



Accuracy of 64-MDCT in the Diagnosis of Ischemic Heart Disease

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OBJECTIVE. The aim of this study was to evaluate the potential clinical value of a new generation of 64-MDCT systems with that of invasive coronary angiography in the diagnosis of coronary artery disease (CAD).

SUBJECTS AND METHODS. Seventy-two consecutive patients with known or suspected CAD underwent both 64-MDCT and quantitative coronary angiography (QCA). A CT system with acquisition of 64 slices per gantry rotation was used with a spatial resolution of $0.4 \times 0.4 \times 0.4$ mm and a gantry rotation time of 330 milliseconds. Sensitivity, specificity, and diagnostic accuracy of 64-MDCT in the detection or exclusion of CAD were evaluated on both a per patient and a per segment basis.

RESULTS. Sixty-eight of 72 coronary CT angiograms (CTAs) (94%) were of diagnostic image quality. QCA showed significant CAD (i.e., one or more stenoses in $> 50\%$) in 57% (39/68) and nonsignificant disease or healthy CTAs in 43% (29/68) of the patients. Sensitivity, specificity, and the negative predictive value (NPV) of 64-MDCT per patient were 97%, 79%, and 96%, respectively. Per segment, 923 of 1,020 coronary artery segments were assessable (90%). For the detection of stenoses of more than 50% and more than 75% per segment, 64-MDCT showed a sensitivity of 82% and 86%, respectively. Per segment, specificity and NPV were as high as 95% and 97%, respectively.

CONCLUSION. In clinical routine, coronary CTA will primarily be used for risk stratification on a per patient basis. In the present study, coronary 64-MDCT showed a high diagnostic accuracy on both per patient and per segment analyses.

Keywords: CT angiography, CT coronary arteriography, MDCT

DOI:10.2214/AJR.05.1697

Received September 24, 2005; accepted after revision January 6, 2006.

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AJR 2006; 187:111–117

0361–803X/06/1871–111

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The established generation of 16-MDCT systems provides for routine submillimeter cardiac imaging at short breath-hold times [1]. Even with remarkable results reported on the diagnostic accuracy of this scanner generation [2–5], however, a number of limitations remained, hindering the full acceptance of this promising noninvasive technology as an established diagnostic tool in the routine clinical workup of coronary artery disease (CAD). These limitations included impaired assessability of small coronary artery branches smaller than 2 mm, cardiac motion artifacts in fast or arrhythmic heart rates, and partial voluming effects of severe calcium deposits in the coronary artery wall, rendering a significant number of scans or vessel segments completely interpretable [6]. Even after limiting the assessed vessels to segments larger than 1.5 mm or 2.0 mm in diameter, recent studies on coronary 16-MDCT reported percentages of 7% to 17% (mean, 11%) of nonassessable ves-

sel segments [3, 7, 8]. The recent introduction of a new scanner generation with high spatial and high temporal resolution generating 64 slices per rotation and covering the entire volume of the heart in approximately 10 seconds promises a significant improvement in image quality that may allow a more precise evaluation of coronary artery stenoses [9]. Initial reports on this system are very promising, reporting a sensitivity and specificity for the detection of significant stenoses of 94% and 97%, respectively [10]. Comparing 64-MDCT with intravascular sonography, a good correlation between these techniques assessing the degree of a given coronary artery stenosis could be shown [11].

In clinical routine, coronary CT angiography (CTA) is primarily used for risk stratification on a per patient basis; that is, the decision to be made based on 64-MDCT is whether a specific patient with or without a history of CAD has significant disease or significant disease progression and should or

should not go for further diagnosis and potentially invasive therapy. Enabling an accurate differentiation of significant versus nonsignificant CAD on a per patient basis, coronary MDCT could have enormous clinical value as a reliable tool for the further stratification of CAD patients, helping make a clinical decision of whether invasive coronary intervention is required or not. Thus the aim of the present study was the evaluation of the diagnostic accuracy of 64-MDCT for detecting significant CAD in both patients with known CAD and in patients without a history of CAD. This was done on both per patient and per segment analyses.

Subjects and Methods

Patient Population

Seventy-two patients (59 men, 13 women; mean age, 64 ± 10 years; range, 38–89 years) were included in this study over a period of 6 months. All patients underwent both conventional and MDCT angiography of the coronary arteries. The mean time interval between MDCT and X-ray angiography was 3 ± 13 days (range, 0–85 days). In most patients (48/72), CTA was performed before conventional angiography, and in 24 patients, X-ray angiography was performed first. In 29 patients, significant CAD was already diagnosed (i.e., angiographically proven); 15 of these patients had previously undergone percutaneous transluminal coronary angioplasty with stent implantation (total, 24 stents). In the remaining 43 patients, no CAD was known before the examination, and patients presented with typical or atypical anginal complaints. No patients after coronary artery bypass grafting were included. Further exclusion criteria were known allergic reactions to iodine-containing contrast media, severe renal failure, pregnancy, or an unstable clinical condition. The study protocol included the IV administration of 5–10 mg of metoprolol shortly before the scheduled CT scan in patients with heart rates higher than 70 beats per minute (bpm) ($n = 11$). However, in the presence of contraindications for a β -blocker or an unsatisfactory lowering of the heart rate, the scan was still performed, even at higher heart rates. The hospital's ethics committee approved the study protocol, and all patients gave their informed consent to participate in the study.

