

Coronary Artery Stenosis in High-risk Patients: 64-Section CT and Coronary Angiography—Prospective Study and Analysis of Discordance¹

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Purpose:

To assess the diagnostic accuracy of multisection (64-section) computed tomography (CT) versus coronary angiography in detection of and assignment of grades for coronary artery stenoses in a high-risk population and to investigate causes for discordance between the two.

Materials and Methods:

The protocol was approved by the local ethics committee. Patients gave informed consent. The study included 114 patients (103 men, 11 women; mean age, 63 years \pm 8.2 [standard deviation]) with potential myocardial ischemia. Multisection CT images were interpreted independently by two radiologists with unequal experience in reading coronary CT angiograms. Diagnostic performance of 64-section CT in detection of stenoses of 50% or more was assessed per patient, per artery, and per segment. Interrater agreement was assessed by using the Cohen κ coefficient. Agreement between 64-section CT and coronary angiography for assigning grades to stenoses was assessed by using Bland-Altman analysis.

Results:

Sixty-eight percent of patients had stenoses of 50% or more. Good interrater agreement was found, with κ values of 0.77–0.85. For the most experienced radiologist, the sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio were 73.4%, 95.0%, 14.7, and 0.28 per segment, 95.2%, 94.7%, 18.0, and 0.05 per artery, and 100%, 89.2%, 9.26, and zero per patient, respectively. Discordance between 64-section CT and coronary angiography was related to either under- or overestimation of the degree of stenosis, anatomic misclassification, and coronary artery segments that were not assessable at 64-section CT. Bland-Altman analysis showed poor agreement, especially for intermediate stenosis (mean bias, 1.3%; 95% limits of agreement: -27.3% , 29.9%).

Conclusion:

Despite excellent sensitivity and negative likelihood ratios in a per-patient or per-vessel analysis, some coronary artery stenosis remained misdiagnosed with 64-section CT, resulting in limited sensitivity on a per-segment basis owing to anatomic discordance and failure to accurately quantify intermediate stenosis.

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Coronary angiography is the reference standard for diagnosing coronary artery disease (CAD), but its widespread use is hampered by its invasiveness and cost (1). Moreover, coronary angiography is performed for mostly diagnostic purposes only and does not include interventional procedures. Multisection (64-section) computed tomography (CT) includes electrocardiogram-synchronized scanning and reconstruction techniques that have enabled imaging of both the coronary artery lumen and atherosclerotic plaque burden in the vessel wall. In selected populations at high risk for CAD, the diagnostic performance for coronary artery stenosis of multisection CT has been shown to be accurate, in comparison with the performance of coronary angiography (2,3). Overall studies have reported a high negative predictive value of multisection CT for the presence of coronary artery stenosis (4,5).

The latest generation of 64-section CT scanners has shown substantial improvement in diagnostic performance (4,6,7). However, the diagnostic accuracy of 64-section CT has been assessed in only a few studies; these studies did not include analysis of the reasons for discordance between multisection CT and coronary angiography. In addition, the accuracy of multisection CT for quantifying the degree of stenosis is not fully elucidated.

Accordingly, we conducted a prospective study to assess the diagnostic accuracy of 64-section CT versus coronary angiography in the detection of and assignment of grades to coronary artery stenoses in a high-risk population and to

investigate causes for discordance between the two techniques.

Materials and Methods

This study was financially supported in part by the Institut de l'Athérombose, founded and supported by Sanofi-Aventis (Paris, France) and Bristol-Myers-Squibb Pharmaceuticals (New York, NY), which had no role in the analysis or interpretation of the data or in the decision to publish this article. The authors, who are not employees of the companies providing support, had control of the data and information submitted for publication.

Population

The local ethics committee (Cochin Hospital, Paris, France) approved this study. All participating patients gave written informed consent. This was a single-center prospective diagnostic study. A total of 511 patients were referred for diagnostic coronary angiography between September 2006 and September 2007. Patients were eligible to participate in the study if they had stable or unstable angina, atypical chest pain, silent ischemia, or valvular diseases. Exclusion criteria included ST-segment elevation or non-ST-segment elevation myocardial infarction ($n = 258$), out-of-hospital cardiac arrest ($n = 21$), prior coronary artery revascularization ($n = 26$), renal failure (creatinine clearance, <60 mL/min) ($n = 6$), allergy to contrast medium ($n = 1$), pregnancy ($n = 0$), atrial fibrillation ($n = 38$), and known left ventricular ejection fraction of less than 40% ($n = 45$).

Among the 116 patients eligible for inclusion, two patients declined to participate. Therefore, a total of 114 patients (103 men, 11 women; mean age,

63 years \pm 8.2 [standard deviation]) were included in the present study.

