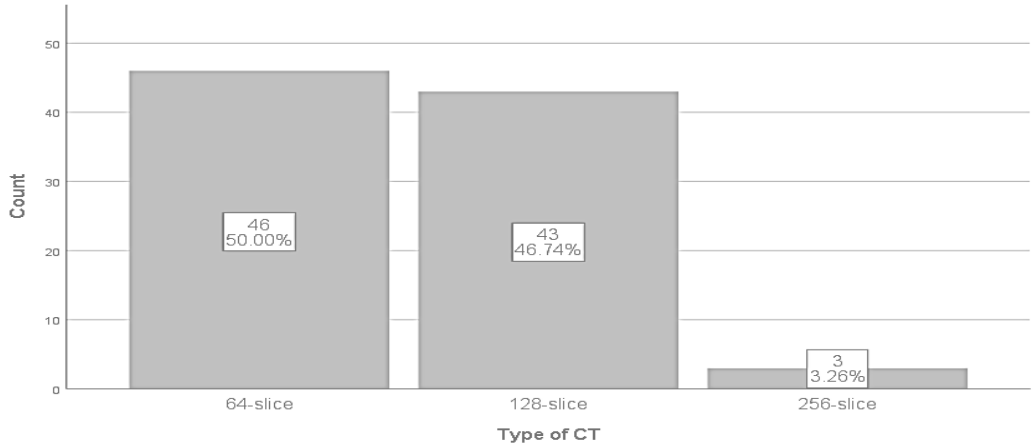

Figure 3. Type of CT performed.

The sensitivity of CCTA was 100% with specificity of 66.7%. The diagnostic accuracy of CCTA was 98.9% with PPV of 98.8% (which mean CCTA can identify positive cases in 98.8% of patients) and NPV of 100% (which mean CCTA can exclude all negative cases and did not miss any case).

Table 4. Comparison between CCTA and Conventional invasive angiography for diagnosis of CAD

		Conventional invasive angiography		Total
		Positive	Negative	
CT	Positive	89 (100%)	1 (33.3%)	90 (97.8%)
	Negative	0	2 (66.7%)	2 (2.2%)
Total		89 (100%)	3 (100%)	92 (100%)

P=0.0001

Table 5. Diagnostic accuracy of CCTA based on conventional invasive angiography

Test	Value
Sensitivity	100%
Specificity	66.7%
Positive predictive value	98.8%
Negative predictive value	100%
Accuracy	98.9%

For specific artery accuracy, the highest accuracy was observed for LAD artery while LCX artery showed lowest accuracy (95.6% and 78.2% respectively). The highest sensitivity was observed with LAD (98.9%) while LMS showed lowest sensitivity (33.3%). The specificity was at its highest level with RCA (95.2%) while lowest specificity was observed with LAD (40%).

Table 6. Comparison between CCTA and conventional invasive angiography for diagnosis of CAD per location

Location	CCTA		Angiography		P value
	Positive	No lesion	Positive	No lesion	
LMS	10 (10.9%)	82 (89.1%)	3 (3.3%)	89 (96.7%)	0.2
LAD	89 (96.7%)	3 (3.3%)	87 (94.6%)	5 (5.4%)	0.001
RCA	42 (45.7%)	50 (54.3%)	50 (54.3%)	42 (45.7%)	0.001
LCX	60 (65.2%)	32 (34.8%)	54 (58.7%)	38 (41.3%)	0.001

Table 7. Diagnostic accuracy of CCTA based on conventional invasive angiography per location

Artery	Sensitivity	Specificity	PPV	NPV	Accuracy
LMS	33.3%	89.9%	90%	97.6%	88%
LAD	98.9%	40%	96.6%	66.7%	95.6%
RCA	80%	95.2%	95.2%	80%	86.9%
LCX	87%	65.8%	78.3%	78.1%	78.2%

Factors associated with CCTA positivity: By running binary logistic regression analysis for positive CCTA (negative as reference) with all studies variables to test the factors that impact CCTA positivity, the test showed that, IHD, lesion in LAD artery, lesion in LCX artery, and type of CT (128 and 256 slices) effect negatively CCTA ($p<0.05$) (Table 8).

Table 8. Factors associated with CCTA positivity

			Score	DF	P value
	Variables	Age	0.003	1	0.959
		Sex	0.989	1	0.320
		Occupation	6.133	4	0.189
		HTN	0.336	1	0.562
		Hyperlipidemia	1.644	1	0.200
		DM	1.439	1	0.230
		IHD	44.978	1	0.001
		Smoking	2.044	1	0.432
		SBP	0.628	1	0.428
		DBP	3.087	1	0.079
		HR	0.316	1	0.574
		RR	2.870	1	0.090
		BMI	1.307	1	0.253
		ECG Changes	0.681	3	0.878
		LMS	0.249	1	0.618
		LAD	60.652	1	0.001
		RCA	1.717	1	0.190
		LCX	3.833	1	0.050
		Type of CT	14.723	2	0.001
		Chest Pain	0.117	1	0.732
		Dyspnea	2.135	1	0.144
		Palpitation	1.439	1	0.230
	Overall Statistics		77.802	41	0.001

There was no significant association between the comorbidities and CT nor O2 saturation (P>0.05) (Table 9).

