Original Article

Comparison of Diagnostic Accuracy between Coronary CT Angiography and Conventional Coronary Angiography

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ABSTRACT

***Background*:** Coronary computed tomography angiography (CCTA) is a noninvasive imaging method with a high diagnostic value and minimal complications for evaluating coronary arteries. Therefore, in cases with low and moderate probabilities of coronary artery disease, CCTA can be a good alternative to conventional coronary angiography (CCA). Previous studies with 64-slice CTA have tried to determine its diagnostic accuracy compared with CCA as the gold standard. In this survey, we compared the results of 256-slice CCTA with CTA.

***Method*:** The present cross-sectional descriptive study evaluated 53 patients (36 men) undergoing CCTA and then CCA (except for 4 patients with pervious CCAs). Our primary goal was to compare the 2 imaging methods for the evaluation of coronary lesions and their runoff.

***Results*:** In the coronary artery bypass graft group, the diagnostic accuracy of CCTA for the arterial graft lesions (left internal mammary artery to left anterior descending) had 72.73% sensitivity, 100% specificity, 100% positive predictive value, and 84.2% negative predictive value and its diagnostic accuracy for the venous graft lesions had 100% sensitivity, 80% to 100% specificity, 80% to 100% positive predictive value, and 66.4% to 100% negative predictive value. Apropos runoff (adequacy of perfusion), CCTA had 100% sensitivity, 63.64% specificity, 80% positive predictive value, and 100% negative predictive value in the arterial grafts and 54% to 100% sensitivity and 100% specificity in the venous grafts. In the percutaneous coronary intervention group, CCTA had 90% specificity, and 75% positive predictive value, and 0% negative predictive value in the differentiation of significant from nonsignificant in-stent restenoses.

Conclusions: The diagnostic accuracy of CCTA in determining the severity of arterial graft stenoses and their runoff was similar to that reported in previous studies with 64-slice CTA. Strikingly, CCTA had low sensitivity for significant in-stent restenosis. ***(Iranian Heart Journal 2018; 19(1):30-36)***

KEYWORDS: Coronary CT angiography, Conventional coronary angiography

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Coronary artery disease is one of the most serious and common causes of mortality and morbidity the world over. As with therapeutic measures aimed at improving patients' lives quantitatively and qualitatively, diagnostic methods are also rapidly progressing.

An imaging method, coronary computed tomography angiography (CCTA) can noninvasively and accurately show the coronary tree. The sensitivity and negative predictive value (NPV) of CCTA have been reported to be more than 90% in several studies. [1] This imaging modality can easily substitute conventional coronary angiography (CCA) in patients with low and moderate probabilities of coronary artery disease [2] and can also have a complementary role for CCA—not least where there is an abnormal origin and course for the coronary arteries. However, CCTA has some limitations, the most significant of which is that with severe vascular calcification, it cannot show the lesion clearly, and nor is it capable of accurately demonstrating the vessels during rapid and irregular heart rhythms because of coronary motion artifacts. Moreover, not only does CCTA yield at least the same dose of radiation as CCA according to some studies but also it is expensive and dependent on intravenous radiopaque contrasts with the concomitant risk of contrast-induced side effects (eg, allergic reactions and nephropathy). CCTA uses "spatial" and "temporal" resolution and 3D reconstruction of images. Obtaining higher-resolution images via CCTA requires that the slices be increased from 4 to 16, 64, 256, and ultimately, 512. [3] Each slice is a narrow channel whose arrays are detected by "scintillation crystals" through it. Adding to the number of "slices" or "detectors" leads to the shortening of the radiation time and results in a decrease in the dose of exposure. Many of the previous comparative studies on CCTA and CCA have utilized fewer than 256 detectors. It should be noted that increased time and dose of radiation and relatively low resolution usually compel some physicians to use CCA in lieu of CCTA.

In the present study, we compared the results of 256-slice CCTA with CTA.

METHOD

The present cross-sectional descriptive study was conducted on 53 patients, who underwent 256-slice CCTA followed by CCA at Rajaie Cardiovascular, Medical, and Research Center between September 2009 and March 2012. The data analyzed encompassed age, sex, coronary risk factors (diabetes, dyslipidemia, hypertension, family history, and peripheral arterial disease), and chronic kidney disease. Additionally, the severity of coronary calcification—expressed as the Agatston score—was recorded for the whole study population from their CCTA reports. Subsequently, the CCA films were reviewed once again and the severity of the lesions was reported with the Gensini standard scale. Eyeball estimation was used for coronary runoff (adequacy of perfusion after a lesion or bypass graft). Finally, the data obtained from both CCTA and CCA were compared using SPSS, version 15. The study protocol was approved by the institutional ethics committee, and informed written consent was obtained from all the patients.