Multisection CT Imaging Technique

Multisection CT examinations were performed with a scanner (LightSpeed VCT; GE Healthcare, Waukesha, Wis). A gantry rotation time of 350 msec and a collimation with 64 detector rows and 0.625-mm section thickness, allowing 40-mm coverage per rotation, were used. The pitch was set according to the patient's heart rate and ranged from 0.16 to 0.24, and a multisector reconstruction algorithm was used for a heart rate faster than 75 beats per minute, allowing a temporal resolution of up to 44 msec. The tube voltage and tube current were set to 100 kV and 600 mA, respectively, if the body weight of the patient was 80 kg or lighter, and to 120 kV and 800 mA, respectively, if the body weight was heavier than 80 kg. Electrocardiographically gated tube modulation was used to minimize radiation dose. The acquisition time was between 5 and 7 seconds. The dose-length product, as displayed on the dose report of the CT scanner, was recorded. The effective dose in millisieverts was calculated by multiplying the dose-length product by the chest conversion coefficient k (0.017 mSv \cdot mGy $^{-1}$ \cdot cm $^{-1}$). A volume of 80 mL of one contrast agent (iohexol, Omnipaque; GE Healthcare), with 350 mg or 300 mg of iodine per

Advances in Knowledge

- The overall diagnostic accuracy of 64-section CT on a per-segment basis is still limited by false-positive or false-negative results caused by failure to accurately quantify intermediate stenosis.
- Poor agreement for quantifying coronary artery stenosis diameter was noted between coronary angiography and 64-section CT.

Implication for Patient Care

- The newer technology for 64-section CT is still of limited value because of poor agreement with angiography for assignment of grades for coronary artery stenosis severity, especially for evaluation of intermediate stenosis.

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Abbreviations:

CAD = coronary artery disease
CI = confidence interval

Author contributions:

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See Materials and Methods for pertinent disclosures.

milliliter, or another contrast agent (iodixanol, Visipaque 320; GE Healthcare) was injected intravenously through an 18-gauge intravenous antecubital catheter by using a three-phase protocol: In the first phase, 60 mL of iodinated contrast medium was injected at a rate of 5 mL/sec. In the second phase, 20 mL of iodinated contrast medium and saline solution were injected at a rate of 2 mL/sec. In the third phase, a 30-mL saline flush was injected at a rate of 2 mL/sec. Scanning was triggered by using a bolus-tracking software feature (SmartPrep; GE Healthcare) for tracking the bolus arriving in the ascending aorta. Multisection CT examinations were performed in a craniocaudal direction, with simultaneous recording of the patient's electrocardiographic signal to enable retrospective registration of the reconstructed image obtained during the desired cardiac phase. Reconstruction was performed routinely at 75% of the R-R interval, and multiphase reconstruction was performed from 0% to 90% for every 10% of the R-R interval. A standard filter (SnapShot; GE Healthcare) was used routinely. Patients ($n = 68$) with a heart rate faster than 60 beats per minute and no contraindications to the use of β -adrenergic blocking agents were treated with metoprolol tartrate (Astra Zeneca, Rueil Malmaison, France), with a dose of 50–100 mg administered orally 1 hour before multisection CT. In addition, all patients received a 0.4-mg nitroglycerin tablet (NitroQuick; Ethex, St Louis, Mo) sublingually 2 minutes before scanning.

Coronary Angiography

All 114 patients underwent coronary angiography, which was performed with a catheter inserted via the radial or femoral artery, at least 2 hours after multisection CT. For hydration, 250 mL of 0.9% NaCl was administered intravenously for 2 hours, and assessment of renal function was performed before coronary angiography. Antithrombotic and antispastic agents (5000 IU of unfractionated heparin and 2.5 mg of verapamil chlorhydrate [Abbott, Rungis, France]) were administered when the radial approach was used. Coronary an-

giography was performed by using a standard technique with 5-F coronary artery diagnostic catheters (JL 4.0 and JR 4.0 [Cordis; Johnson and Johnson, New Brunswick, NJ]) and a maximum of 100 mL of contrast agent.

Prospective Image Analysis

The coronary CT images and angiograms (64-section CT and coronary angiography) were stored digitally. For the analysis, a method for coronary artery segmentation derived from Austen et al (8) was used for both multisection CT and coronary angiography, including a maximum of 18 segments per patient.

