Accuracy of 16-Row Multidetector Computed Tomography for the Assessment of Coronary Artery Stenosis

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CORONARY ARTERY DISEASE REPRESENTS A LEADING CAUSE OF DEATH AND HEALTH CARE EXPENDITURE IN WESTERN COUNTRIES. Establishing its anatomic diagnosis requires coronary angiography, a procedure that is costly and carries risks and discomfort.1,2 Recent technical advances in multidetector computed tomography (MDCT) have led to fast electrocardiogram-gated acquisition with submillimeter spatial resolution, thus allowing excellent visualization of the coronary arteries.

Single-center studies have reported sensitivities between 30% and 95% and specificities between 86% and 98% for the detection of obstructive coronary lesions using 16-row MDCT scanners.3-13 In most of these studies, assessment of stenosis was performed qualitatively and up to 5% to 30% of coronary segments were considered nonevaluable. Moreover, only a few studies have reported performance characteristics of MDCT using patient-based analysis.4,8,10,12,13 Although these studies have raised considerable enthusiasm, it remains uncertain whether their findings may be replicated in clinical centers with variable expertise.

Accordingly, we sought to investigate the diagnostic accuracy of 16-row MDCT based exclusively on quantitative analysis and performed in a multicenter study.

CONTEXT Multidetector computed tomography (MDCT) has been proposed as a non-invasive method to evaluate coronary anatomy.

OBJECTIVE To determine the diagnostic accuracy of 16-row MDCT for the detection of obstructive coronary disease based exclusively on quantitative analysis and performed in a multicenter study.

DESIGN, SETTING, AND PATIENTS Eleven participating sites prospectively enrolled 238 patients who were clinically referred for nonemergency coronary angiography from June 2004 through March 2005. Following a low-dose MDCT scan to evaluate coronary artery calcium, 187 patients with an Agatston score of less than 600 underwent contrast-enhanced MDCT. Conventional angiography was performed 1 to 14 days after MDCT. Conventional angiographic and MDCT studies were analyzed by independent core laboratories.

MAIN OUTCOME MEASURES Segment-based and patient-based sensitivities and specificities for the detection of luminal stenosis of more than 50% (of luminal diameter) and more than 70% (of luminal diameter) based on quantitative coronary angiography.

RESULTS Of 1629 nonstented segments larger than 2 mm in diameter, there were 89 (5.5%) in 59 (32%) of 187 patients with stenosis of more than 50% by conventional angiography. Of the 1629 segments, 71% were evaluable on MDCT. After censoring all nonevaluable segments as positive, the sensitivity for detecting more than 50% luminal stenoses was 89%; specificity, 65%; positive predictive value, 13%; and negative predictive value, 99%. In a patient-based analysis, the sensitivity for detecting patients with at least 1 positive segment was 98%; specificity, 54%; positive predictive value, 50%; and negative predictive value, 99%. After censoring all nonevaluable segments as positive, the sensitivity for detecting more than 70% luminal stenoses was 94%; specificity, 67%; positive predictive value, 6%; and negative predictive value, 99%. In a patient-based analysis, the sensitivity for detecting patients with at least 1 positive segment was 94%; specificity, 51%; positive predictive value, 28%; and negative predictive value, 98%.

CONCLUSIONS The results of this study indicate that MDCT coronary angiography performed with 16-row scanners is limited by a high number of nonevaluable cases and a high false-positive rate. Thus, its routine implementation in clinical practice is not justified. Nevertheless, given its high sensitivity and negative predictive value, 16-row MDCT may be useful in excluding coronary disease in selected patients in whom a false-positive or inconclusive stress test result is suspected.

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row MDCT for the detection of obstructive coronary disease in a larger multicenter study, based exclusively on quantitative analysis. The primary hypothesis tested was whether MDCT could detect more than 50% luminal narrowing in coronary artery segments larger than 2.0 mm in diameter and have a sensitivity of more than 85% and a specificity of more than 85%.

