The Diagnostic Performance of 64-Slice Multislice Computed Tomography in Assessment of Coronary Artery Disease

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Abstract

The diagnostic performance of 64 slice multislice computed tomography in assessment of coronary artery disease.

Aim of the Work: To assess the diagnostic performance of 64-slice computed tomography coronary angiography (CTCA) to detect or rule out coronary artery disease (CAD).

Secondary Objective: To assess the usefulness of CTCA in patients with various estimated pretest probabilities of CAD.

Background: The pretest probability of the presence of CAD may impact the diagnostic performance of CTCA.

Design: Analytic comparative study.

Sampling: Comprehensive universal sample.

Site of the Study: Farwania Hospital, Kuwait.

Methods: 42 patients, mean age 54 (±18) years with known and suspected coronary artery disease underwent 64-slice MSCT. Patients with heart rates >65 beats/min. received beta-blockers before CTCA. The pretest probability for significant CAD was estimated by type of chest discomfort, age, gender, and traditional risk factors and defined as high (>71%), intermediate (31% to 70%), and low (<30%). Significant CAD was defined as the presence of at least ≥50% coronary stenosis on quantitative coronary angiography, which was the standard of reference.

Main Outcome Measures: Diagnostic accuracy of 64-slice MSCT to detect obstructive (>50% luminal narrowing) stenosis in patients.

Results: On segmental level, 608 coronary segments were of sufficient quality (85.2%). In the 42 patients included; the sensitivity (88.4%) and specificity (94.3%) on a segmental level.

On a patient level, the sensitivity (87%), specificity (78.9%) whereas on the vessel level, the sensitivity and specificity were 91.2% and 87.4% respectively.

The estimated pretest probability of CAD in the high (n = 18), intermediate (n = 13), and low (n = 11) groups was 88%, 54%, and 12%, respectively.

The diagnostic performance of CT was different in the 3 subgroups. The estimated post-test probability of the presence of significant CAD after a negative CT scan was 16%, 0% and 0% and after a positive CT was 95%, 86%, and 66%, respectively.

Conclusion: The findings confirm the high diagnostic accuracy of 64–slice MSCT coronary angiography. CTCA is useful in symptomatic patients with a low or intermediate estimated pretest probability of having significant CAD, and a negative CT accurately rules out the presence of significant CAD. CTCA does not provide additional relevant diagnostic information in symptomatic patients with a high estimated pretest probability of CAD.

Key Words: Computed tomography coronary angiography – Coronary artery disease.

Introduction

CAD is the leading cause of mortality in the Western world and it is rapidly becoming the number one killer in the developing countries [1]. Currently, invasive coronary angiography provides the standard of reference for definitive diagnosis [2]. Thus, in many patients with an intermediate pre-test probability for CAD, significant coronary artery stenosis is being ruled out by invasive angiography. To prevent ‘unnecessary’ invasive tests, a reliable and reproducible non-invasive diagnostic method for the detection and grading of coronary artery stenosis is highly desirable. Non-invasive MSCT is a promising diagnostic methodology for the identification of significant coronary artery stenosis in vessels >1.5-2mm in size [3-8]. However, in most studies comparing non-invasive MSCT with invasive coronary angiography, the presented sensitivities and specificities to detect significant coronary stenosis were calculated after the exclusion of coronary segments with inadequate image quality. Furthermore, these studies did not address the clinical usefulness of coronary MSCT in a well-defined patient population in which the diagnostic value is expected to be greatest. According to the Bayesian theory, coronary MSCT angiography is anticipated to have the greatest impact in increasing
or lowering the likelihood of significant CAD in patients with an intermediate probability for CAD. Finally, the diagnostic impact of the recent advances in MSCT technology with 64-slice scanners needs to be more evaluated.

MSCT CA allows direct non-invasive visualization of coronary arteries and accurate detection of obstructive lesions as compared with invasive coronary angiography. Indeed, the reported mean sensitivity and specificity of 64-slice MSCT are 87% and 96%, respectively. In particular, the negative predictive value was extremely high (approaching 100%), allowing reliable exclusion of CAD [6,7]. The estimated pretest probability of having significant CAD in a study population should be taken into account in the evaluation of the diagnostic accuracy of CTCA to detect or rule out the presence of coronary stenosis. The estimated pretest probability of having obstructive CAD in patients who present with chest pain is related to age, gender, type of chest discomfort, and traditional risk factors. The estimated pretest probability is lowest in younger female patients with non-anginal chest pain and highest in older male patients with typical angina [8]. The diagnostic performance of CTCA has mostly been tested in symptomatic patient populations with a high estimated pretest probability of having significant CAD, and a few studies have reported on the impact of different estimated pretest probabilities on the performance of CTCA [9].