Coronary angiographic analysis.—Quantitative off-line coronary angiographic analysis was performed (Medicis CM 40, version 4.0; Medis, La Haye, the Netherlands) with automatic edge detection by a cardiologist who had 10 years of experience in reading coronary angiograms and was blinded to the clinical data and multisection CT results. All coronary artery segments that were 1.5 mm or larger in diameter at visual inspection were considered for quantitative coronary angiography. A 5-F contrast material-filled catheter was used for the calibration. After coronary angiography, coronary artery segments were classified visually as normal (no detectable stenosis), as demonstrating nonstenotic atherosclerosis (diameter of the stenosis in the most severe view was <50%), or as having significant stenosis of 50% or greater. To avoid not including any segments with significant stenosis for quantitative coronary angiographic analysis, all segments exhibiting stenosis of 30% or greater were analyzed visually by using quantitative coronary angiography.

Multisection CT analysis.—All 64-section CT images were interpreted independently at a computer workstation by two senior radiologists (J.L.S., H.G.) with different levels of experience in reading coronary artery CT scans. The first (J.L.S.) is a qualified radiologist with 30 years of experience who specializes in cardiovascular radiology. He has read more than 15 000 coronary artery CT scans. The other (H.G.) is

certified in general radiology, has 7 years of experience, and was trained by reading 482 coronary artery CT scans over a period of 6 months before starting this study. Both were blinded to the clinical data and coronary angiographic results. For each coronary artery segment, the readers assessed image quality by using the following classification: excellent (no motion artifacts or minor artifacts and clear delineation of the coronary artery segment), fair (moderate artifacts without vessel wall discontinuity or severe artifacts with a vessel wall discontinuity but maintained visualization of the arterial lumen), and poor (noninterpretable coronary artery segments).

As for coronary angiography, only arterial segments that were visually estimated to be 1.5 mm or larger in diameter were analyzed. A workstation (AW VolumeShare; GE Healthcare) with software (CardIQ Xpress; GE Healthcare) was used to first select the optimal phase in the multiphase study and then to perform postprocessing of coronary artery images. Analysis of the coronary arteries was started by using three-dimensional volume-rendered, three-dimensional maximum intensity projection, and axial row data to see small vessels. The assignment of a grade to a stenosis in the coronary arteries was performed on the basis of curved reformatted and cross-sectional images. The degree of a stenosis was quantified on orthogonal views of the vessel by using a semiautomatic vessel analysis tool as described previously (9). The degree of stenosis was measured only if the visually observed degree of stenosis was 30% or greater on a 64-section CT scan. The percentage of stenosis was evaluated as a diameter percentage of stenosis (calculated as $[D_R - D_S]/D_R$, where D_R is reference diameter and D_S is stenosis diameter) with both 64-section CT and coronary angiography.

Conflicting Results

In regard to the assignment of grades to coronary artery stenoses, all conflicting results were analyzed retrospectively by the two radiologists (H.G., J.L.S.) and a cardiologist (O. Varenne) who did not

perform coronary angiography to investigate the reasons for disagreement. Disagreement was resolved with consensus reading.

Statistical Analysis

Assuming a prevalence of 70% for coronary artery stenosis of 50% or greater and a sensitivity of 90% for 64-section CT at the coronary artery segment level and taking inpatient correlation into account, a sample size of 100 patients was needed to provide a precision of 10% around the observed sensitivity.

Some coronary artery segments were uninterpretable or not seen at 64-section CT. Thus, we calculated the overall 64-section CT yield (probability of obtaining either a positive or negative result [ie, whether a 64-section CT result is falsely positive or falsely negative]) and the positive yield (ie, probability of obtaining a positive or a negative 64-section CT result when a

stenosis of 50% or greater is present according to results at coronary angiography) (10).

We estimated specificity, sensitivity, and likelihood ratios, including uninterpretable coronary artery segments or those that were not seen at 64-section CT in a six-cell matrix, as described elsewhere (10). Analyses were performed at the patient, coronary artery, and coronary artery segment levels.

In the patient-level analysis, 95% confidence intervals (CI) of proportions were calculated by using the Wilson method (11), and 95% CIs of likelihood ratios were calculated by using the score test method (12). In the per-artery and per-segment analyses, we considered the patient as a cluster and the coronary arteries (or segments) as the diagnostic units within each cluster. Therefore, the calculation of 95% CIs for proportions was based on a ratio estimator for the variance of clustered binary data, which takes intracluster correlations into account (13). The 95% CIs of likelihood ratios were calculated by using bootstrap resampling (14).

The interrater agreement was assessed by using the Cohen κ coefficient, considering positive and negative 64-section CT results only. The 95% CIs were computed by using the bootstrap resampling method. The agreement between 64-section CT and coronary angiography for assignment of a grade to a stenosis was assessed by using the Bland-Altman method. This assessment included computation of the mean difference between the two techniques and 95% limits of agreement (taking inpatient correlation into account) and the difference plot (15). This analysis included coronary artery segments in which a stenosis of 30% or greater was found with both imaging techniques.