METHODS

The Coronary Assessment by Computed Tomographic Scanning and Catheter Angiography (CATSCAN) study was designed to prospectively include patients between the ages of 30 and 70 years, who were referred for clinically indicated nonemergency coronary angiography, for evaluation of chest pain, and for intermediate or high probability of disease. Potential study participants were screened and enrolled by site research nurse coordinators if they met the inclusion and exclusion criteria. Study participants were asked to undergo a research MDCT coronary angiogram and data and blood collection as specified by the research protocol.

Individuals were excluded from enrollment if they were women of childbearing age or if they had previous coronary artery bypass graft surgery, cardiac rhythm other than sinus, presence of internal cardiac pacemakers and/or defibrillators, acute myocardial infarction within 30 days, contraindications to iodine contrast, contraindications to β-blockers, renal insufficiency (creatinine level >1.5 mg/dL [133 μmol/L]), diabetes requiring drug therapy, inability to sustain a breath hold for 25 seconds, inability to comply with the protocol requirements, morbid obesity (body mass index >40 [calculated as weight in kilograms divided by height in meters squared]), decompensated heart failure, resting heart rate greater than 100/min or greater than 75/min if pulse rate interval greater than 200 msec.

Institutional review boards from all of the participating centers approved the study protocol and informed consent form. After detailed explanation of study objectives and risk and benefits by the specific site research coordinator or principal investigator, willing individuals were asked to read and sign the informed consent form.

It was anticipated that 70% of the patients enrolled in the study would complete both MDCT and conventional angiography procedures and have adequate MDCT images for interpretation. It also was assumed that participants included for analysis would have an average of 7 evaluable coronary arterial segments larger than 2.0 mm in diameter and that the prevalence of stenosis of more than 50% would be approximately 30%. Accordingly, we estimated a sample size of 234 patients to achieve 80% power to reject the null hypotheses.

The study was conducted at 5 centers in the United States and 1 center each in the United Kingdom, the Netherlands, Israel, Japan, Argentina, and Germany. Prior to initiation of patient enrollment, each center provided 6 qualifying data sets performed in accordance with the protocol guidelines. The protocols for patient enrollment, safety monitoring, image acquisition, and interpretation were developed by a steering committee. Patients were monitored during preparation and for up to 30 minutes following MDCT. Adverse events were recorded and follow-up interviews were conducted 24 hours before and 5 to 8 days following conventional angiography. Adverse events were followed up by an independent data and safety monitoring board.

It is well established that the likelihood of significant obstructive coronary disease is high in symptomatic patients with elevated calcium scores and that MDCT coronary angiography has limited accuracy for the analysis of luminal stenosis in segments with extensive coronary calcifications. Accordingly, enrolled patients first had a noncontrast calcium score scan and MDCT angiography was performed only if the Agatston calcium score was less than 600.15

All MDCT studies were transferred for interpretation at the MDCT core laboratory at the University of Ulm (Ulm, Germany). Conventional angiograms were analyzed at the angiography core laboratory at the Cleveland Clinic Foundation (Cleveland, Ohio). Results were combined and statistical analysis was performed by the data management center at the Cleveland Clinic Foundation. An independent adjudication process was performed to confirm agreement on segment nomenclature.

MDCT Studies

Patients underwent a cardiac MDCT examination 1 to 14 days prior to conventional angiography using 16-row MDCT scanners (Brilliance 16, Philips Medical Systems, Andover, Mass). Following a scout radiograph of the chest, a calcium score scan was performed using 3-mm slice thickness, tube voltage of 120 kVp, and current seconds of 55 mAs. Calcium score analysis was performed onsite using a dedicated workstation and analysis software (Brilliance Workspace version 1.0, Philips Medical Systems). Patients with an Agatston calcium score of less than 600 proceeded to have MDCT coronary angiography. Metoprolol was administered intravenously until heart rate was below 65/min or a maximum of 15 mg was injected. For the MDCT angiogram, between 80 and 130 mL of nonionic iodinated contrast (Iosave, Bracco Diagnostics Inc, Princeton, NJ) was injected according to predetermined biphasic protocols based on the patient’s mass, scan duration, and contrast density. Other parameters were adjusted according to the patient’s mass (voltage of 120-140 kVp, current of 400-500 mAs). To reduce radiation exposure, electrocardiogram-based dose modulation was implemented according to the patient’s heart rate.

