Radiology

Prospective versus Retrospective ECG-gated 64-Detector Coronary CT Angiography: Assessment of Image Quality, Stenosis, and Radiation Dose[1]

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Purpose: To show that prospective electrocardiographically (ECG)-triggered coronary computed tomographic (CT) angiography (hereafter, prospective CT angiography) is at least as effective as retrospective ECG-gated coronary CT angiography (hereafter, retrospective CT angiography).

Materials and Methods: Institutional review committee approval and informed consent were obtained. Sixty patients with heart rates of less than 75 beats per minute who were referred for coronary CT angiography were enrolled. Both prospective and retrospective CT angiography were performed with a 64-detector scanner. Data acquisition times were recorded. Two independent cardiac radiologists evaluated subjective image quality (1, excellent; 4, poor) and severity of stenosis (0% occlusion, 1%–49% occlusion, 50%–75% occlusion, and >75% occlusion) with the 17-segment American Heart Association classification model. Discrepancies were settled by consensus. Effective radiation doses of prospective and retrospective CT angiography were calculated with volume CT dose index. Data regarding acquisition time and radiation exposure for prospective and retrospective CT angiography were compared. The Student *t* test was performed, and κ statistics were calculated.

Results: Mean data acquisition time of prospective CT angiography was shorter than that of retrospective CT angiography (5.6 seconds ± 1.1 [standard deviation] vs 6.7 seconds ± 1.1, respectively; $P < .01$). Consensus-determined image quality in coronary artery branches was similar between prospective CT angiography and retrospective CT angiography (1.15 vs 1.13, respectively; $P = .992$). Excellent agreement between prospective CT angiography and retrospective CT angiography was observed in the detection of significant (≥50% occlusion) coronary artery stenoses per segment (κ = 0.882) and in the grading of stenoses per patient (κ = 0.829). Calculated effective dose with prospective CT angiography was 79% lower than that with retrospective CT angiography (4.1 mSv ± 1.8 vs 20.0 mSv ± 3.5, respectively; $P < .001$).

Conclusion: Prospective CT angiography can reduce radiation dose below that of retrospective CT angiography with dose modulation, while maintaining image quality and the ability to assess luminal obstructions in patients with heart rates of less than 75 beats per minute.

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In studies of 64-detector retrospective electrocardiographically (ECG)-gated coronary computed tomographic (CT) angiography (hereafter, retrospective CT angiography), researchers have found high sensitivities (93%–97%) and specificities (95%–99%) for the detection of coronary artery stenoses (1). The use of 64-detector coronary CT angiography also results in high negative predictive values (95%–99%), thereby offering the opportunity to exclude coronary artery disease with less invasiveness (1) than that with coronary angiography. This is achieved by virtue of improved spatial resolution and faster rotation time on the 64-detector CT unit than on older multidetector CT units. The major drawback of retrospective CT angiography, however, is that it entails a high radiation dose (10–21 mSv) during CT (2–4) because data that are not used for image reconstruction are acquired.

Prospective ECG-triggered coronary CT angiography (hereafter, prospective CT angiography) has been performed with an electron-beam CT scanner. However, the section thickness is limited to 1.5 mm, even on e-Speed electron-beam scanners (GE-Imatron, South San Francisco, Calif) (5). On a 64-detector CT unit, the wide detector array (64 × 0.625-mm collimation), improved table control, and ECG gating recently have made available a prospective ECG-triggered data acquisition technique (the step-and-shoot technique) that enables coverage of the whole heart in three or four steps (6). The purpose of this study was to show that prospective CT angiography is at least as effective as retrospective CT angiography.

Advances in Knowledge

- Data acquisition time of prospective electrocardiographically (ECG)-triggered coronary CT angiography is shorter than that of retrospective ECG-gated coronary CT angiography (mean, 5.6 seconds ± 1.1 vs 6.7 seconds ± 1.1, respectively; $P < .01$).
- Image quality and assessment of luminal obstructions are similar between prospective ECG-triggered coronary CT angiography and retrospective ECG-gated coronary CT angiography in patients with a heart rate of less than 75 beats per minute.
- The calculated effective dose of prospective ECG-triggered coronary CT angiography was 79% lower than that of retrospective ECG-gated coronary CT angiography (4.1 mSv ± 1.8 vs 20.0 mSv ± 3.5, respectively; $P < .001$).