Results

The median time between multisection CT and coronary angiography was 370 min (range, 130–550 min). Renal function was normal before multisection CT and remained within the normal range in all patients before coronary angiography. The mean effective

dose of radiation with multisection CT was 12 mSv \pm 2.4. The mean heart rate was 58 beats per minute (range, 46–72 beats per minute).

Table 1 summarizes the clinical data of the patients. Most patients (67.5%, 77 of 114) were admitted for diagnostic coronary angiography because of symptoms compatible with myocardial ischemia. A total of 42.1% (48 of 114) of the patients had at least two risk factors for CAD.

A total of 1817 coronary artery segments were seen at coronary angiography. On 64-section CT scans, 1745 (96.0%) segments were identified by reader 1 and 1711 (94.2%) segments were identified by reader 2. Because some segments were not interpretable on multisection CT scans, 1729 segments were analyzed by reader 1 and 1688 segments were analyzed by reader 2, resulting in an overall test yield of 95% and 93%, respectively. For readers 1 and 2, the positive yield was 97.5% and 95.6%, respectively. Image quality was excellent in 87.8% of the segments analyzed (Table 2). Sixteen (0.9%) of 1745 segments were excluded from the analysis by reader 1 because of impaired image quality.

Interrater Agreement and Diagnostic Accuracy of 64-Section CT

On a per-segment basis, the interrater agreement for the detection of a stenosis of 50% or greater at multisection CT was good ($\kappa = 0.77$; 95% CI: 0.72, 0.81). The interrater agreement was excellent on the artery ($\kappa = 0.85$; 95% CI: 0.8, 0.9) and patient ($\kappa = 0.83$; 95% CI: 0.72, 0.94) basis.

Table 3 summarizes the diagnostic performance of multisection CT compared with coronary angiography for readers 1 and 2 in the detection of coronary artery stenosis of 50% or greater by using coronary angiography as the reference standard. Results varied slightly if the analysis was performed per patient, per artery, or per segment.

In 191 segments in which a stenosis of at least 30% was quantified with both 64-section CT and coronary angiography, we found substantial disagreement between the two methods of

Table 1

Clinical Data for Patient Population

Characteristic	Value
No. of patients	114
Mean age (y)*	
Population study	63 \pm 8.2
Men (<i>n</i> = 103)	64 \pm 8.2
Women (<i>n</i> = 11)	54 \pm 8.1
Cardiovascular risk factors [†]	
No. with family history	30 (26.3)
No. with dyslipidemia	50 (43.9)
No. with hypertension	51 (44.7)
No. who currently smoke cigarettes	57 (50.0)
No. with diabetes mellitus	31 (27.2)
Clinical presentation [†]	
No. with unstable angina	17 (14.9)
No. with atypical angina	6 (5.3)
No. with nonspecific chest pain	15 (13.2)
No. with no chest pain	22 (19.3)
No. with chronic angina	54 (47.4)
No. with previous myocardial infarction [†]	12 (10.5)
No. with ST or T wave changes [†]	54 (47.4)
Mean heart rate before multisection CT (beats/min)*	58 \pm 4

* Data are the mean \pm standard deviation.

[†] Numbers in parentheses are percentages. Percentages were rounded.

Table 2

Image Quality of Multisection CT according to Coronary Artery Segment for Reader 1

Image Quality	No. of Segments Identified (n = 1745)	Left Main Coronary Artery Segment (n = 123)	Left Anterior Descending Artery Segment (n = 354)	Left Circumflex Coronary Artery Segment (n = 222)	Right Coronary Artery Segment (n = 573)	Obtuse Marginal Branch Segments (n = 223)	Diagonal Branch Segments (n = 224)	Ramus Intermedius Segment (n = 26)
Excellent	1532 (87.8)	114 (92.7)	312 (88.1)	198 (89.2)	482 (84.1)	198 (88.8)	205 (91.5)	23 (88.5)
Fair	197 (11.3)	9 (7.3)	38 (10.7)	20 (9.0)	88 (15.4)	22 (9.9)	17 (7.6)	3 (11.5)
Poor	16 (0.9)	0	4 (1.1)	4 (1.8)	3 (1.0)	3 (1.3)	2 (1.0)	0

Note.—Numbers in parentheses are percentages. Percentages were rounded.