Images were reconstructed at several phases of the cardiac cycle and sent for blinded analysis at the MDCT core laboratory. Image quality was rated in a nominal 5-step scale, with scores of 1 to 2 considered nonevaluable. The
presence of calcified, noncalcified, and mixed plaques was reported. When visual assessment suggested a vessel diameter reduction of more than 20%, electronic calipers were used to measure lumen diameter from 2 orthogonal views, which allowed the percentage quantification of obstructive lesions based on a 17-segment model. Segments with coronary stents were excluded from analysis.

Catheterization Studies

All studies were performed using digital equipment. Multiple projections were recorded for each vessel using standard orientations. The diameters of the catheters used were documented for calibration purposes. Cinefluoroscopy images were sent for analysis at the angiography core laboratory. The maximum percentage of lumen reduction was determined for each stenotic segment using standard software (CAAS QCA for Research version 1.3.0.0, PIE Medical Imaging BV, Maastricht, the Netherlands).

Data Analysis

Continuous variables are expressed as mean (SD). Quantitative measurements of percentage stenosis were compared for each segment using Pearson correlation and Bland-Altman plots. Only those segments with a reference diameter of 2 mm or larger, as defined on conventional angiography, were included. Segment-based analysis included all evaluable segments and nonevaluable segments that were censored as positive and excluded nonevaluable segments. True positives were defined as correct identification by MDCT of segments of more than 50% and true negatives were defined as correct identification by MDCT of segments of 50% or less.

In addition to segment-based analysis, patient-based analysis was performed and included all patients, sanctioning any nondistal, nonevaluable coronary segments by MDCT as positive and taking into consideration that this finding would also lead to conventional angiography in clinical practice. For patient-based analysis, a true positive was defined as having at least 1 positive segment by both modalities, regardless of location.

The area under the receiver operating characteristic curve was calculated for MDCT to detect obstructive lesions at the 50% and 70% thresholds defined by conventional angiography. A bivariate logistic model was used to test for variance in accuracy parameters among different participating sites. Statistical analyses were performed using SPSS software version 10 (SPSS Inc, Chicago, Ill) and Microsoft Excel 2003 (Microsoft Corp, Redmond, Wash). The level of significance was set at P < .05.

RESULTS

There were 238 patients (mean [SD] age, 60 [9] years; 162 men) enrolled in the study from June 2004 through March 2005. Clinical characteristics are summarized in Table 1. Figure 1 provides a summary of the protocol steps and segment-based results for detection of more than 50% coronary stenosis. The mean (SD) Agatston calcium score in the patients enrolled was 235 (731). From the initial group, 37 patients were excluded due to a calcium score higher than 600. Of the remaining 201 patients, 14 were excluded. Of these 14 patients, 8 were excluded because conventional angiography was canceled; 1 patient each were excluded due to patient noncompliance, major protocol deviation, poor intravenous access, and MDCT equipment unavailability; and 2 patients were excluded for dysrhythmias detected before MDCT performance.

The mean (SD) heart rate during MDCT was 59 (9)/min; scan duration, 24 (2.9) seconds; and dose of iodine contrast received, 106 (17) mL. Single-phase tube current modulation was performed in 60% of the patients and dual-phase modulation in 40%. The estimated mean (SD) radiation exposure for the contrast-enhanced MDCT scans was 8.0 (2.3) mSv.20 There were 5 reported adverse events, including 2 patients with infiltration of the intravenous line and 1 each with an allergic reaction, hypotension, and need for urgent revascularization following conventional angiography. The mean (SD) serum creatinine level prior to MDCT was 0.96 (0.20) mg/dL (84.9 [17.9] µmol/L); prior to invasive angiography, 0.92 (0.22) mg/dL (81.3 [19.4] µmol/L); and at discharge, 0.94 (0.19) mg/dL (83.1 [16.8] µmol/L).