MDCT Scanning Protocol

CTA was performed using a new generation of MDCT scanners (Sensation 64, Siemens Medical Solutions), operating at an increased rotation rate and acquiring 64 slices per gantry rotation. In addition, z-axis resolution was increased by a new z-flying focal spot technology [9]. A contrast agent bolus of 80 mL of iomeprol 300 (Imeron, Altana) was injected with a

flow rate of 5 mL/s. For timing purposes, an automated bolus-tracking software was used, starting the scan automatically 6 seconds after contrast agent density in the ascending aorta reached a predefined threshold of 100 H [12]. The entire volume of the heart was covered during one breath-hold in approximately 10 seconds with simultaneous recording of the ECG trace. Further acquisition parameters were as follows: detector collimation, 32×0.6 mm; spatial resolution, $0.4 \times 0.4 \times 0.4$ mm; gantry rotation, 330 ms; temporal resolution, 165 ms; pitch, 0.2 mm per gantry rotation; tube voltage, 120 kV; tube current, 850 mAs; dose modulation (ECG pulsing) [13]. For optimal motion-free image quality, data sets were reconstructed in mid diastole (mean interval, 614 ± 175 ms after the R wave). In all patients, mid-diastolic reconstructions were first performed at 70% of the R-R interval. If image quality in this data set was not optimal, two additional reconstructions were performed at 65% and 75%. This was done in 49% of the patients ($n = 35$). No systolic reconstructions were performed because ECG dose modulation was used to reduce the radiation exposure. Dose estimation for these protocol parameters applying ECG pulsing is in the range of approximately 8–10 mSv.

Conventional X-Ray Coronary Angiography

Invasive coronary angiograms were evaluated by quantitative coronary angiography (QCA) (Quant Cor QCA, Siemens Medical Solutions) by an independent, blinded investigator. QCA was performed for all coronary artery lesions, determining the mean diameter reduction of these lesions in two projections and recording the segmental location of the stenosis according to the 15-segment American Heart Association (AHA) coronary artery model [14]. Significant CAD on a per patient basis was diagnosed if at least one significant stenosis was detected.

MDCT Image Analysis

All MDCT data sets were analyzed by two independent experienced observers, using a commercially available postprocessing workstation (Leonardo, Siemens Medical Solutions), blinded to any results from X-ray coronary angiography and blinded to the patient's history—that is, the CT observers did not know if CAD was known or suspected in a specific patient.

In the first step, both investigators determined image quality subjectively in a consensus interpretation on a per patient basis and on a per segment basis. In the per patient qualitative analysis, a three-point grading scale was applied: high image quality, optimal depiction of the coronary arteries; moderate image quality, sufficient depiction of coronary arteries for diagnostic purposes, but minor motion artifacts and/or reduced signal-to-noise ratio; and poor image quality, data not adequate for diagnostic assessment.

In the per segment-based quality assessment according to the AHA 15-segment model, segments were divided into two groups (diagnostic vs nondiagnostic image quality). Including all 15 coronary artery segments of 72 patients, a total of 1,080 coronary artery segments were assessed. For further analysis of coronary artery stenoses, only patients fulfilling two requirements were included: high or moderate image quality in the per patient-based qualitative analysis and diagnostic image quality in at least the proximal six segments of the major coronary arteries (i.e., of segments 1, 2, 5, 6, 7, and 11).

In the second step, the value of 64-MDCT in the detection of significant coronary artery stenoses was assessed, applying a combination of the original axial images, multiplanar reformations (multiplanar reconstruction), maximum intensity projections (MIPs), and 3D volume-rendering techniques (VRTs). For each coronary artery segment, both observers made the postassessment independently, applying a three-point grading scale: 1 = no signs of atherosclerosis; 2 = atherosclerotic vessel wall changes present but no significant stenosis; and 3 = significant lesion with more than 50% luminal obstruction. After the independent interpretation, a consensus interpretation was performed for a final MDCT diagnosis on a per patient and per segment basis. The consensus interpretation was performed as soon as the diagnoses of observers 1 and 2 differed. No third observer was involved. On a per patient basis, significant CAD was diagnosed if one or more significant stenoses (> 50%) were detected, independent of the segmental location. The estimated interpreting time for the diagnostic interpretation, using all 3D reformation methods described earlier, was approximately 15 minutes per observer.

Coronary artery segments with stents were included in the assessment and evaluated as follows by both observers: stent assessable or nonassessable; if assessable, the following three-point grading scale was used: 1 = stent patent with no in-stent disease, 2 = stent patent but in-stent plaque visible, and 3 = stent occluded.