Table 3

Performance of 64-Section CT in Assigning Grade to Stenoses of 50% or Greater for Both Readers

Reader, Analysis, and CT Result	Angiography Results*		Sensitivity (%) [†]	Specificity (%) [†]	Positive Likelihood Ratio [‡]	Negative Likelihood Ratio [‡]
	Positive	Negative				
Reader 1						
Per segment	...	...	73.4 (66.9, 79.9)	95.0 (93.1, 97.0)	14.7 (11.8, 19.0)	0.28 (0.22, 0.35)
Positive	146	76	...	...	...	...
Negative	53	1454	...	...	...	...
Not interpretable	5	11	...	...	...	...
Not visualized	0	72	...	...	...	...
Per artery	...	...	95.2 (91.3, 99.1)	94.7 (91.9, 97.5)	18.0 (12.1, 31.0)	0.05 (0.02, 0.09)
Positive	139	18	...	...	...	...
Negative	7	320	...	...	...	...
Not interpretable	0	24	...	...	...	...
Per patient	...	...	100 (95.3, 100)	89.2 (75.3, 95.7)	9.26 [‡]	0
Positive	77	4	...	...	...	...
Negative	0	33	...	...	...	...
Not interpretable	0	0	...	...	...	...
Reader 2						
Per segment	...	...	65.6 (57.6, 73.7)	94.4 (92.5, 96.4)	11.7 (9.5, 15.1)	0.36 (0.29, 0.44)
Positive	128	83	...	...	...	...
Negative	67	1410	...	...	...	...
Not interpretable	7	16	...	...	...	...
Not visualized	2	104	...	...	...	...
Per artery	...	...	86.3 (80.4, 92.2)	93.4 (90.7, 96.2)	13.1 (9.2, 21.3)	0.15 (0.09, 0.21)
Positive	126	22	...	...	...	...
Negative	20	313	...	...	...	...
Not interpretable	0	0	...	...	...	...
Per patient	...	...	94.8 (87.4, 98.0)	83.8 (68.9, 92.3)	5.8 (3.1, 13.7)	0.06 (0.02, 0.14)
Positive	73	6	...	...	...	...
Negative	4	31	...	...	...	...
Not interpretable	0	0	...	...	...	...

Note.—Negative = stenosis of less than 50% by using angiography or CT, positive = stenosis of 50% or greater by using angiography or CT.

* Angiography is coronary angiography.

[†] Numbers in parentheses are the 95% CIs.

[‡] Nonassessable.

measurement. The mean bias was 1.3%, with large 95% limits of agreement ranging from -27.3% to 29.9%, with discordance being greater for intermediate stenoses (Fig 1). The

Bland-Altman plots did not demonstrate an increase in the discrepancies for stenosis measurement between coronary angiography and multisection CT for the smaller, more distal

vessels. The performance of 64-section CT in the assignment of grades to stenoses of 50% or greater in distal and proximal segments did not significantly differ (Table 4).

Figure 1

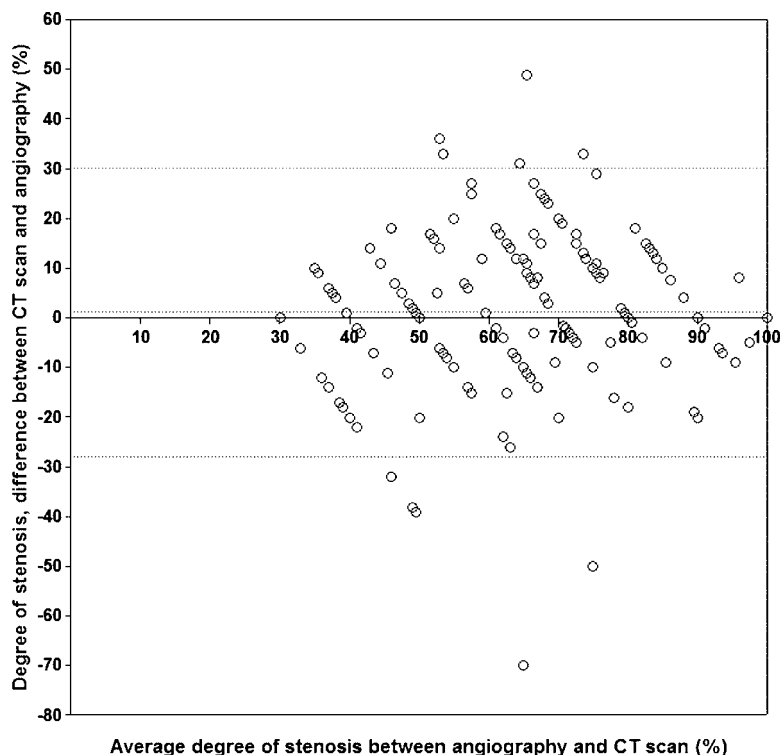


Figure 1: Bland-Altman plot of differences between coronary angiography and 64-section CT in percentage of coronary artery stenosis detected compared with average percentage of stenosis detected by using both methods. Mean difference was 1.3% (middle dotted line); 95% limits of agreement ranged from -27.3% to 29.9% (upper and lower dotted lines), indicating lack of agreement between the two methods. Disagreement was stronger for intermediate stenoses.