Accordingly, the purpose of this study is to compare the diagnostic accuracy of 64-slice CTCA in different pretest probabilities, using conventional coronary angiography as a gold standard.

Aim of the work:

1- To evaluate the diagnostic performance of CTCA in diagnosis of CAD.

2- To evaluate the diagnostic yield of CTCA in patients with high, intermediate, or low estimated pretest probability of having significant coronary stenosis.

Patients and Methods

Study population:

Patient demographics are shown in Table (1). During about two year period, 42 patients presenting with typical angina pectoris, atypical angina pectoris, and non-anginal chest pain who were referred for CTCA were included into the study.

Typical angina was defined as having 3 characteristics:
- Substernal discomfort;
- That is precipitated by physical exertion or emotion; and
- Relieved with rest or nitroglycerin within 1 0min.

Atypical angina pectoris was defined as having 2 of 3 of the definition characteristics. Non-anginal chest pain was characterized as 1 or absence of the described chest pain features. The estimated pretest probability for obstructive CAD was estimated using the Duke Clinical Score, which includes type of chest discomfort, age, gender, and traditional risk factors [10,11].

Patients were categorized into a low (1 % to 30%), intermediate (31% to 70%), or high (71% to 99%) estimated pretest probability group of having significant CAD.

Excluding criteria: Previous history of percutaneous coronary intervention, coronary artery bypass surgery, prior myocardial infarction, impaired renal function (serum creatinine >120 µmol/l), persistent arrhythmias, or known allergy to iodinated contrast material.

Conventional coronary angiogram was performed and served as the gold standard. The median interval between conventional and MSCT coronary angiography was 4 (0-8) weeks. No intervening changes in the clinical condition of the patients occurred between the two examinations.

Ethical considerations:

All subjects gave informed consent.

Patient preparation: In patients with a heart rate of >60b.p.m. up to four doses of 5mg of metoprolol were administered intravenously to lower heart rate at the time of the CT study. In addition, coronary vasodilatation was achieved by the administration of nitroglycerin 0.8mg sublingually in all patients with a systolic blood pressure of at least 100mmHg. An initial non-enhanced ECG-gated scan was performed for calcium scoring.

Scan protocol: All scans were performed with a 64-slice CT scanner that features a gantry rotation time of 330ms, a temporal resolution of 165ms, and a spatial resolution of 0.4mm³ (GE, light speed, VCT 64 slice). A calcium scoring scan was performed with the following parameters: 64 X 0.6mm collimation, 330ms rotation time, 120 kV tube voltage, 150mAs tube current, 3.8mm/rotation table feed, prospective electrocardiogram (ECG)
X-ray tube modulation. Afterward, the CTCA was performed using identical parameters aside from a higher tube current between 850 and 960mAs and without the use of prospective ECG X-ray tube modulation. A bolus of 95ml of contrast material (350mgI/ml; Omnipaque, Iohexol, GE, Ireland) was injected intravenously in an antecubital vein at 5ml/s, and a bolus-tracking technique was used to synchronize the arrival of contrast in the coronary arteries and the initiation of the scan. Images were reconstructed in mid-diastole; additional image reconstructions were performed in end-systole if required. The position of the reconstruction window within the cardiac cycle was individually optimized to minimize motion artifacts [12,13].

**Image reconstruction:** Datasets were reconstructed immediately after the scan after a stepwise approach as previously described [14,15]. If necessary, multiple datasets of a single patient were used separately in order to obtain optimal image quality for all available coronary segments. Quantitative coronary angiography (QCA): All scans were carried out within 8 week before or after CCA. One experienced cardiologist, unaware of the results of CTCA, identified and analyzed all coronary segments, using a 17-segment modified American Heart Association classification [10]. All segments, regardless of size, were included for comparison with CTCA.