Segment-Based Evaluation

A total of 16 stented segments in 8 patients were excluded from analysis. Of 1629 segments, there were 24 (5%) in 819 (32%) of 187 patients with stenosis of more than 50% by conventional angiography. Multidetector CT correctly identified 55 diseased segments. Of the 472, there were 24 (5%) nonevaluable segments by MDCT that had a stenosis of more than 50%. The sensitivity of MDCT was similar in the...
39 patients who had single-segment (87%) vs the 20 patients with multisegment disease (90%) by quantitative coronary angiography. Figure 2 shows a representative example of a stenotic segment. There was a fair correlation between MDCT and conventional angiography measurements of stenosis ($r=0.57; P<.001$) with no significant bias (−1.1%; limits of agreement, −23.9% to 21.7%). There were 96 false-positive cases, most associated with calcified plaques (74%). In some of the apparent false-positive cases, however, quantitative coronary angiography may have underestimated the presence of disease due to absence of a normal reference segment (Figure 3). There were 10 false-negative cases, all involving a single vessel per patient and none involving the left main trunk. The accuracy parameters for segment-based evaluation using a 50% stenosis threshold appear in Table 2 and using a 70% stenosis threshold appear in Table 3. The area under the receiver operating characteristic curve was 0.91 (95% confidence interval, 0.86-0.96) for identification of evaluable segments with more than 50% stenoses and 0.97 (95% confidence interval, 0.96-0.99) for segments with more than 70% stenoses. There was no significant variation in accuracy among different participating sites.

**Patient-Based Evaluation**

There were 59 patients (32%) in the study group who had at least 1 segment larger than 2 mm with more than 50% stenosis by conventional angiography. Of these, 44 had at least 1 segment with more than 50% stenosis identified by MDCT. Of 63 patients (38%) with nonevaluable segments, 24 had at least 1 segment with stenosis of more than 50%. The accuracy parameters for patient-based evaluation appear in Table 2 and Table 3. If all non-evaluable MDCT segments were excluded (or considered negative), 15 patients with stenosis of more than 50% would have been missed. If all non-evaluable, nondistal MDCT segments were considered positive, only 1 patient with obstructive single vessel disease in a distal segment would have been missed.

Of 37 patients with a calcium score higher than 600 who did not undergo contrast-enhanced MDCT, 23 (62%) had at least 1 segment with more than 50% stenosis on conventional angiography.

**COMMENT**

The results of this multicenter study demonstrate a higher number of false-positive and nonevaluable segments than previously reported with MDCT coronary angiography. Because the prevalence of obstructive coronary artery disease was significant (38%) in patients with nonevaluable segments, these patients would need to proceed to conventional angiography or additional noninvasive testing in clinical practice.

To the best of our knowledge, this is the first study in which patients were studied in several independent centers using a predefined protocol and in which the analyses of MDCT and conventional angiograms were performed quantitatively by independent core laboratories. The differences in results obtained in this study compared with previous single-center reports may be due to reduced patient selection and analysis bias but also to variable center expertise and different patient characteristics, or different imaging and interpretation protocols, or both, especially the use of strictly quantitative analysis.
In this patient population, the prevalence of obstructive coronary artery disease was lower than expected, resulting in low positive predictive values. In part, this may be related to the exclusion of patients with very high calcium scores, patients with diabetes who were taking medications, and patients with renal insufficiency. Excluding patients with high calcium scores seems justified because the prevalence of obstructive coronary artery disease in these patients is significant, particularly in those who are symptomatic or have abnormal stress test results, or both. Moreover, the presence of extensive calcification represents a limitation to MDCT coronary angiography. Dense calcifications tend to be exaggerated due to partial volume overestimation, which relates to spatial reso-