Table 9. Group Statistics comparison of BMI with CT and O2 saturation

	Variable	N	Mean	SD	P value
C.T scan	Hypertension	36	67.78	15.741	0.76
	No	64	66.80	15.207	
O2 sat.	Hypertension	36	83.92	5.674	0.71
	No	64	83.44	7.536	
C.T scan	DM	27	70.37	14.539	0.2
	No DM	73	65.96	15.538	
O2 sat.	DM	27	82.44	5.235	0.3
	No DM	73	84.04	7.404	
C.T scan	Others	10	63.00	18.439	0.36
	No comorbidities	90	67.61	14.995	
O2 sat.	Others	10	85.10	6.903	0.47

DISCUSSION

When it comes to visualizing coronary artery disease, CCTA is state-of-the-art. CCTA is useful for assessing heart chambers, valves, great vessels, pericardium, and surrounding tissues, even though coronary atherosclerosis is the primary cause for the burden of cardiovascular illnesses [(2)]. This study was created to evaluate CCTA's diagnostic performance specifically for coronary arteries.

Among all patients, there was a mean age of 57.2 7.3 years. This matched the results of a recent study by Mohammad et al. in Iraq, which found that CAD patients, on average, were 55 years old [(13)], Another study by Mohammad et al. found that patients with advanced CAD had a mean age of 63, thus ours is in line with that. 9 Additionally, Elliott et al. found that the average age of CAD patients was 55 in research conducted in the United Kingdom. These findings lend credence to the widely held belief that coronary artery disease is a leading cause of death and disability among adults [(56)].

Most patients in this study were male, which is consistent with a study conducted in Iraq by Mohammad et al. that found 62% of adults with CAD were male [(13)].

13 Elliott et al. conducted research in the UK and found that 58% of CAD patients were female. 9 Possible explanations for this discrepancy include varying sample sizes and underlying genetic variables [(9)].

The most common presenting complaint was chest pain (94 percent). Historically, coronary artery disease has been represented by angina, which is a pain in the sub-sternal region that is described as a squeezing or heavy feeling and that may radiate to the medial aspect of the left upper extremity, to the neck, or to the jaw, and that may be accompanied by nausea, vomiting, palpitations, diaphoresis, syncope, or even sudden death. Even if a patient presents with seemingly unrelated symptoms, doctors and other medical professionals should keep their guard up and treat them with caution [(52)].

Patient prevalence of hypertension, elevated cholesterol levels, diabetes mellitus, and ischemic heart disease was 84%, 55%, 58%, and 4%, respectively. The most common risk factor was found to be hypertension (55.3%), followed by dyslipidemia (42.7%), type 2 diabetes mellitus (29%), smoking (11%), and ex-smoking (22%). (9.3 percent). A possible explanation for the discrepancy could be because the two-research used different sized samples [(13)].

Carbon monoxide, tar, nitrosamines, polycyclic aromatic hydrocarbons, hydrogen cyanide, aldehydes, and heavy metals are only few of the thousands of toxic chemicals found in tobacco. Evidence from epidemiological and clinical investigations shows that cigarette smoking increases the risk of cardiovascular events in a dose- and time-dependent manner. Acute myocardial infarction occurred roughly ten years earlier in smokers [(53)].

CCTA's sensitivity was 100%, and its specificity was 66%. CCTA has a 98.9% sensitivity, a 98.8% specificity (meaning it can detect positive cases in 98.8% of patients), and a 100% NPV (meaning it can detect no false positives) (which mean CCTA can exclude all negative cases and did not miss any case). Similar results were found in another study by Joshi et al., which found a sensitivity and specificity of 100% (95 percent confidence interval [CI]: 39.76 percent -100 percent) and 91.30 percent (95 percent CI: 79.21 percent -97.58 percent) for CT angiography, respectively. CT angiography had a strong positive predictive value (50 percent; 95% CI: 15.70 percent to 84.30 percent) and a high negative predictive value (100 percent; 95% CI: 91.59 percent to 100 percent) in this group of patients [40,41].

In addition, Mannan et al. found that CCTA has a sensitivity of 83.8% for detecting stenosis, a specificity of 98.4%, and an accuracy of 96.5%; based on these results, the authors concluded that CCTA permits the identification of coronary stenosis with excellent accuracy and well correlation with conventional angiogram. Despite this, Mannan et al. relied on only 64 CCTA slices in their analysis [43,45,46], In addition, the positive CCTA was shown by Meinel et al. to have a positive predictive value of 83% for individuals with clinically significant CAD, 100% sensitivity, and 84% specificity [47,48].