**Segments were classified as:**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Smooth parallel or tapering borders</td>
</tr>
<tr>
<td>Non-Significant disease</td>
<td>Wall irregularities or &lt;50% stenosis.</td>
</tr>
<tr>
<td>Significant disease</td>
<td>&gt;50% stenosis.</td>
</tr>
</tbody>
</table>

Stenoses were evaluated in the worst view, and classified as significant if the lumen diameter reduction exceeded ≥50% measured by validated quantitative coronary angiography (QCA) algorithm (CAAS, Pie Medical, Maastricht, the Netherlands) [14].

**CT image evaluation:** One observer analyzed total calcium scores of all patients using dedicated software. Two observers, radiologist, unaware of the results of CCA, evaluated the CTCA data sets on an offline workstation, (GE advantage workstation, France), using (curved) multiplanar reconstruction. Segments were scored positive for significant CAD if there was ≥50% diameter reduction of the lumen by visual assessment. Segments distal to a chronic total occlusion were excluded. Inter-observer disagreements were resolved by a third reader [15].

**Statistical analysis:** The diagnostic performance of CTCA for the detection of significant coronary artery stenoses as defined by QCA is presented as accuracy, sensitivity, specificity with the corresponding 95% confidence intervals. Comparison between CTCA and QCA was performed on 3 levels: Patient-by-patient, vessel-by-vessel, and segment-by-segment analysis. A Mantel-Haenszel test was performed to evaluate the trend in sensitivity and specificity relative to the estimated pretest probability for obstructive CAD. Categorical characteristics are expressed as numbers and percentages, and compared between the 3 groups using the chi-square test. Continuous variables are expressed as means (standard deviation) and compared with 1-way analysis of variance followed by post-hoc Bonferroni correction to adjust for multiple comparisons. If not normally distributed, continuous variables are expressed as medians (25th to 75th percentile range) and compared with Kruskal-Wallis test. Interobserver and intraobserver variability for the detection of significant coronary stenosis and agreement between techniques to classify patients as having no, single-, or multi-vessel disease was determined by k-statistics.

**Results**

In this study, a total of 42 patients, 169 coronary arteries with 608 segments were analyzed. The prevalence of significant stenosis was 20.1% and 7.1% on a per-artery and on a per-segment basis, respectively. Additional beta-blockers before CT scanning were administered in 90.5% (38 of 42) of patients decreasing the mean heart rate from 73±14beats/min to 60±7beats/min. The mean scan time was 13.1±1.7s. Initially, all data sets were reconstructed in the mid- to end-diastolic phase. In 26.2% of the cases (11 of 42), additional higher quality reconstructions obtained during end systole were used for evaluation.

Diagnostic performance of 64-slice CTCA: All patients with chest pain.

The observed pretest probability of significant CAD, defined as having at least 1 ≥50% coronary stenosis per patient was 50%. The diagnostic performance of CTCA for detecting significant stenoses on a patient level is detailed in Table (2).

Four patients with angiographic non-significant disease were incorrectly classified as having significant CAD by CT: 4 patients were scored as...
having single-vessel disease, and no patient was misinterpreted as having multi-vessel disease. Eighty seven percent (20 of 23) of patients with significant CAD on CCA were correctly identified by CTCA (Fig. 1). The 3 patient in whom the severity of disease was underestimated showed two significant lumen narrowing in the circumflex coronary artery (51 % diameter reduction, in the mid- and lower segment) and one stenosed (52%) left anterior descending artery. Seven patients with single vessel disease were evaluated as having multi-vessel disease by CTCA due to overestimation of disease severity in other vessels. Agreement between CTCA and QCA on a per patient (no or any disease) level was very good (k-value: 0.84), whereas agreement between techniques to classify patients as having no, single-, and multi-vessel disease was good (k-value: 0.61).

Diagnostic performance of 64-Slice CTCA: patient-by-patient analysis: The analysis comprised 18 (42.9%) patients with a high estimated pretest probability for CAD, 13 (31%) patients with an intermediate, and 11 (26.2%) patients with a low estimated pretest probability for CAD. The mean age between patients with high estimated probability and intermediate estimated probability was significantly different from the mean age in the low probability group, and the median calcium score was significantly different in all 3 groups. The mean heart rate was significantly lower in the high estimated probability group compared with those seen in the intermediate and low estimated probability groups (Table 1).