Statistical Analysis

For the statistical analysis, two Microsoft Windows-based software products were used (MedCalc, Version 7.0.0.2, 2002, MedCalc Software; and SPSS 12.0.1, 2003, LEAD Technologies). For all statistical tests, a significance level of $p < 0.05$ was considered a statistically significant result. Continuous variables are presented as mean \pm SD. The results of 64-MDCT to detect significant coronary artery lesions were evaluated using QCA as the standard of reference. Sensitivity, specificity, diagnostic accuracy, error rate, negative predictive value (NPV), and positive predictive value (PPV) were calculated per patient and per segment. All these statistical values were

Accuracy of 64-MDCT in Diagnosis of Coronary Disease

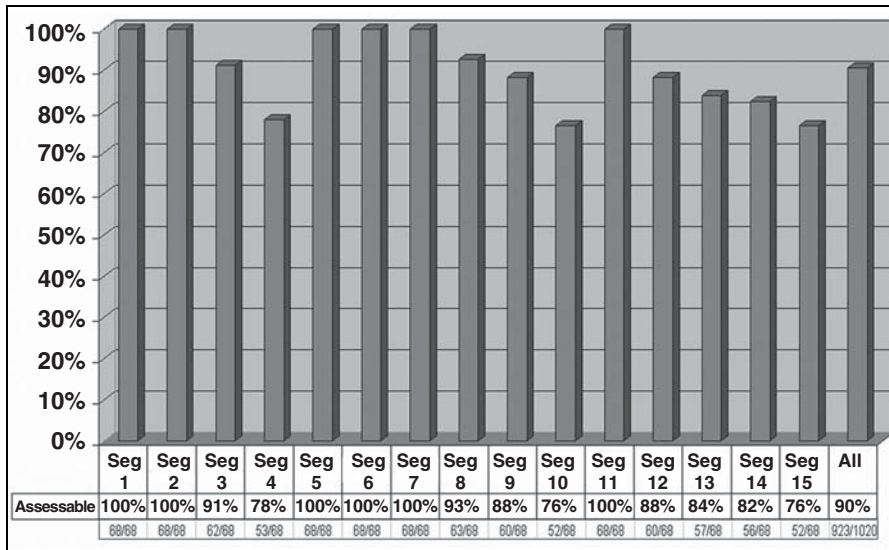


Fig. 1—MDCT image quality: assessability per segment (Seg) (American Heart Association 15-segment coronary artery model).

given for the consensus interpretation and for the individual interpretations of observer 1 and observer 2. In the per segment-based analysis, sensitivities were calculated for stenoses more than 50% and more than 75%, according to the QCA results. For the detection or exclusion of significant CAD on a per patient and on a per segment basis, the interobserver agreement for the two MDCT observers was quantified using the kappa value and interpreted as follows: less than 0.20, poor agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, good agreement; and 0.81–1.00, very good agreement.

Results

MDCT Success Rate and Image Quality

The mean heart rate during the MDCT scans was 61 ± 9 bpm (range, 42–87 bpm). Sixty-eight of 72 (94%) coronary CT angiograms were of diagnostic image quality (image quality: 64% high, 30% moderate, and 6% poor). Reasons for nonassessability were breathing artifacts ($n = 1$) and tachyarrhythmia ($n = 3$).

Three of 11 patients with a heart rate above 70 bpm showed suboptimal image quality, whereas only one patient (of the remaining 61 patients) with a heart rate below 70 bpm was judged as having a nondiagnostic study.

On a per segment basis, 923 of 1,020 coronary artery segments were assessable (90%). Reasons for nonassessability on a per segment basis were mostly cardiac motion artifacts or small-vessel caliber in distal segments. Figure 1 shows the detailed distribution of coronary artery segments assessable by MDCT.

Results of Conventional X-Ray Angiography

In the 68 patients available for comparison, invasive coronary angiography showed significant CAD (i.e., one or more stenoses > 50%) in 57% (39/68) and nonsignificant disease or normal coronary angiograms in 43% (29/68) of the patients. Dividing the 68 patients into two subgroups, those with known CAD (group 1, $n = 29$) and those with suspicion for CAD

(group 2, $n = 39$), recurrent disease (group 1) or a first diagnosis of CAD (group 2) was reported in 17 and 22 patients, respectively. In 22, 8, and 9 of the 39 patients with significant disease, the diagnosis was one-vessel, two-vessel, and three-vessel disease, respectively. On a per segment basis, 923 coronary artery segments were included in the diagnostic comparison of 64-MDCT and QCA. According to QCA, 118 and 56 of these 923 coronary artery segments (13% and 6%) showed coronary artery stenoses more than 50% and more than 75%, respectively. Table 1 shows the vessel distribution of these significant stenoses detected by QCA. In 24 of 923 coronary artery segments and 15 of 68 patients, stents were present. Of these 24 stents, 8 were located in the right coronary artery (RCA), 12 in the left anterior descending (LAD) coronary artery, and 4 in the left circumflex (LCX) coronary artery, respectively. Nineteen of the stents (79%) were patent, without signs of in-stent restenosis, and five stents (21%) showed signs of in-stent restenosis. However, none of these in-stent restenoses required intervention, and no stent obstructions were diagnosed.