RESULTS

Among the 53 patients, 36 (67.9%) were male and 77.35% were 50 years of age or older. The time elapsed between CCTA and CCA was between 1 day and 2.5 years (average = 3.5 mon). The most and least common risk factors were, respectively, hypertension (35.8%) and family history (1.88%); 30% had no risk factors. History of coronary revascularization was reported in 47 (88.6%) patients: 33 had coronary artery bypass graft surgery (CABG), 14 percutaneous coronary intervention (PCI), and 8 both CABG and PCI. The majority of the patients (43.38%) had mild coronary calcification (coronary artery calcium score $\leq$100) and only 9.9% were in the moderate group(coronary artery calcium score=101–400).

Table 1. Classification of the patients based on the coronary artery calcium score

Grade	Agatston Score	Prevalence
0 (mild)	$\prec$100	23 (43.38%)
1 (moderate)	101-400	5 (9.4%)
2 (severe)	401-1000	11 (20.7%)
3 (very severe)	$\succ$100	14 (26.4%)

In the CABG group, 36.3% of the patients had severe calcification (grade 3), whereas 50% of the patients after PCI had mild calcification (grade 1). In the patients with a history of both PCI and CABG, 37.5% were in grade 0 and 37.5% in grade 2. Among the 53 patients, in 90% of the CCTA cases and 16.9% of the CCA cases, the indication for imaging was not mentioned. In the others, the most frequent indication for CCTA was acute coronary syndrome, followed by other reasons (3.77%). Apropos of CCA, most cases underwent CCA because of stable angina (47.16%). In the present study, more than 1000 coronary segments (> ⅔, native) were reviewed. Our goal was to compare diagnostic accuracy in terms of differentiating significant from nonsignificant lesions (significant lesions described as > 50% stenosis in the left main coronary artery and 70% stenosis in the other arteries) between CCTA and CCA (as the gold standard).

Table 2. Diagnostic accuracy of coronary computed tomography angiography for the severity of arterial graft lesions

Indicator	Prevalence (%)
Sensitivity (%)	72
Specificity (%)	100
Disease prevalence (%)	40.7
Positive predictive value (%)	100
Negative predictive value (%)	84.2

1-Posterior descending artery
2-Posterior left ventricular
3-Left internal mammary artery

Table 3. Diagnostic accuracy of coronary computed tomography angiography for the severity of venous graft lesions

Indicator \ Segment	SVG to OM	SVG to Diagonal	SVG to Ramus	SVG to RCA	SVG to PDA
Sensitivity (%)	81.8	80	0	100	50
Specificity (%)	100	80	100	100	100
Disease prevalence (%)	57.8	80	33.3	50	18.8
Positive predictive value (%)	80	80	66.6	100	100
Negative predictive value (%)	80	80	0	100	90

SVG, Saphenous vein graft; OM, Obtuse marginal; RCA, Right coronary artery; PDA, Posterior descending artery

In the current study, we also sought to assess the ability of CCTA to show vascular runoff (adequacy of perfusion after lesions or bypass grafts). Nonetheless, a dearth of available CCTA reports forced us to focus only on bypass grafts. To that end, we divided runoff into poor and good and again used CCA as the gold standard reference.

Table 4. Diagnostic accuracy of coronary computed tomography angiography for the runoff of bypass grafts

Indicator \ Graft	Arterial Graft (prevalence (%)	SVG to OM	SVG to Diagonal	SVG to Ramus	SVG to RCA	SVG to PDA
Sensitivity (%)	100	54.5	100	100	100	70
Specificity (%)	63.6	75	60	0	100	100
Disease prevalence (%)	59.2	57.8	37.5	66.6	50	90
Positive predictive value (%)	80	75	60	0	100	100
Negative predictive value (%)	100	54.5	100	66.6	100	65

SVG, Saphenous vein graft; OM, Obtuse marginal; RCA, Right coronary artery; PDA, Posterior descending artery

One of the properties of imaging processes is revealing in-stent restenosis after PCI. In the current study, our objective was to compare CCTA and CCA to estimate significant in-stent stenosis (> 50% stenosis in the stent lumen); nevertheless, of the 14 PCI patients, only data on 12 patients were complete.