The diagnostic performance of CTCA was different in the patient groups with various estimated pretest probabilities. The specificity showed a trend with a lower specificity in the high estimated pretest probability (p<0.05, sensitivity p=NS). The diagnostic impact of CTCA on the estimated pretest probability of having significant CAD is shown in Tables (2&3).

Diagnostic performance of 64-slice CTCA: vessel-by-vessel analysis: The diagnostic performance of CTCA for the detection of significant lesions on a vessel-based analysis is detailed in Table (2). One significantly diseased left anterior descending artery and two diseased circumflex coronary arteries were incorrectly classified as non-significantly diseased by CTCA. Of a total of 169 vessels, the severity of a lesion was overestimated in 17 non-obstructive vessels (false positives). The diagnostic performance of the CT scan was different in the 3 subgroups.

The specificity showed a trend towards lower specificity (tiny difference) in the high estimated pretest probability. Agreement between CTCA and QCA on a per-vessel level was good (k-value: 0.71).

Diagnostic performance of 64-slice CTCA: segment-by-segment analysis: Overall, 608 (of 714 potentially available segments) were included for comparison with QCA. Unavailable segments included 88 anatomically absent segments on CCA and 18 segments distal to an occluded coronary segment. Segments were not excluded for reasons such as severe calcifications or poor image quality. The k-value for interobserver and intraobserver variability was 0.70 and 0.72, respectively. The diagnostic performance of CTCA for detecting significant stenoses is detailed in Table (2). Agreement between CTCA and QCA on a per-segment level was good (k-value, 0.64). The severity of 5 significant coronary stenoses was underestimated or missed and classified as non-significant by CTCA. All of these significant lesions (5 of 5) were located in distal segments or in side branches. The severity of 32 non-significant lesions was overestimated by CTCA. The diagnostic performance of the CT scan was different in the 3 subgroups with a lower sensitivity and a higher specificity in all groups, more in the low pretest probability group (Table 2).

The MSCT study demonstrated a total of 4/42 (9.5%) patients with an absence of coronary calcifications (ASE of 0). Of these 4 patients, 1 (25%) patients presented with a significant stenosis by invasive angiography, and all of these non-calcified lesions were correctly detected by CT angiography.

Influence of heart rate on multislice spiral computed tomography accuracy: A heart rate of >65 b.p.m. was present in 2 (4.8%) of 42 patients during scanning despite the administration of B-blockers. In these patients, significantly more segments were considered inconclusive on a per-segment basis, resulting in significantly lower specificity.

Influence of coronary calcifications: Two patients with 21 coronary segments presented with an ASE over 1000. In these patients, significantly more segments were difficult to interpret and affect the specificity on a per-segment basis. On a per-patient basis, CT angiography results in false positive, as it can not rule out stenosis with high calcium score. Invasive angiography demonstrated significant coronary artery stenosis in 20 (83%) of these 24 patients.
Table (1): Pretest probability of significant CAD.

<table>
<thead>
<tr>
<th></th>
<th>High &gt;70% (n=18)</th>
<th>Intermediate 30% to 70% (n=13)</th>
<th>Low &lt;30% (n=11)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>16</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Age (yrs) mean ± SD</td>
<td>63±9</td>
<td>61±8</td>
<td>48±12</td>
<td>0.0001</td>
</tr>
<tr>
<td>BMI (kg/m²)*</td>
<td>27.4±3.1</td>
<td>28.2±3.9</td>
<td>27.1±4.5</td>
<td>0.45</td>
</tr>
<tr>
<td>Heart rate)*</td>
<td>58-5</td>
<td>63±4</td>
<td>61±5</td>
<td>0.005</td>
</tr>
<tr>
<td>Calcium score $</td>
<td>379 (99-625)</td>
<td>131 (4-250)</td>
<td>0 (0-67)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Typical angina</td>
<td>15</td>
<td>6</td>
<td>0</td>
<td>0.004</td>
</tr>
<tr>
<td>Atypical angina</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0.005</td>
</tr>
<tr>
<td>Non-anginal chest pain</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Risk factors

Hypertension & 12 | 6 | 5 | 0.021
Hypercholesterolemia @ 12 | 6 | 6 | 0.01
Diabetes mellitus # 5 | 5 | 1 | 0.11
Current smoker 8 | 3 | 1 | 0.12
Previous smoker 2 | 1 | 0 | 0.3
Family history of CAD ∞ 7 | 6 | 5 | 0.09
Obesity Ω 11 | 7 | 6 | 0.07

*p*: (Beats/min).
$*: Agatston score.
&*: (Blood pressure ≥140/90mmHg or treatment for hypertension).
@*: (Total cholesterol ≥180mg/dl or treatment for Hypercholesterolemia).
#: (Treatment with oral antidiabetic medication or insulin).
∞*: (Family history of CAD, having first- or second-degree relatives with premature CAD (age <55 years).
Ω*: (Body mass index (BMI) ≥30kg/m²). The p-values <0.05 were considered statistically significant [16].