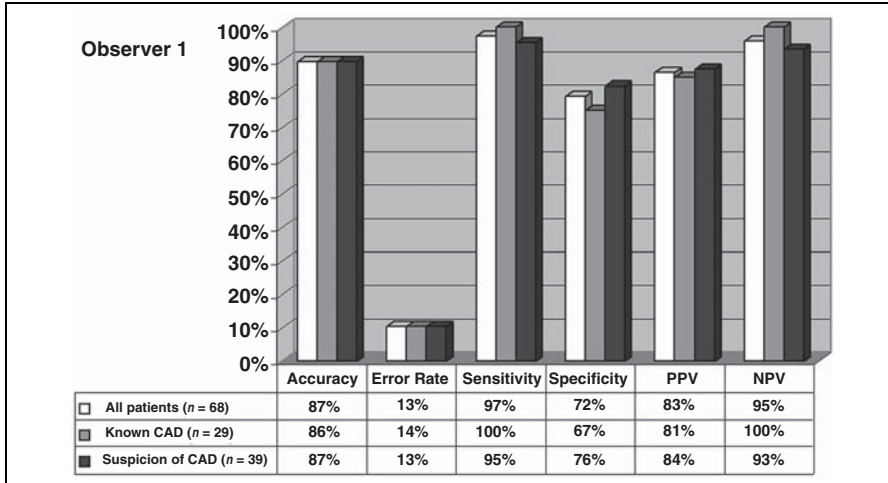
MDCT Diagnostic Accuracy

Diagnostic accuracy per patient—Thirty-eight of 39 patients with significant CAD according to QCA were correctly identified using 64-MDCT (sensitivity, 97%). Figure 2 shows the other statistical parameters (i.e., specificity, diagnostic accuracy, error rate, NPV, and PPV) of 64-MDCT for the correct detection or exclusion of significant CAD on a per patient basis separately for each observer and the consensus interpretation. For the two subsets of patients with known and suspected CAD, sensitivities for detecting significant CAD were 100% and 95%, respectively. The remaining data on these two subgroups can also be found in Figure 2. The kappa value as an indicator of interobserver agreement in the diagnosis or exclusion of significant CAD on a per patient basis was

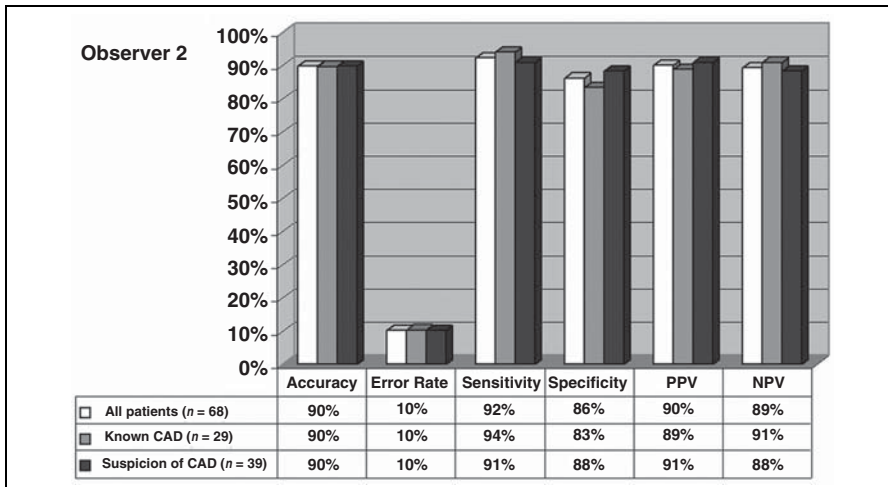
TABLE 1: Diagnostic Accuracy of 64-MDCT in Detecting Coronary Artery Stenoses in Assessable Segments Per Segment-Based Analysis: Consensus Reading

Artery	Assessable Segments	Sensitivity Stenoses > 50%	Sensitivity Stenoses > 75%	Sensitivity > 75% Proximal/Middle Segment	Specificity	Diagnostic Accuracy	Error Rate	Positive Predictive Value	Negative Predictive Value
LM	100 (68/68)	100 (4/4)	100 (3/3)	100 (3/3)	100 (64/64)	100 (64/64)	0 (0/68)	100 (4/4)	100 (64/64)
LAD	91 (311/340)	78 (47/60)	83 (25/30)	88 (15/17)	92 (232/251)	90 (279/311)	10 (32/311)	70 (47/67)	95 (232/244)
RCA	92 (251/272)	87 (26/30)	92 (12/13)	90 (9/10)	96 (212/221)	95 (238/251)	5 (13/251)	74 (26/35)	98 (212/216)
LCX	86 (293/340)	83 (20/24)	80 (8/10)	100 (5/5)	94 (254/269)	94 (274/293)	6 (19/293)	71 (20/28)	96 (254/265)
All	90 (923/1,020)	82 (97/118)	86 (48/56)	91 (32/35)	95 (762/805)	93 (859/923)	7 (64/923)	72 (97/134)	97 (762/789)