Our results demonstrated coronary anomalies in 13.2% of the patients. Except for 1 case of left anterior descending muscle bridge in CCA, which was not mentioned by CCTA, in the other cases, there was a good correlation between the 2 imaging methods. Even in 2 patients with the anomalous origin of the coronary artery, both methods were able to demonstrate the abnormal origin. There was 1 missed case of left anterior descending muscle bridge in CCA because injection into the left coronary system had not been done.

One of our goals was to compare imaging findings in patients with acute coronary syndrome. However, CCTA was conducted only for 1 patient for this indication, while 27 (50.94%) patients underwent CCA because of suspected acute coronary syndrome. Statistical comparison was, therefore, not logical.

There was also a good correlation in the final diagnosis of coronary lesions. Although the time elapsed between the 2 procedures was relatively long (average = 3.5 mm), even the severity of calcification did not have a negative effect. There were a few other differences as well. One case of single-vessel disease in CCA was reported to be minimal coronary artery disease by CCTA. In addition, for 1 patient with minimal coronary artery disease, slow flow was not mentioned in the CCTA report. Furthermore, there was 1 patient with an old thrombotic lesion in the right coronary artery; the CCTA report included only single-vessel disease. (The patient had thrombotic thrombocytopenic purpura with recurrent thrombotic events.) And finally, in 1 case, 2-vessel disease by CCA was reported as single-vessel disease by CCTA.

Planning appropriate therapy based on imaging data needs the consideration of several factors such as history taking, physical examination, coronary artery disease risk factors, functional tests, response to medical treatment, technical issues of revascularization, and comorbidities. Normally, one or more ways can be offered—from merely no-medication follow-up to CABG.

In the present study, no complication was reported. There were only 3 cases of failed PCI, and 88.6% had a history of revascularization (72% CABG).

The severity of coronary calcification is an important prognostic factor in patients with suspected or documented atherosclerotic coronary artery disease. In middle-aged women with detectable left anterior descending coronary arteries, the risk of coronary events is more than 2%, but it increases with more calcification. The coronary artery calcium score is even helpful for assessing the possibility of coronary artery disease. In the new AHA/ACCF guidelines, coronary CT angiography is recommended as class IIa indication for subgroups (eg, family history of premature coronary artery disease in low-risk patients). [9] The coronary artery calcium score determines the risk of coronary artery disease even after standard risk factors. With this method, the quantity of calcium precipitated in each coronary artery and plaque is summed to determine the coronary artery calcium score for every patient. Unstable plaques have punctuated walls and the more stable ones show a diffuse pattern of calcification. [6] The presence and extent of the coronary artery calcium score is dependent on sex, age, race, and standard coronary artery risk factors. In the current study, a single coronary artery calcium score was used for each patient.

Most of our patients had a mild coronary artery calcium score (43%); this finding chimes in with some previous studies. Nonetheless, this pattern differed between the CABG and PCI groups insofar as after CABG, most patients had a coronary artery calcium score greater than 1000 (very severe) before PCI , with less than 100 (mild) after PCI. This high score can disrupt the assessment of coronary lesions because of artifacts.

As was noted above, we were not able to compare the 2 groups with respect to acute coronary syndrome indications. After CABG, the bypass grafts are easier to assess than the native vessels because of their higher diameter and less mobility; still, artifacts (from metallic sutures and severe coronary calcification) may disturb the image.

The indication of imaging was not mentioned in 48 (90.6%) patients in the CCTA group and in 9 (17%) patients in the CCA group. As regards symptoms, while 33 CCA patients were symptomatic (stable angina), only 3 (5.6%) patients in the CCTA group were symptomatic—rendering a statistical comparison illogical.

DISCUSSION

CCTA is an advanced imaging modality in coronary artery disease. Although coronary atherosclerosis is the chief culprit for the burden of cardiovascular diseases, CCTA is valuable for evaluating other structures such as cardiac chambers, valves, great vessels, pericardium, and adjacent tissues. [10, 11] We designed the present study to assess the diagnostic accuracy of CCTA only for coronary arteries.

As is the case with most imaging studies conducted on atherosclerotic disease, the age and gender of our patients influenced the overall patterns of their disease. Men accounted for 67.4% of our study population, and 77.35% of our patients were aged 50 years or older.