Reasons for Diagnostic Discordance between 64-Section CT and Coronary Angiography

A total of 204 coronary artery segments with a stenosis of 50% or greater were identified at coronary angiography in 77 patients (68% of the study population). Of these segments, 146 were depicted as manifesting a 50% or greater stenosis by using multisection CT, whereas the remaining 58 stenotic segments were missed. In contrast, a stenosis of 50% or greater was falsely read in 76 segments at multisection CT.

Three major reasons for diagnostic discordance between the two imaging methods (Table 5) were as follows: (a) under- or overestimation of the degree of stenosis (Fig 2), (b) nonassessable coronary artery segments at multisection CT caused by poor image quality, and (c) discordance between multisection CT and coronary angiography in defining the coronary artery segment according to the American Heart Association classification (Fig 3). Small vessels such as the first obtuse marginal branch were sometimes not seen at multisection CT. Therefore, if a stenosis was noted in a larger second marginal branch, it was classified as a stenosis of the first marginal branch at multisection CT. Because the first marginal branch was seen on the coronary angiogram, it

Table 4

Performance of 64-Section CT in Assigning Grades to Stenoses of 50% or Greater in Distal and Proximal Segments

Segments and CT Results	Angiography Results*		Sensitivity (%) [†]	Specificity (%) [†]	Positive Likelihood Ratio [†]	Negative Likelihood Ratio [†]
	Positive	Negative				
Proximal segments	...	...	73.8 (64.0, 83.6)	95.7 (93.7, 97.6)	17.2 (12.0, 26.8)	0.27 (0.19, 0.37)
Positive	76	26	...	...	...	...
Negative	27	575	...	...	...	...
Not interpretable	3	2	...	...	...	...
Not visualized	0	25	...	...	...	...
Distal segments	...	...	72.9 (63.7, 82.1)	94.6 (92.7, 96.6)	13.5 (10.2, 18.9)	0.29 (0.20, 0.38)
Positive	70	50	...	...	...	...
Negative	26	879	...	...	...	...
Not interpretable	2	9	...	...	...	...
Not visualized	0	47	...	...	...	...

Note.—Negative = stenosis of less than 50% by using angiography or CT, positive = stenosis of 50% or greater by using angiography or CT. Proximal segments include left main coronary artery, proximal left anterior descending artery, left circumflex coronary artery, and right coronary artery.

* Angiography is coronary angiography.

[†] Numbers in parentheses are the 95% CIs.

Table 5

Reasons for Diagnostic Discordance between 64-Section CT and Coronary Angiography for Detection of 204 Stenoses of 50% or Greater by Reader 1

Results	Value
No. of false-negative tests (<i>n</i> = 58)	
Nonassessable coronary segments at CT	5 (9)
Discordance in anatomic classification	30 (52)
Underestimation of degree of stenosis	19 (33)
Others	4 (7)
No. of false-positive tests (<i>n</i> = 76)	
Discordance in anatomic classification	30 (39)
Overestimation of degree of stenosis	40 (53)
Others	6 (8)

Note.—Numbers in parentheses are percentages. Percentages were rounded.

was noted as a stenosis on the second marginal branch.

Finally, the cause for the disagreement could not be found in four segments with false-negative multisection CT results, which corresponded to four patients. These four patients had two or three coronary blood vessels with significant CAD, and the four significant stenoses missed at multisection CT were located in distal segments. False-positive stenoses of greater than 50% were diagnosed in six patients, with no explanation in the retrospective analysis. These six false-positive lesions were located in proximal (*n* = 3) and distal (*n* = 3) segments.

Discussion

The main finding from this study is that the overall diagnostic accuracy for 64-section CT on a per-segment basis is limited by false-positive and false-negative results. Another important result is the poor concordance between 64-section CT and coronary angiography for assigning grades to coronary artery stenoses, especially for intermediate stenoses. As reported previously (4,6,7,16,17), the high accuracy of 64-section CT in the