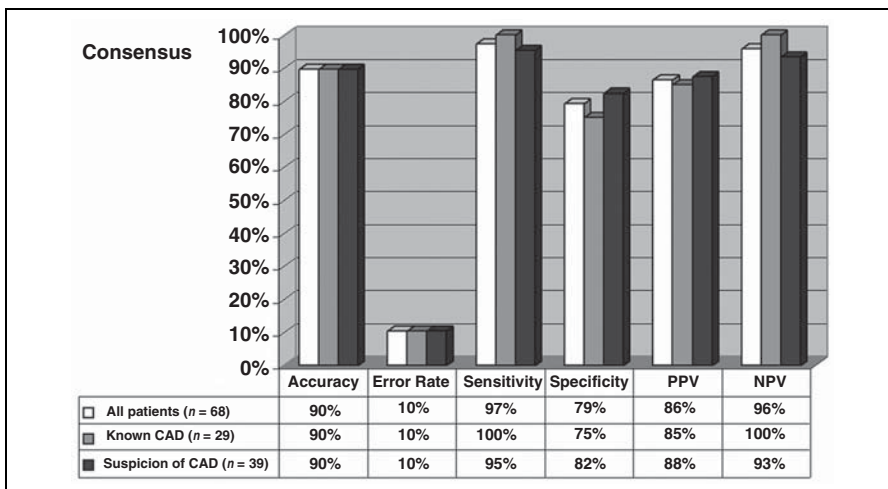
Note—Values expressed as percent; numbers in parentheses are actual results. LM = left main coronary artery, LAD = left anterior descending (coronary artery), RCA = right coronary artery, LCX = left circumflex (coronary artery).



A



B



C

Fig. 2—Patient-based diagnostic accuracy: detection of significant coronary artery disease (CAD) (i.e., one or more significant stenoses > 50%). PPV = positive predictive value, NPV = negative predictive value. **A–C**, Values are given separately for observer 1 (**A**), observer 2 (**B**), and the consensus interpretation (**C**).

0.81, indicating a very good agreement of the two MDCT observers (SE, 0.09; 95% confidence interval [CI], 0.61–0.96). Figures 3 and 4 give examples of correctly diagnosed significant stenoses by MDCT.

Diagnostic accuracy per coronary artery segment—Of the 118 significantly diseased coronary artery segments (i.e., stenosis > 50% according to QCA), 97 were diagnosed correctly (sensitivity, 82%), with 45 false-positive and 21 false-negative decisions. In 859 of 923 segments, a correct decision (significant disease present, yes or no) was made based on the MDCT data (diagnostic accuracy, 93%). Considering only stenoses more than 75% and stenoses more than 75% located in proximal and middle vessel segments, sensitivities were as high as 86% and 91%, respectively. Table 1 shows the complete statistical analysis for all coronary artery vessels. The kappa value as an indicator of interobserver agreement in the diagnosis or exclusion of significantly diseased coronary artery segments was 0.75, indicating a good agreement of the two MDCT observers (SE, 0.05; 95% CI, 0.65–0.85). Table 2 gives the results for observers 1 and 2 compared with the results of the consensus interpretation, including all kappa values for single coronary arteries assessed by MDCT.

Diagnostic accuracy in coronary artery stents—Of the 24 coronary artery stents, 92% (22/24) were assessable by MDCT according to the qualitative consensus analysis of the two MDCT observers. In the remaining 22 stents available for comparison, MDCT made a correct diagnosis (patent/patent but diseased/occluded) in 11 patients (50%); one false-negative diagnosis (5%, in-stent plaque not detected); and 10 false-positive diagnoses (45%, eight cases of false-positive in-stent restenosis and two cases of false-positive stent obstruction). Assessing stent patency only (stent patent, yes or no), MDCT made a correct diagnosis in 20 of 22 patients (91%).

Discussion

Technical Considerations

Cardiac imaging has been one of the major and most exciting focuses of MDCT since its introduction. Clinical progress by the development of MDCT technology beyond 16 slices can more likely be expected from further improved spatial and temporal resolution rather than from a mere increase in the volume coverage speed. Results of clinical 16-MDCT studies have been promising [2, 4, 5], but a number of challenges remain, including the assessment of severely calcified vessels, in-stent

Accuracy of 64-MDCT in Diagnosis of Coronary Disease

stenoses, reliable image quality in patients with high or arrhythmic heart rates, and others. These limitations of earlier MDCT systems in the assessment of CAD are, in part, the consequence of beam-hardening artifacts and partial volume effects and could be overcome by a higher, ideally isotropic, spatial resolution. Further improved temporal resolution is desirable to avoid, or at least reduce, the need for heart rate control. In contrast to earlier MDCT scanner generations, the evaluated 64-MDCT system makes use of a periodic motion of the focal spot in the longitudinal direction (*z*-flying focal spot technology) to double the number of simultaneously acquired slices per gantry rotation and to improve data sampling along the *z*-axis. This way, spatial resolution in the longitudinal direction is increased, and ob-

jects as small as 0.4 mm in diameter can be resolved [9]. The total scanning time for a cardiac scan is shortened to approximately 10 seconds, reducing breath-hold times and the volume of contrast media, improving patient comfort, minimizing breathing motion artifacts, and making the technique more robust. The rotation time of this latest generation MDCT system has been shortened to 330 msec, enabling a temporal resolution of 165 msec, as compared with earlier 4- and 16-MDCT models rotating at 370–500 msec. The temporal resolution can further be improved to a minimum of 83 msec by applying a multisegmental reconstruction algorithm; however, this might result in motion artifacts if heart rate is not constant [1] and was not applied in the present study.