**Figure 2.** Patient With Severe Stenosis in the First Diagonal (D1) Branch of the Left Anterior Descending Artery

In panel D, calcified (white) and noncalcified (dark) plaques are seen in the proximal and middle segments of the left anterior descending artery (LAD). A indicates anterior; AR, anterior right; C, cranial; CRX, circumflex; H, head, L, left; LA, left anterior; MDCT, multidetector computed tomography; OM1, first obtuse marginal branch; OM2, second obtuse marginal branch. Arrowheads indicate location of stenosis.
solution of current MDCT detectors. In the present study, use of purely quantitative stenosis analysis appears to have had a major impact on overdiagnosis in the presence of calcified lesions, many of which may have been scored as insignificant based on subjective analysis alone. Small and poorly opacified arteries were often judged as being nonevaluable because of the requirement to analyze lesions quantitatively. The exclusion of diabetic patients taking medications and patients with renal insufficiency in our study was done with the intention of minimizing risk, especially because the patients received no direct benefit from participating in this study.

Multidetector CT coronary angiography may be useful to exclude coronary artery disease in selected patients in whom a false-positive stress test result is suspected. Our results indicate that a negative MDCT coronary angiogram could have a significant discriminative power to exclude significant stenosis in patients with intermediate

Table 2. Accuracy Parameters for Segment-Based and Patient-Based Detection of More Than 50% Coronary Stenosis

<table>
<thead>
<tr>
<th>All Segments for Analysis With Nonevaluable Segments “Positive” (n = 1629)</th>
<th>Segments for Analysis Only (n = 1157)*</th>
<th>All Patients for Analysis and Patients With Nonevaluable Segments “Positive” (n = 187)</th>
<th>Patients for Analysis Only (n = 187)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stenoses by conventional angiography, No.</td>
<td>65</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td>Stenoses by MDCT, No.</td>
<td>151</td>
<td>117</td>
<td>73</td>
</tr>
<tr>
<td>False-positive, No.</td>
<td>96</td>
<td>58</td>
<td>29</td>
</tr>
<tr>
<td>False-negative, No.</td>
<td>10</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Sensitivity, % (95% CI)</td>
<td>85 (76-96)</td>
<td>98 (95-100)</td>
<td>75 (63-86)</td>
</tr>
<tr>
<td>Specificity, % (95% CI)</td>
<td>62 (62-67)</td>
<td>45 (45-63)</td>
<td>77 (70-85)</td>
</tr>
<tr>
<td>Positive predictive value, % (95% CI)</td>
<td>36 (29-44)</td>
<td>50 (41-59)</td>
<td>60 (49-72)</td>
</tr>
<tr>
<td>Negative predictive value, % (95% CI)</td>
<td>99 (98-100)</td>
<td>99 (96-100)</td>
<td>87 (81-93)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; MDCT, multidetector computed tomography.
*Excludes 472 (29%) of 1629 segments considered nonevaluable.
†Excludes nonevaluable segments in the counts of stenosis by MDCT.
‡Calculated by bivariate logistic model used to test for variance in accuracy parameters among different participating sites.

Figure 3. Patient With Large Atherosclerotic Plaque in the Left Main Coronary Artery

Quantitative analysis indicated 65% stenosis by multidetector computed tomography vs 34% by conventional angiography. A indicates anterior; AF, anterior front; H, head; LAH, left anterior head; MDCT, multidetector computed tomography; R, right. Arrowheads indicate location of stenosis; white boxes, area of detail.
probability in the absence of nonevaluable segments. This is supported by our receiver operating characteristic curves, which are independent of disease prevalence.10 In our study population, if clinically implemented, a negative evaluable MDCT study may have avoided conventional angiography in 69 (37%) of 187 patients, while missing only 1 patient with single vessel obstructive disease (0.4%).