Materials and Methods

Patients

This study was approved by the local hospital ethics committee at Hiroshima University Hospital. Written informed consent was obtained from all patients after the nature of the procedure, including radiation dose information, had been fully explained. From September 2006 to April 2007, 62 patients who were referred for coronary CT angiography to rule out coronary artery disease were consecutively enrolled in this study. The study population included 42 men and 20 women (mean age, 65 years ± 11 [standard deviation]; age range, 36–87 years). Exclusion criteria were as follows: arrhythmia, post coronary artery stent placement, postoperative state of bypass grafts or valve replacement, allergy to iodinated contrast media, and insufficient renal function (creatinine level > 1.5 mg/dL). Premedication with an oral β-blocker (40 mg Seloken; Astra Zeneca, Tokyo, Japan) was used to lower the heart rate 1 hour before the examination in 18 patients with a baseline heart rate higher than 70 beats per minute. No additional intravenous β-blocker was administered at the time of the examination. Nitroglycerin spray (Mycor; Astellas Pharma, Tokyo, Japan) also was used 5 minutes before the examination to dilate the coronary arteries (7). Patients with a preexamination heart rate of 75 beats per minute or higher were excluded and underwent routine retrospective CT angiography. Two patients had a heart rate of 75 beats per minute or higher during the examination. Their data were excluded from analysis; thus, the final study population comprised 60 patients (40 men, 20 women).

Implication for Patient Care

- Low-dose prospective ECG-triggered coronary CT angiography can be used to assess coronary artery disease in low-risk patients with a low heart rate (less than 75 beats per minute in our single-institution study).

Scanning Protocols

All examinations were performed with a 64-detector CT scanner (Lightspeed VCT; GE Healthcare, Waukesha, Wis). The scanning direction was craniocaudal and extended from the level of the carina to the diaphragm. Prior to scanning, a technologist (C.F.) instructed all patients regarding breath holding in an effort to minimize changes in body posture during the examination. The scanning sequence was as follows: Topography was performed and was followed by a test bolus examination and two coronary CT angiography algorithms. The 62 patients were randomly assigned to two groups: In the first group, 34 patients were scanned with retrospective CT angiography first and prospective CT angiography second. The remaining

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Abbreviations:
CI = confidence interval
ECG = electrocardiography

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28 patients were examined in reverse order. The interval between examinations was 5 minutes.

The test bolus was tracked in the ascending aorta at the level of the pulmonary trunk every 2 seconds after administration of 10 mL iopamidol (Iopamiron 370; Bayer-Schering, Berlin, Germany) followed by injection of a 25-mL saline chaser at a rate (*R*, measured in milliliters per second) calculated with the following equation: $R = (0.06 \cdot W)/T$, where W is the patient's body weight (measured in kilograms) and T is time (measured in seconds). The scan delay was defined 3 seconds after peak enhancement. For both prospective CT angiography and retrospective CT angiography, individual body weight–adapted volume of contrast media (V) was determined with the following equation: $V = W \cdot 0.6$. Contrast material was injected over the course of 10 seconds and followed by a 25-mL saline chaser.

Prospective CT angiography was performed with the following parameters: step-and-shoot axial scanning direction, 233-msec x-ray exposure time (two-thirds of the gantry rotation speed), 64 × 0.625-mm collimation, 0.35-second gantry rotation time, 120-kV tube voltage, 650-mA tube current, and the center of the imaging window set at 75% of the R-R interval. Prospective CT angiography data were acquired with a 40-mm axial scan (64 × 0.625-mm collimation) when the table was stationary. Thereafter, the table was moved 35 mm, thereby allowing a 5-mm overlap for the next examination. Retrospective CT angiography was performed with the following parameters: helical scanning direction, 0.16–0.22 pitch, and use of dose modulation (peak tube current of 650 mA during 65%–85% of the R-R interval and minimal tube current of 300 mA). The other parameters were the same as those used for prospective CT angiography.

Image Processing and Evaluation

A radiology technologist (C.F., 5 years of experience) created curved multiplanar reconstruction and "angiographic view" maximum intensity projection images (8) of the three major branches (left main to left anterior descending, left circumflex, and right coronary arteries) (Figs 1, 2) at six viewing angles every 30° on a separate workstation (Advantage Workstation, version 4.2; GE Healthcare) by using Card IQ Xpress software. All images were arranged randomly for separate evaluation by two experienced cardiac radiologists (J.H., N.H.; 8 and 7 years of experience, respectively) who were blinded to the coronary CT angiography algorithms and patient information. The images obtained with prospective CT angiography and those obtained with retrospective CT angiography were read separately, with an interval of at least 1 month. In addition, lesions detected on the two aforementioned reconstruction images were assessed on cross-sectional images. Coronary artery segments, classified according to a modified 17-segment American Heart Association model of vessel disease (9), with a luminal diameter of 1.5 mm or larger, as judged by the radiologist (N.H.), were evaluated. For any disagreement in data analysis, consensus reading was performed.