Table (2): Observed and estimated pretest probability of CAD.

<table>
<thead>
<tr>
<th>Patient-based Analysis</th>
<th>Observed Pretest Probability, %</th>
<th>Estimated Pretest Probability, %</th>
<th>N</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>50</td>
<td>42</td>
<td>20</td>
<td>15</td>
<td>4</td>
<td>3</td>
<td>87</td>
<td>78.9</td>
<td>83.3</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>77</td>
<td>88</td>
<td>18</td>
<td>13</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>92.9</td>
<td>50</td>
<td>83.3</td>
</tr>
<tr>
<td>Intermediate</td>
<td>40</td>
<td>54</td>
<td>13</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>83.3</td>
<td>85.7</td>
<td>84.6</td>
</tr>
<tr>
<td>Low</td>
<td>17</td>
<td>12</td>
<td>11</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>66.7</td>
<td>87.5</td>
<td>81.8</td>
</tr>
</tbody>
</table>

Vessel-based Analysis

<table>
<thead>
<tr>
<th></th>
<th>Observed* Pretest Probability, %</th>
<th>N</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>18</td>
<td>169</td>
<td>31</td>
<td>118</td>
<td>17</td>
<td>3</td>
<td>91.2</td>
<td>87.4</td>
<td>88.1</td>
</tr>
<tr>
<td>High</td>
<td>30</td>
<td>69</td>
<td>21</td>
<td>37</td>
<td>10</td>
<td>1</td>
<td>95.5</td>
<td>78.7</td>
<td>84.1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>14</td>
<td>53</td>
<td>6</td>
<td>42</td>
<td>4</td>
<td>1</td>
<td>85.7</td>
<td>91.3</td>
<td>90.6</td>
</tr>
<tr>
<td>Low</td>
<td>5</td>
<td>47</td>
<td>4</td>
<td>39</td>
<td>3</td>
<td>1</td>
<td>80</td>
<td>92.9</td>
<td>91.5</td>
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</tbody>
</table>

Segment-based Analysis

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>8</td>
<td>608</td>
<td>38</td>
<td>533</td>
<td>32</td>
<td>5</td>
<td>8.8.4</td>
<td>94.3</td>
</tr>
<tr>
<td>High</td>
<td>11</td>
<td>245</td>
<td>27</td>
<td>194</td>
<td>21</td>
<td>3</td>
<td>90.2</td>
<td>98.5</td>
</tr>
<tr>
<td>Intermediate</td>
<td>5</td>
<td>203</td>
<td>8</td>
<td>185</td>
<td>9</td>
<td>1</td>
<td>95.4</td>
<td>99.5</td>
</tr>
<tr>
<td>Low</td>
<td>3</td>
<td>160</td>
<td>3</td>
<td>154</td>
<td>2</td>
<td>1</td>
<td>98.7</td>
<td>99.4</td>
</tr>
</tbody>
</table>

Observed pretest probability: Based on conventional coronary angiography (≥1 significant coronary stenosis as determined by quantitative coronary angiography [QCA]); estimated pretest probability: Estimated using Duke Clinical Score; the sensitivity showed a trend with a lower sensitivity in the low estimated pretest probability in the per-segment analysis (p <0.05); the specificity showed a trend with a lower specificity in the high estimated pretest probability in the per-patient, per-vessel, and per-segment analysis (p <0.05, p<0.0001, p<0.0001, respectively).

NPV = Negative predictive value. PPV = Positive predictive value. TN = True negative. TP = True positive.
### Table (3): Impact of CTCA on Various Estimated Pretest Probabilities of Significant CAD.