Nevertheless, the results of our study do not support the routine indiscriminate use of 16-row MDCT coronary angiography as a primary modality to evaluate patients with suspected coronary artery disease. The high number of nonevaluable segments would lead to a high number of diagnostic coronary angiographic procedures if 16-row MDCT were to be implemented indiscriminately in the clinical practice. Therefore, stress testing should remain as the primary diagnostic modality for this purpose unless further data obtained with newer generation MDCT technology should demonstrate improved performance characteristics. Electrocardiogram-editing tools that improve image reconstruction and reduce imaging artifacts caused by dysrhythmias have also been recently implemented. Future technological advances in MDCT may increase temporal resolution and shorten image acquisition times even further, therefore reducing the number of cardiac motion artifacts that render many studies uninterpretable.

In addition to its diagnostic value, stress testing has an important and well-established role in determining prognosis and the need for revascularization. The presence of ischemia, scar, or both, as demonstrated by stress imaging tests, have been shown to be better predictors of benefits derived from revascularization compared with anatomic information derived by angiography alone. Although several studies indicate that calcium scoring has independent prognostic utility, similar data are not yet available for contrast-enhanced MDCT coronary angiography. Large-scale trials comparing the diagnostic and prognostic utility of MDCT with stress testing modalities are needed to determine whether the routine implementation of MDCT could lead to equivalent or superior outcomes.

Other important considerations when performing MDCT are radiation exposure and use of iodine contrast. The estimated total body radiation exposure after an MDCT coronary angiogram is 2 to 3 times the average exposure from a diagnostic catheterization22 but similar or lower than the exposure from a rest–stress myocardial scintigraphic study. Nevertheless, organ-specific radiation exposure varies with these tests. An important consideration with MDCT is radiation exposure to breast tissue in young premenopausal women. A typical coronary angiogram performed with a 16-row MDCT requires 90 to 120 mL of iodine contrast. Therefore, MDCT is not a good alternative for patients with renal insufficiency, in whom a diagnostic coronary angiogram may be performed with lower contrast volume. On the other hand, the volume of contrast may be lower with MDCT in specific cases, such as patients with coronary artery bypass grafts.

The number of nonevaluable segments also may decrease with the use of newer generation scanners.23-26 New generation 64-slice MDCT systems permit the acquisition of cardiac studies in less than 10 seconds, allowing faster contrast injection rates and having lower contrast volume requirements, and reducing the number of artifacts related to inadequate breath holding and heart rate variability. One report suggests that the performance characteristics of 64-slice MDCT in terms of spatial and temporal resolution lead to measurable improvements in image quality.26 Detector width in 64-slice CT scanners results in lower resolution than fluoroscopy. It is unlikely that MDCT will reach the spatial and temporal resolution of fluoroscopic angiography in the foreseeable future; moreover, the technology required to achieve

### Table 3. Accuracy Parameters for Segment-Based and Patient-Based Detection of More Than 70% Coronary Stenosis

<table>
<thead>
<tr>
<th></th>
<th>All Segments for Analysis</th>
<th>Segments for Analysis Only</th>
<th>All Patients for Analysis</th>
<th>Patients for Analysis Only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 1629)</td>
<td>(n = 1157)*</td>
<td>(n = 187)</td>
<td>(n = 187)†</td>
</tr>
<tr>
<td>Stenoses by conventional angiography, No.</td>
<td>36</td>
<td>29</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Stenoses by MDCT, No.</td>
<td>552</td>
<td>80</td>
<td>105</td>
<td>57</td>
</tr>
<tr>
<td>False-positive, No.</td>
<td>518</td>
<td>53</td>
<td>76</td>
<td>31</td>
</tr>
<tr>
<td>False-negative, No.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Sensitivity, % (95% CI)</td>
<td>94 (87-100)</td>
<td>93 (84-100)</td>
<td>94 (89-100)</td>
<td>84 (71-97)</td>
</tr>
<tr>
<td>Specificity, % (95% CI)</td>
<td>67 (65-70)</td>
<td>95 (94-97)</td>
<td>51 (43-59)</td>
<td>80 (74-86)</td>
</tr>
<tr>
<td>Positive predictive value, % (95% CI)</td>
<td>6 (4-8)</td>
<td>34 (23-44)</td>
<td>28 (19-36)</td>
<td>46 (33-59)</td>
</tr>
<tr>
<td>Negative predictive value, % (95% CI)</td>
<td>99 (98-100)</td>
<td>99 (98-100)</td>
<td>98 (94-100)</td>
<td>96 (93-100)</td>
</tr>
<tr>
<td>P value for site‡</td>
<td>.53</td>
<td>.08</td>
<td>.08</td>
<td>.08</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; MDCT, multidetector computed tomography.
*Excludes 472 (29%) of 1629 segments considered nonevaluable.
†Excludes nonevaluable segments in the counts of stenosis by MDCT.
‡Calculated by bivariate logistic model used to test for variance in accuracy parameters among different participating sites.
this would likely result in increasing radiation exposure to the patient. However, fluoroscopic angiography is limited by the obtainable angles and number of projections that are taken while MDCT is a 3-dimensional technique. Thus, MDCT may potentially identify eccentric and ostial branch lesions, which are underestimated by coronary angiography, by interrogating the vessel through an infinite number of projections. Rotation in 3-dimensions removes vessel overlap and foreshortening. Thus, the limited spatial and temporal resolution of MDCT may be balanced by its 3-dimensional nature and infinite number of projections provided.