Figure 2

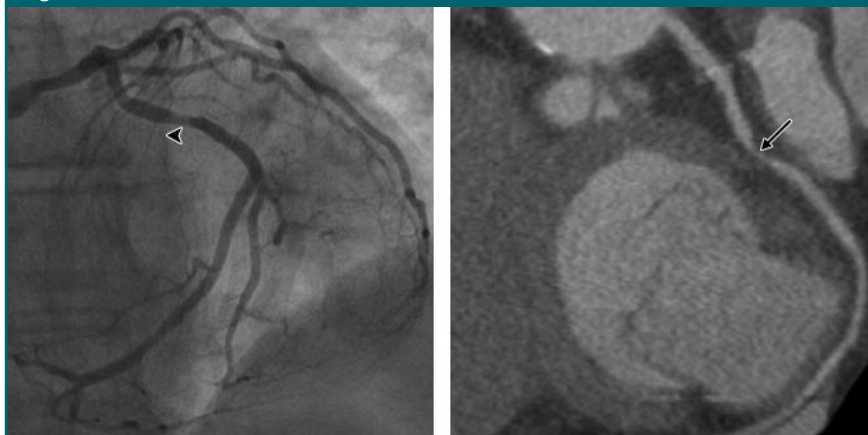


Figure 2: Left anterior oblique view of left circumflex coronary artery in 42-year-old man. **(a)** Coronary angiogram shows 20% stenosis in proximal left circumflex coronary artery (arrowhead). **(b)** On curved multi-planar reformation of retrospectively electrocardiographically gated section from 64-section CT, stenosis (arrow) was overestimated as 60% owing to low-attenuation plaque in this area.

detection of coronary artery stenoses of 50% or greater in a large cohort of patients with a high prevalence of CAD in a per-artery and per-patient analysis was confirmed by findings in our study. In addition, despite differences in reading experience, agreement between the two investigators in detecting segments with coronary artery stenosis was very good. To the best of our knowledge, there are no guidelines on specific training, number of cases read, and background for coronary artery CT. The less experienced reader was a qualified radiologist who acquired experience by reading close to 500 coronary artery CTs during 6 months. This may be relevant for the clinical use of 64-section CT and for the training of radiologists interested in multisection CT analysis.

Our results show an increase in sensitivity and a decrease in specificity for detection of stenoses of 50% or greater as one moves from segment- to vessel- to patient-based analysis. Similar findings have been reported previously with 16- (4,18,19) and 64-section (20,21) CT angiography. Nevertheless, our study shows that the sensitivity and specificity on a per-segment basis were lower than those observed by others (20). Indeed, in prior reports (22,23), the exclusion of many coronary artery segments un-

derscored the shortcomings of multisection CT. In our study, only 1.0% of the coronary artery segments were excluded from the analysis as a consequence of impaired image quality, reflecting the decrease in nonassessable segments with 64-section CT (6,7). Second, we found an anatomic discrepancy between multisection CT and coronary angiography for the assignment of a stenosis to a specific segment in 60 coronary artery segments. A substantial number of both false-positive and false-negative results were obtained in the assignment of a stenosis to a specific coronary artery segment, whereas the overall presence of a coronary artery stenosis regardless of assignment to a specific segment was correctly identified. This discrepancy was mostly caused by the limited spatial resolution of multisection CT. Small vessel size resulted in nonvisualization of coronary artery segments, thereby decreasing sensitivity and specificity on the basis of a per-segment analysis. Nevertheless, the clinical relevance of misdiagnosis at 64-section CT in the per-segment analysis is debatable because the patient may still receive a correct diagnosis of a coronary artery stenosis. Moreover, by excluding whether the misdiagnosis is caused by improper vessel assignment

(eg, first instead of second marginal branch), the global accuracy, sensitivity, and specificity in our study would increase to levels comparable to those of other studies (sensitivity of 86.9% [95% CI: 82.6%, 91.3%] and specificity of 96.8% [95% CI: 94.8%, 98.8%] on a per-segment basis for reader 1). Third, we demonstrated poor agreement between coronary angiography and multi-section CT in evaluating the degree of a

stenosis, especially when the stenosis is of intermediate severity. Large limits of agreement for assignment of a stenosis grade both with 16- (24,25) and 64-section (26) CT have been previously reported.

There were limitations to our study. The study population had a high probability of CAD, whereas in clinical practice multisection CT is more likely to be applied to patients with a low to inter-

mediate probability. However, the positive predictive value is closely related to the incidence of CAD in the population studied and is therefore better assessed in a high-risk population. Another limitation was that we did not compare multisection CT and coronary angiography with intravascular ultrasonography (US) for assessment of the severity of coronary artery stenosis and the composition of atherosclerotic plaques. However, intravascular US is not routinely used for detection of atherosclerosis.

Ionizing radiation is a major drawback of both multisection CT and coronary angiography and limits their application in follow-up examinations. Nevertheless, decreasing the effective radiation dose of multisection CT can be achieved in several ways, especially by electrocardiographically gated dose modulation or prospective electrocardiographically gated coronary CT. In this way, the required level of radiation has been reduced for 64-section CT to a level of 5–7 mSv, depending on the patient's heart rate, and is close to the effective radiation dose associated with coronary angiography (27).