Whereas in previous studies smoking was the second important risk factor after age, [1] we found that it ranked fourth after age, hypertension, and dyslipidemia (24.5% were smokers). Vis-à-vis risk factors, 28% of our patients had 2 or more risk factors (including diabetes, hypertension, smoking, dyslipidemia, family history, chronic kidney disease, and peripheral arterial disease), and 30% had none of them.

Both imaging methods had a good correlation for coronary anomalies in our study.

Our comparison of CCTA and CCA showed that there was a good correlation vis-à-vis the final diagnosis with the exception of 5 cases amid a heavy burden of calcification in the CABG group. Be that as it may, it seems that this comparison would not be logical for the “therapeutic plan” because it depends on several other factors such as comorbidities, noninvasive tests, and response to medication.

There was no documented complication in any of the groups, but it may have been merely because no complication was mentioned because of the absence of a long-term follow-up (eg, cutaneous effects of radiation).

Coronary Lesions

A. Native arteries:

1-Left main coronary artery: Sensitivity was about 50%, and specificity ranged between 89.8% (distal) and 95.7% (proximal).

2- Left anterior descending artery: Sensitivity ranged from 27.78% (distal) to 67.86% (mid-part), and specificity ranged between 68.18% (mid-part) and 100% (ostium). This finding is concordant with other studies, although we had low CCTA sensitivity for the ostial left anterior descending lesions.

3-First diagonal artery: Sensitivity and specificity were 60% and 89.4%, correspondingly.

4-Second diagonal artery: Sensitivity was 20% (low) and specificity was 86.6%.

5-Left circumflex artery: The ostium could not be assessed, but sensitivity ranged between 30% (distal) and 63.6% (proximal) and specificity ranged from 83.3% (distal) to 82.2% (mid-part), which is low-to-moderate sensitivity for significant lesions.

6-First obtuse marginal branch: Sensitivity and specificity were 60% and 91.6%, respectively.

7-Second obtuse marginal branch: Both sensitivity and specificity were 100%.
8-Ramus intermedius artery: Sensitivity was 33.3% and specificity for all the segments was 100%.
9-Right coronary artery: specificity of 100% for the ostial segment. For the other segments, sensitivity ranged from 58.33% (distal) to 70.54% (mid-part) and specificity ranged between 83.78% (distal) and 94.74% (proximal).
10- Posterior descending artery: Sensitivity and specificity were 50% and 90.32%, correspondingly (P = 0.03).
11- Posterior left ventricular branch: There was 50% sensitivity and 100% specificity.
Accordingly, the specificity of CCTA was relatively acceptable for significant lesions, but its sensitivity was lower than that reported in previous studies.

B- Bypass grafts:
CCA was done for 33 patients after CABG: 31 of them had 1 arterial graft (only left internal mammary artery to left anterior descending). Our results showed 63.64% sensitivity for arterial graft lesions. It should be mentioned, however, that a previous study with 64-slice MDCT reported a sensitivity of more than 90%. For the venous grafts, sensitivity was about 100% for saphenous vein graft to obtuse marginal and posterior left ventricular branch and specificity ranged from 80% (saphenous vein graft to diagonal) to 100% (other vein grafts).
Concerning bypass runoff, sensitivity was 100% for the arterial grafts and specificity was 63.64% for the venous grafts. Sensitivity ranged between 54.5% (saphenous vein graft to obtuse marginal) and 100% (other saphenous vein grafts) and specificity for (saphenous vein graft to ramus) was 100% (saphenous vein graft to posterior descending artery and right coronary artery). A previous study employed 64-slice MDCT and showed sensitivity and specificity of 95% for runoff after CABG.

CCTA is also used for the evaluation of in-stent restenosis.[4, 5] It is more valuable in stents with larger diameters (≥ 3 mm); nonetheless, the metallic structure can cause misinterpretation because of artifacts. In our study, CCTA had specificity of 90% (coefficient variation = 0.13; P = 0.56) for in-stent stenosis. However, a previous study reported sensitivity of 90.9% and specificity of 95.2% for the ability of CCTA to detect the severity of in-stent stenosis.

Recommendations

With the constant increase in the number of patients, it seems advisable that hospital forms be filled more carefully and completely. In addition, there should be common protocols of imaging for physicians involved in cardiovascular care.

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