Clinical Value of 64-MDCT

In our study population of 72 patients referred for coronary CTA, a percentage of 6% (patient based) and 10% (segment based) was not adequate for diagnostic evaluation showing a satisfying robustness of the technique. Excluding the diagonal branches of the LAD and peripheral branches of the LCX (segments 9, 10, 14, and 15), segment-based assessability was as high as 95%. Earlier studies on 16-MDCT have reported similarly small numbers of nonevaluable scans. This fact shows that, in principle, 64-MDCT is subject to similar limitations, rendering a certain number of scans uninterpretable.

Already with 4- and 16-MDCT, high sensitivities and specificities for the detection of significant coronary artery stenoses were reported in several independent investigations [2, 4, 5, 15–17]. These studies aimed to detect high-grade coronary stenoses in preselected patient populations, predominantly in coronary segments with a diameter of at least 2 mm, and assessing CAD on a per segment or per vessel basis rather than on a per patient basis. The present study was designed to determine the accuracy of MDCT in a clinical setting, namely making a decision on a per patient basis whether significant CAD is present or not. This approach seems to represent a more realistic way of using coronary MDCT angiography in a clinical setting rather than to look at a given segmental stenosis or even to try to assess the exact degree of the luminal obstruction, even if initial studies using 64-MDCT this way showed promising results [10, 11]. In the present study, the hypothesis to be proven was that MDCT can reliably help in clinical decision making of whether invasive coronary intervention is required or not.

In our analysis of 68 patients with known or suspected CAD, we found a high sensitivity (97%) and NPV (96%) and a satisfying PPV (86%) for the correct detection or exclusion of significant CAD. These promising results were found in patients with suspected CAD and in patients with known CAD, with no significant differences in diagnostic accuracy between these two subgroups. However, the specificity found was somewhat reduced (79%). These results indicate two facts: First, as reflected by a reduced specificity, 64-MDCT seems to overestimate disease on a per patient basis; that is, a number of patients without significant disease would be sent for invasive angiography for a definite diagnosis. However, in a clinical setting, it seems more important not to miss any patient with significant disease, and according to the high sensitivity and NPV found, 64-MDCT could possibly fulfill this premise. Second, it seems that 64-

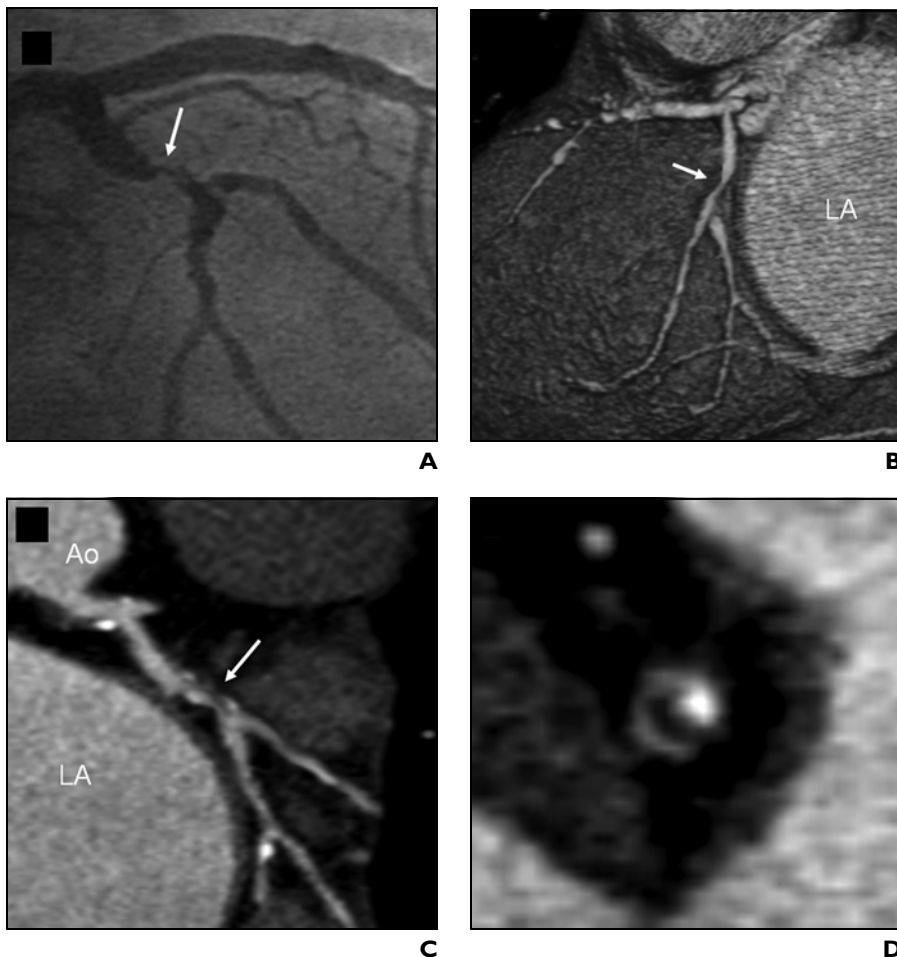


Fig. 3—65-year-old man.