The diagnostic accuracy of coronary computed tomography angiography for coronary artery disease (CAD) was also demonstrated by Nielsen et al. to be higher than that of standard exercise electrocardiography and single-photon emission computed tomography [47].

Wu et al. found that coronary CT coronary angiography (CTCA) was more sensitive than the ‘standard diagnostic technique' in identifying patients with angina owing to coronary heart disease while also being less expensive [48,49].

In addition, a recent Egyptian study by Abd Ella et al indicated that CTCA has a sensitivity, specificity, and accuracy of 97.1, 96.8, and 96.8 percent, respectively, when compared to traditional angiography for diagnosing severe stenosis in coronary arteries [36 ,37].

Based on 64-slice CT evaluations of 923 segments from 68 patients, Nikolaou et al. found a sensitivity of 82%, specificity of 91%, a positive predictive value of 72%, a negative predictive value of 97%, and an accuracy of 93%. On a sample of 113 patients, Kerl et al. found that 64-slice CT had a sensitivity of 90.5%, specificity of 98.4%, positive predictive value (PPV) of 85.5%, negative predictive value (NPV) of 99.0%, and accuracy of 97.7% [40].

Accuracy for individual arteries varied, with the LAD artery showing the most precision and the LCX artery the least (95.6 percent and 78.2 percent respectively). LAD demonstrated the most sensitivity (98.9%), whereas LMS had the lowest (33.3 percent). The RCA had the most specificity (95.2%), while the LAD had the lowest (40 percent). Similar findings were seen in a recent Egyptian study by Abd Ella et al., demonstrating varying sensitivity and specificity with respect to particular artery obstruction [54].

To further investigate the factors that influence CCTA positivity, we ran a binary logistic regression for positive CCTA (negative as reference) with all study variables. The results showed that IHD, LAD artery lesion, LCX artery lesion, and CT slice count (128 vs. 256) all have a negative effect on CCTA positivity. These factors may influence the outcomes; however, the size of the sample may be more influential [30.31].

In a study comparing CCTA and invasive coronary angiography, Knaapen concluded that CCTA was close but not close enough to replace invasive coronary angiography, but that over the past decade, noninvasive computed tomographic coronary angiography (CCTA) has emerged as a viable alternative to its invasive counterpart [53]. A negative CCTA of adequate quality virtually excludes out obstructive CAD and considerably minimizes unnecessary invasive treatments, which is especially important given the low yield of ICA for detecting CAD [52,53] However, CCTA is used more as a screening tool for ICA rather than as a replacement for it because of worse image quality due to reduced spatial and temporal resolution, motion and blooming artifacts, and the need for a low and steady heart rate for optimal image capture. Due to its low specificity and high false-positive rate, CCTA has always been its own downfall, and further diagnostic methods are warranted in the event of a positive scan. After a CCTA that is either inconclusive or positive, myocardial perfusion imaging has been recommended to boost specificity. However, this approach has been shown to contribute little to no value over CCTA alone to identify CAD, and instead just boosts specificity at the expense of sensitivity without significantly improving total diagnosis accuracy, and therefore may be regarded even un useful for clinical decision-making. Now that we're moving away from these hybrid or sequential imaging methodologies, we can put our energy into perfecting CCTA as a stand-alone diagnostic tool that can potentially replace ICA [50,53].

It's interesting to note that a March 2022 study by Li et al. found that CCTA's diagnostic performance changes depending on the level of experience of the reading physician. It has been demonstrated that as one's experience with CCTA grows, so does its diagnostic precision. Few patients had 256-slice CCTA, and the sample size was limited overall [54].

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Nil.

Conflicts of interest:

There are no conflicts of interest**.**

CONCLUSION

1. We found that CCTA has a sensitivity of 100% and a specificity of 66.7% in our investigation.
2. CCTA has a 98.9% sensitivity, a 98.8% specificity (meaning it can detect positive cases in 98.8% of patients), and a 100% NPV (meaning it can detect no false positives) (which mean CCTA can exclude all negative cases and did not miss any case).
3. When looking at individual arteries, the accuracy of the LAD was highest while that of the LCX was lowest. Contrary to LMS, LAD was shown to have the highest sensitivity. The sensitivity was highest for RCA and lowest for LAD.

RECOMMENDATION

1. To diagnose CAD and provide crucial information to guide treatment, therapy, and prognostic evaluation in patients with suspected CAD, CT coronary angiography is a first-line, noninvasive diagnostic test alternative to ICA.
2. In individuals with a moderate to low pre-test risk of CAD, for whom a diagnosis or exclusion of the condition cannot be made based on clinical examination alone, this test is invaluable.
3. In individuals experiencing chest pain other than from a heart attack, it can be used to quickly rule out coronary artery disease.
4. The impact of CT (128 and 256 slices) on diagnostic precision: a large cohort study.

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