<table>
<thead>
<tr>
<th>Pre-test Probability for CAD</th>
<th>Pre-test Probability</th>
<th>Pre-test Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>Est: 88% Obs: 77%</td>
<td>Est: 54% Obs: 40%</td>
</tr>
<tr>
<td><strong>Intermediate</strong></td>
<td>Est: 54% Obs: 40%</td>
<td>Est: 12% Obs: 17%</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>Est: 12% Obs: 17%</td>
<td></td>
</tr>
</tbody>
</table>

- **CTCA**
  - N : 18
  - N : 13
  - N : 11

- **Positive**
  - N = 15
  - N = 6
  - N = 3
  - N = 6
  - N = 3
  - N = 8

- **Negative**
  - N = 3
  - N = 7
  - N = 8
  - N = 7
  - N = 8
  - N = 8

- **Post-test Probability**
  - Est: 95% Obs: 91%
  - Est: 16% Obs: 11%
  - Est: 86% Obs: 79%
  - Est: 0% Obs: 0%
  - Est: 66% Obs: 72%
  - Est: 0% Obs: 0%

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Estimated using Duke Clinical Score (including Diamond-Forrester criteria and prognostic clinical variables); based on conventional coronary angiography (>1 significant coronary stenosis as determined by quantitative coronary angiography); calculated using Bayesian statistics (post-test odds = pretest odds = likelihood ratio).

**Est** = Estimated. **CAD** = Coronary artery disease. **Obs** = Observed. **CTCA** = Computed tomography coronary angiography.

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**Fig. (1):** 49 years old male patient with calcium score 56. MDCT (A, B MIP & C Volume rendering) displays mixed plaque with no significant stenosis. D, Coronary angiography revealed minor irregularities in the proximal segment of LAD.
Fig. (2): Calcium score calculated for a woman 55 years old, (A&B) RCA=1 and LCX=79. (C&D) LAD=5.

Fig. (3): Male 46 years old patient, Calcium score = 255. MDCT shows (A) Calcified plaque at proximal segment of LAD, soft plaque at middle segment results in 30-40% stenosis with patent distal segment. (B,C) LCX displays circumferential soft plaque along middle and distal segment with no significant stenosis. (D,E) RCA shows calcified plaque at proximal segment with no significant stenosis and distal segment displays soft plaque with vessel remodeling without stenosis. (F,G) Volume rendering shows calcified plaques of RCA & LCX. Coronary angiography revealed vessel irregularities without significant stenosis.
Fig. (4): Male 57 years old, calcium score 716. MDCT (A) RCA calcific plaques all the course but patent distal lumen. (B) LAD: Complex calcific plaques at proximal segment with 30-40% stenosis and patent distal segment. (C,D,E) Volume rendering show stenotic LAD and RCA dense calcified plaques with narrowed lumen, LCX, calcific plaques proximal segment, obscure the lumen with patent distal segment. Coronary angiography (F) Documented significant stenosis of LAD, however, no significant stenosis of RCA and LCX.

Fig. (5): Male 48 years old, calcium score 114. MDCT (A,B,C,D) Shows soft plaque mid segment of RCA with 50% stenosis. Coronary angiography (E) Revealed only mild concentric lumen reduction (insignificant).
**Discussion**