Our current study has several limitations. The number of nonevaluable segments may have been overestimated due to several factors. First, we decided not to use sublingual nitroglycerin to match the standard practice of coronary angiography performed in most participating centers. The use of nitroglycerin may have improved coronary blood flow and thus contrast enhancement on MDCT. Second, we used a limited maximum dose of intravenous β-blockers as a safety measure. Suboptimal rate control may have resulted in an increased number of cardiac motion artifacts. Third, we elected to implement tube current modulation to reduce radiation dose. Tube current modulation, however, limits the ability to interpret the coronary anatomy in cardiac phases other than the modulated phase and may result in artifacts in patients with irregular heart rates. Fourth, we analyzed the performance characteristics of MDCT using a quantitative assessment of coronary stenosis. In a recent study comparing conventional angiography with MDCT, qualitative analysis could be performed in 88% of available segments whereas quantitative analysis was only feasible in 73%.

CONCLUSION

In summary, the results of our study indicate that use of MDCT coronary angiography performed with 16-row scanners is limited by a high number of nondiagnostic cases. Thus, routine implementation of MDCT angiography as a primary diagnostic test to evaluate patients with suspected coronary artery disease would lead to an excessive use of conventional angiography, additional confirmatory non-invasive testing, or both. Nevertheless, the high sensitivity and negative predictive value of this test suggests that if selectively applied, MDCT may be a useful alternative to conventional angiography in selected patients with undetermined or suspected false-positive stress test results. Further studies are needed to determine if MDCT coronary angiography performed with newer 64-slice scanners provides improved performance characteristics that could justify routine clinical application as a primary diagnostic test.

Author Contributions: Dr Garcia had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Garcia, Lessick, Hoffman. Acquisition of data: Garcia, Lessick, Hoffman, CATSCAN Investigators. Analysis and interpretation of data: Garcia, Hoffman. Drafting of the manuscript: Garcia. Critical revision of the manuscript for important intellectual content: Garcia, Lessick, Hoffman. Obtained funding: Garcia, CATSCAN Investigators. Administrative, technical, or material support: Garcia, Lessick, Hoffman. Study supervision: Garcia, Lessick, Hoffman. Financial Disclosures: Dr Hoffman reported receiving honoraria for lectures from Philips Medical Systems and Bracco.

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Role of the Sponsor: Philips Medical Systems provided recommendations for computed tomography X-ray dosing and injection protocols, site training, and logistical support for data transfer from individual sites to the core laboratories. Philips Medical Systems did not have any involvement in the design of the study, nor were they involved in the data management and analysis, manuscript preparation, and review or authorization for submission.

REFERENCES


Write while the heat is in you. . . The writer who post-pones the recording of his thoughts uses an iron which has cooled to burn a hole with. He cannot inflame the minds of his audience.
—Henry David Thoreau (1817-1862)