The newer technology for 64-section CT could be an effective diagnostic tool for ruling out CAD or for making a positive diagnosis in high-risk patients. However, multisection CT findings must be interpreted with caution. Although assigning a stenosis to the wrong vessel (eg, first instead of second marginal obtuse branch) is clinically nonrelevant, underestimation of the degree of stenosis can lead to inappropriate therapy.

In summary, our results highlight the potential use of 64-section CT as a diagnostic tool for ruling out CAD or for determining a diagnosis positive for disease in patients who are suspected of having CAD. Although our results show the high diagnostic accuracy of 64-section CT compared with coronary angiography on a per-patient and a per-artery basis, some stenoses remain misdiagnosed, and this misdiagnosis results in a limited sensitivity at the per-segment level. Discrepancies between coronary angiography and 64-section CT

Figure 3

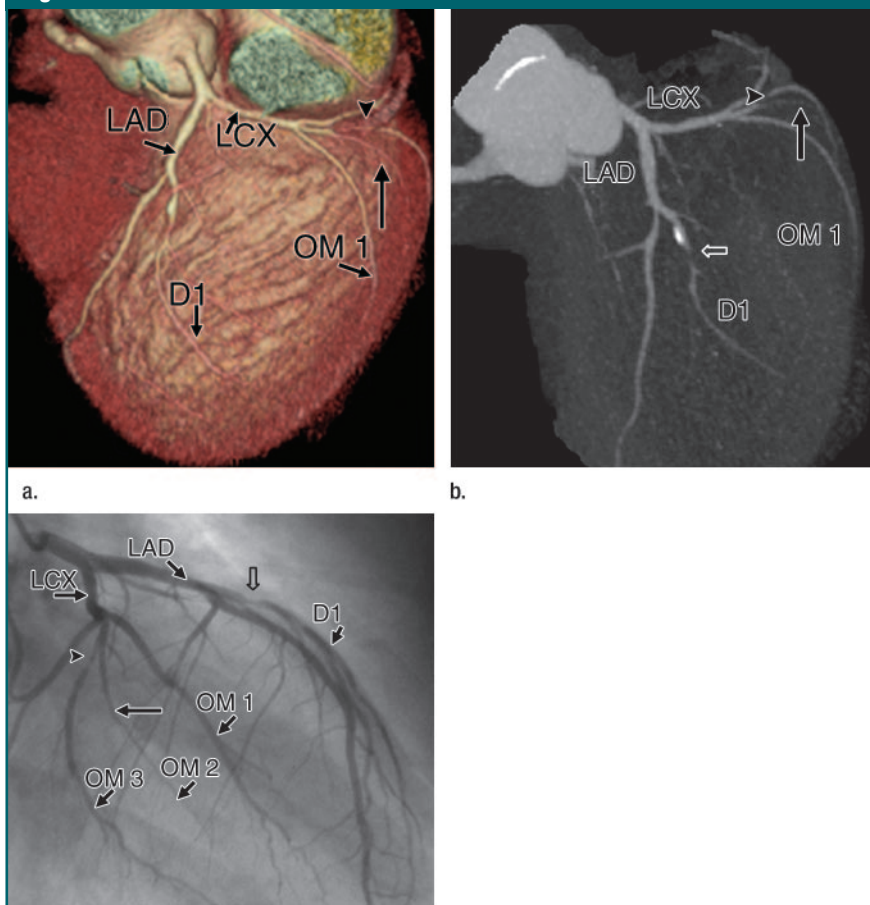


Figure 3: Images in 45-year-old woman. Left anterior oblique (a) volume-rendered three-dimensional reformation and (b) maximum intensity projection from retrospectively electrocardiographically gated section obtained with 64-detector row coronary CT show left anterior descending coronary artery (LAD) and left circumflex coronary artery (LCX). (c) Selective coronary angiogram in 30° caudal projection revealed 70% stenosis in third obtuse marginal branch (OM3). (a, b) Both CT images demonstrated same stenosis in second obtuse marginal branch (arrowheads). This finding can be explained by small diameter of second obtuse marginal branch (OM2) shown on c, which could not be adequately visualized on either CT image (arrow). Both CT images correctly revealed noncalcified 70% stenosis. (c) Coronary angiogram and (b) maximum intensity projection 64-section CT image similarly show stenosis of proximal first diagonal branch (D1) (open arrow, also on b). OM1 = first obtuse marginal branch.

are mostly caused by assignment of a stenosis to the wrong coronary artery segment and poor agreement for quantification of coronary artery stenosis diameter, especially for evaluation of intermediate stenoses. The results should be applied cautiously in a population with a different pretest risk for CAD.

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