MSCT imaging technology, the studies demonstrated that significant coronary artery lesions (>50% stenosis) could be identified with high accuracy. However, all of them present with significant limitations for transferring these results into clinical practice. First, patients with a wide range of pre-test probabilities for having CAD were included in these studies [3-8]. In addition to patients with suspected CAD, other studies included patients with known CAD, with previous percutaneous coronary intervention, or patients before a planned aorto-coronary bypass procedure. Accordingly, the prevalence of patients with at least one significant stenosis ranged from 31 to almost 80% with a majority of studies presenting with a disease prevalence of >50% [16,17]. The diagnostic perfor-
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The majority of these patients presented with a high estimated pretest probability of having significant CAD, and only scant information is available on the diagnostic performance of 64-slice CTCA in patients with a low or intermediate estimated pretest probability of having significant CAD. In this study, I used the Duke Clinical Score, which incorporates clinical presentation of chest pain, age, gender, and traditional risk factors, to estimate the pretest probability of having significant CAD. The pretest probability of CAD may impact of the diagnostic performance of the CT scan. Indeed, the diagnostic performance of CTCA in the 3 groups was different. The specificity was lower in the high pretest probability group compared with the low pretest probability group; whereas sensitivity was low in the per-segment analysis in the low pretest probability group. This observation can probably be explained by the higher calcium scores in the higher probability groups, which tend to overestimate the severity of stenosis. A negative CT scan was present in 72.7% of the patients with a low estimated pretest probability (Figs. 1&2) and in 53.8% of the patients with an intermediate estimated pretest probability (Figs. 3&4). The negative predictive value of CTCA to exclude significant CAD was good in these patients, reducing the estimated post-test probability to zero. Thus, these patients would not need further downstream diagnostic tests. They may be candidates for secondary prevention measures, such as statin therapy in the presence of non-obstructive plaques or could be discharged from further cardiac follow-up in the absence of any visible plaque. A positive CT scan occurred in 27.3% and 46.2% of the patients with a low and intermediate estimated pretest probability, respectively (Figs. 5-7). The number of false positive outcomes was rather high in these patients, which renders a positive CT scan rather unreliable for clinical decision making. In these patients it may be reasonable to proceed to invasive CCA in the case of left main disease, 3-vessel disease, and in the presence of a critical stenosis in the proximal part of a major coronary artery. In case of vessel disease in distal vessels or side branches, equivocal lesions, or uninterpretable scans, one may consider a noninvasive stress test to determine the functional significance of a doubtful coronary stenosis. A negative functional test may overrule the clinical significance of a (false)-positive CT scan and reduce the need for invasive coronary angiography [24]. A positive functional test may further increase the probability of having significant CAD and should be followed by invasive coronary angiography and coronary revascularization if symptoms are not alleviated by the anti-anginal medication. However, further studies are necessary to evaluate the diagnostic value of the combination of functional data from a stress test with the anatomical data provided by CTCA. In the high estimated pretest probability group, a negative CTCA reduced the estimated post-test probability to 16%, whereas a positive CTCA increased the estimated post-test probability to as high as 95%. Given the high estimated pretest probability of significant CAD in this group, the majority of these symptomatic patients are likely to proceed to invasive CCA even if CTCA is negative, since the post-test probability of significant CAD was still >10%. Computed tomography coronary angiography, therefore, appears to be of limited clinical value in the evaluation of the high estimated pretest probability group. Assessment for the presence of myocardial ischemia with a functional test may be more appropriate in this situation [20]. The investigated patients do not resemble patients in whom non-invasive coronary CT angiography is most likely being used [17].

Second, a significant proportion of coronary segments remain inconclusive despite the advances in spatial and temporal resolution [4,18,19]. In previous studies, inconclusive segments were usually excluded from the analysis. In contrast, an ‘intention-to-diagnose’-based analysis without the exclusion of inconclusive coronary segments was used in the current study, and all patients with inconclusive segments were considered as having significant CAD [22]. Therefore, this conservative assessment of CT angiographies resulted in lower specificities and positive predictive values than in previous trials comparing both methodologies. Extensive coronary calcifications have been identified as a substantial problem for the interpretation of CT angiograms and the detection of coronary stenosis, because of the blooming effect and beam hardening of these [4,25]. With current CT scanner systems, the value of the ‘gate keeping’ function is affected by the need for ‘unnecessary’ invasive testing in a small subgroup of patients [23]. MSCT technologies may help to reduce the frequency of inconclusive MSCT readings. On the basis of the current analysis, at least two diagnostic work-up strategies are conceivable to improve the ‘gate keeping’ function of coronary CT angiography: (i) patients with extensive coronary calcifications in the low-dose calcium scoring scan should not undergo subsequent CT angiography, because the
diagnostic yield appears to be low and (ii) patients with inconclusive CT angiography results may undergo other non-invasive functional tests before invasive angiography, e.g. magnetic resonance perfusion imaging or myocardial scintigraphy, to rule out haemodynamically relevant CAD [16,21]. General limitations of coronary MSCT angiography include the pre-requisite of sinus rhythm, the application of potentially nephrotoxic contrast dyes, and the associated radiation exposure.

Conclusion:

The study demonstrates the high diagnostic yield of 64-slice MSCT coronary angiography. CTCA is useful in symptomatic patients with a low or intermediate estimated pretest probability of having significant CAD, and a negative CT scan reliably rules out the presence of significant CAD. CTCA does not provide additional relevant diagnostic information in symptomatic patients with a high estimated pretest probability of CAD.

References