A, Conventional X-ray angiography shows high-grade stenosis in left circumflex coronary artery (LCX) (arrow). **B** and **C**, In MDCT images, volume rendering technique (**B**) and multiplanar reformation (**C**) images show mixed plaque causing stenosis (arrows). LA = left atrium, Ao = aorta. **D**, Cross-sectional view of vessel clearly delineates different plaque components containing calcified and noncalcified tissue. Remaining contrast-enhanced lumen is depicted as thin rim su A0 = aorta, LA = left atrium.

MDCT could not only be useful in the initial stratification of patients with a suspicion of having significant CAD, but it could also be used as a follow-up in patients with already known CAD who present with new or changing complaints. This would give MDCT an important role in the daily cardiology routine because patients with known CAD would typically more often and more easily be referred to invasive X-ray angiography than patients without a history of CAD. MDCT could act as a gatekeeper here for invasive catheter-based angiography. Comparing our results to a study that tested the clinical value of 16-MDCT on a per patient-based analysis in a high-risk population for CAD [7], reporting moderate results of 63% sensitivity and 64% PPV, our data indicate that 64-MDCT could be superior to earlier MDCT generations in this respect. Especially in populations with a

high pretest probability of CAD or angiographically proven CAD, previous MDCT scanners showed significant limitations as shown in a study by Kuettner et al. [18], reporting per patient and per stenosis-based sensitivities as low as 36% and 37%, respectively. However, this study was conducted using 4-MDCT.

Comparing the results of the per patient-based analysis to the results of the per segment-based analysis, the latter showed a comparably high NPV (97%), whereas the sensitivity for significant stenoses (> 50%) was lower (83%) and the specificity was higher (95%) than in the per patient-based analysis. However, as described earlier, it seems more important to detect significantly diseased patients reliably and send them for further testing such as invasive X-ray angiography than to find a diseased vessel segment. When using MDCT as a

gatekeeper for X-ray angiography and correctly identifying a significantly diseased patient, it is not as important where exactly one or several significant segmental stenoses may be located because this information will be obtained by catheter angiography anyway. Conversely, a somewhat reduced specificity of MDCT in a per patient-based analysis might be acceptable. Because of a comparably high number of false-positive diagnoses on a per segment basis ($n = 37$), the PPV was somewhat reduced (72%). Here the question arises whether these diagnoses were indeed false-positive results of MDCT or in fact diagnoses missed by QCA because it is known that MDCT might be more sensitive to atherosclerotic vessel wall changes than QCA (e.g., in positive remodeling effects) [19]. In this respect, QCA might not be the optimal reference standard technique in all cases. However, in the present study, no retrospective matching of these false-positive results by MDCT with the QCA data was performed.

In the present study, coronary artery stents were included in the analysis because we wanted to include and compare patients both with no history of CAD and with known CAD. In the latter group, a total of 15 patients had undergone coronary interventions before, with a total of 24 implanted coronary artery stents. Coronary artery stents have often constituted a diagnostic dilemma in cardiac MDCT, similar to problems faced in the vicinity of heavy calcifications. Therefore, even in the most recent studies on 16-MDCT, coronary artery segments with stents have been excluded from further evaluation [4]. The increased spatial resolution of 64-MDCT might allow an improved evaluation of the in-stent lumen, raising the hope that by using 64-MDCT, the reliable assessment of patients after coronary interventions and stent placement might become feasible. In the present study, 92% of the stents were assessable, and a correct diagnosis on stent patency was made in 91%. However, in trying to grade in-stent disease in patent stents, diagnostic accuracy dropped to 50%, still indicating difficulties in assessing in-stent disease. These results could most probably be improved by applying special reconstruction kernels for optimal stent visualization, which was not performed routinely in our study.

Limitations and Future Perspectives

Despite the considerable technical improvements already described, 64-MDCT is in principle subject to similar restrictions as the earlier generations of MDCT. Temporal and spatial resolution of interventional X-ray coronary angiography is still unmatched. In the distal segments

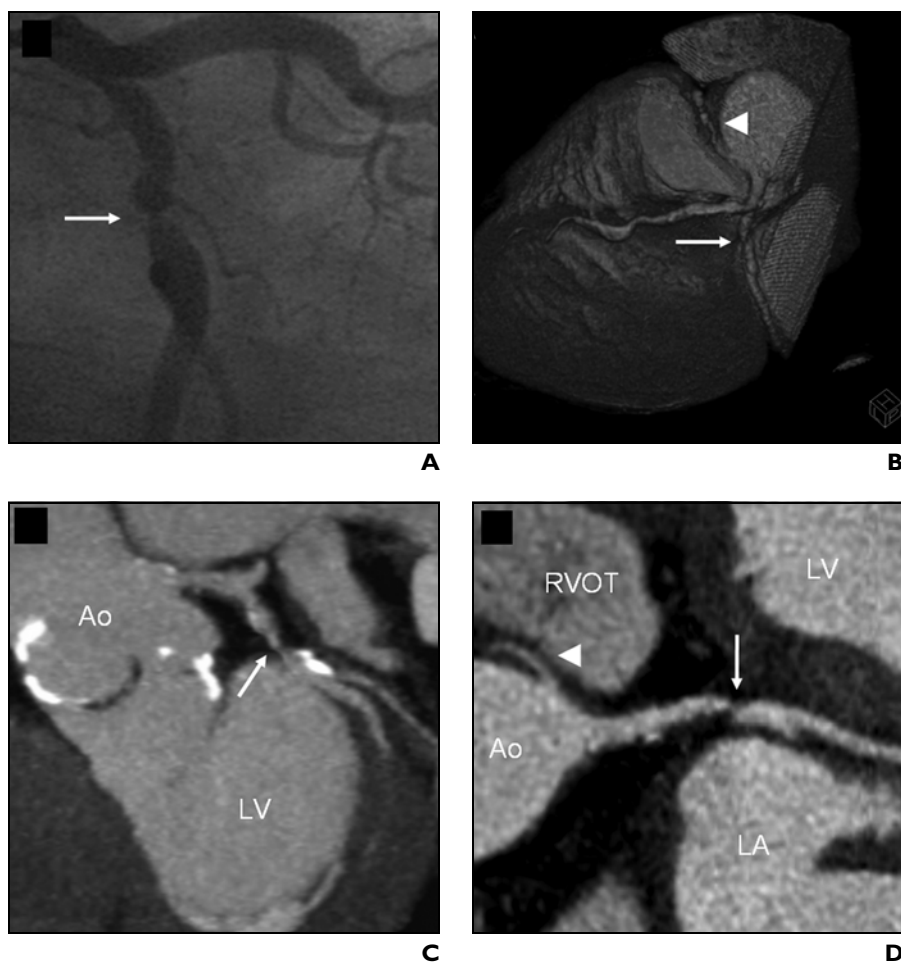


Fig. 4—58-year-old man.

A, Conventional X-ray angiography shows high-grade stenosis in left circumflex (LCX) coronary artery (arrow). **B–D**, Volume rendering technique (**B**) and multiplanar reformation (**C** and **D**) images of 64-MDCT data set clearly show stenosis (arrows). Additionally, an anomalous origin of right coronary artery (RCA) arising from left coronary sinus and intraarterial course of RCA is depicted (arrowheads, **B** and **D**). Ao = aorta, LV = left ventricle, LA = left atrium, RVOT = right ventricular outflow tract.

Accuracy of 64-MDCT in Diagnosis of Coronary Disease

TABLE 2: Overall Assessment by Two Observers for Revealing Significant Coronary Artery Stenoses (> 50%) Comparing 64-MDCT Coronary Angiography Technique with Results of Conventional Coronary Angiography

Artery	Observer 1		Observer 2		Kappa	Consensus	
	Sensitivity	Specificity	Sensitivity	Specificity		Sensitivity	Specificity
LM	100 (4/4)	100 (64/64)	100 (4/4)	100 (64/64)	1.0	100 (4/4)	100 (64/64)
LAD	83 (50/60)	90 (225/251)	75 (45/60)	96 (240/251)	0.68	78 (47/60)	92 (232/251)
RCA	90 (27/30)	95 (209/221)	83 (25/30)	97 (215/221)	0.77	87 (26/30)	96 (212/221)
LCX	88 (21/24)	94 (253/269)	79 (19/24)	95 (256/269)	0.60	83 (20/24)	94 (254/269)
All	86 (102/118)	93 (751/805)	79 (93/118)	96 (775/805)	0.75	82 (97/118)	95 (762/805)

Note—LM = left main coronary artery, LAD = left anterior descending (coronary artery), RCA = right coronary artery, LCX = left circumflex (coronary artery).

and side branches of all major coronary arteries, diagnostic accuracy and percentage of assessable segments dropped significantly, indicating that even with this scanner technology, the spatial resolution is still not sufficient to identify stenoses in peripheral vessel segments reliably. These lesions, however, are rarely targeted for an intervention. Also, the study cohort presented in this study was somewhat inhomogeneous because both patients with known and suspected CAD were included. Future studies will have to focus on larger, well-circumscribed collectives such as patients with stable angina, low pretest likelihood of CAD, or after acute myocardial infarction to determine fully the potential clinical value of 64-MDCT [3, 20]. Finally, radiation exposure of the protocol applied is still considerable, and in tandem with the ongoing improvements in image quality and the robustness of cardiac MDCT, new technologies will be needed to keep the radiation exposure within an acceptable range [21].

In conclusion, 64-MDCT coronary angiography provides a significantly increased spatial and temporal resolution compared with earlier MDCT systems. In a clinical setting, this technique may hold great promise for the reliable diagnosis or exclusion of significant CAD on a per patient basis and could give CTA an important role in the stratification of patients with both known and suspected CAD.

Acknowledgments

We would like to cordially thank Alexander W. Leber, Franz von Ziegler, and Peter Boekstegers from the Department of Internal Medicine, Cardiology, of the University Hospital Munich, for their substantial contribution to the present study, including image analysis, patient recruitment, and manuscript revisions.

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