Figure 1

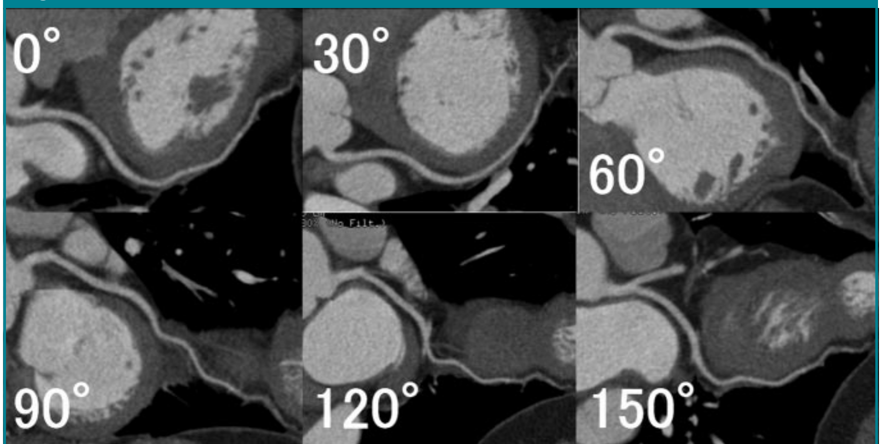

Figure 1: Curved multiplanar reconstruction maximum intensity projection images at six viewing angles obtained to evaluate image quality and coronary artery stenoses.

Figure 2

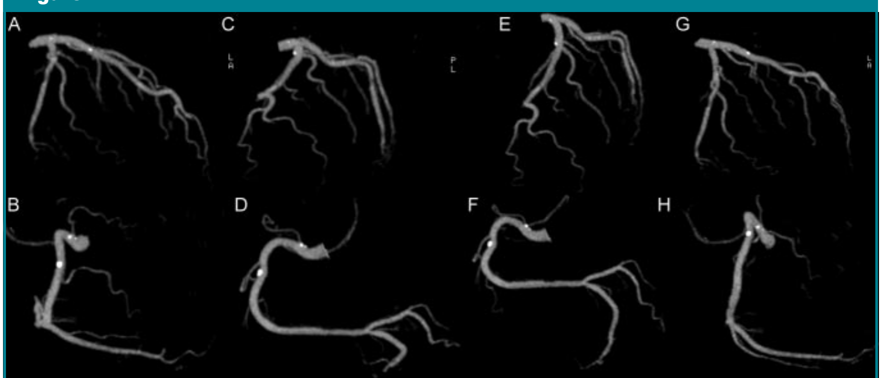

Figure 2: Image data set of maximum intensity projection reconstruction images in the "angiographic view" at four viewing angles obtained to evaluate image quality and coronary artery stenoses. *A, B,* Right anterior oblique 30°; *C, D,* left anterior oblique 60°; *E, F,* right anterior oblique 30° plus caudal 25°; and, *G, H,* left anterior oblique 60° plus cranial 25° images.

Image Quality

The image quality of angiograms that depicted the coronary arteries was evaluated with a four-point grading scale (10): A score of 1 corresponded to excellent image quality (vessels had a continuous course, without stair-step artifacts, and were surrounded by low-attenuation fat) (Fig 3, *A*). A score of 2 corresponded to good image quality (presence of discrete blurring of vessel margin in any planar orientation, minor motion artifacts, and no stair-step artifacts) (Fig 3, *B*). A score of 3 corresponded to fair image quality (noticeably blurred vessel or plaque margins, distinctly broader motion artifacts extending less than 5 mm from the vessel center, and stair-step artifacts of <25% of the vascular diameter) (Fig 3, *C*). A score of 4 corresponded to poor image quality (inadequate delineation between the vessel and the surrounding tissue, presence of streak artifacts extending at least 5 mm from the center of the vessel, and stair-step artifacts of ≥25% of the vessel diameter) (Fig 3, *D*). Images with a score of 3 or lower were considered acceptable for diagnosis.

Figure 3

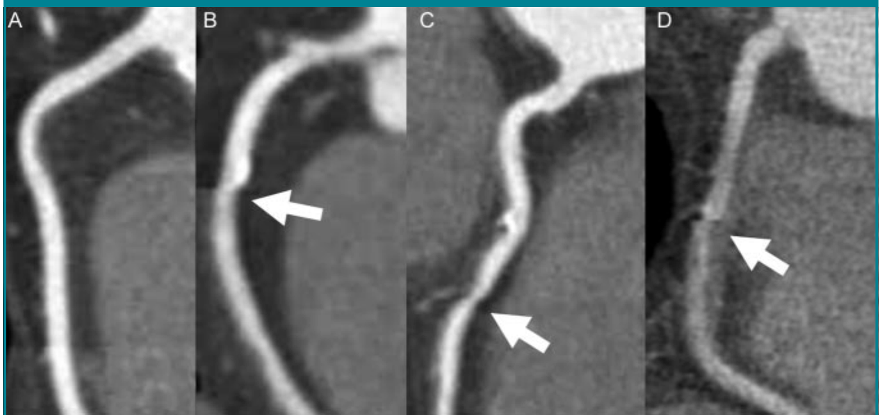

Figure 3: Angiograms show examples of image quality. *A*, Excellent image quality (score of 1). *B*, Good image quality (score of 2). *C*, Fair image quality (score of 3). *D*, Poor image quality (score of 4). Arrows = image evaluation points.

Figure 4

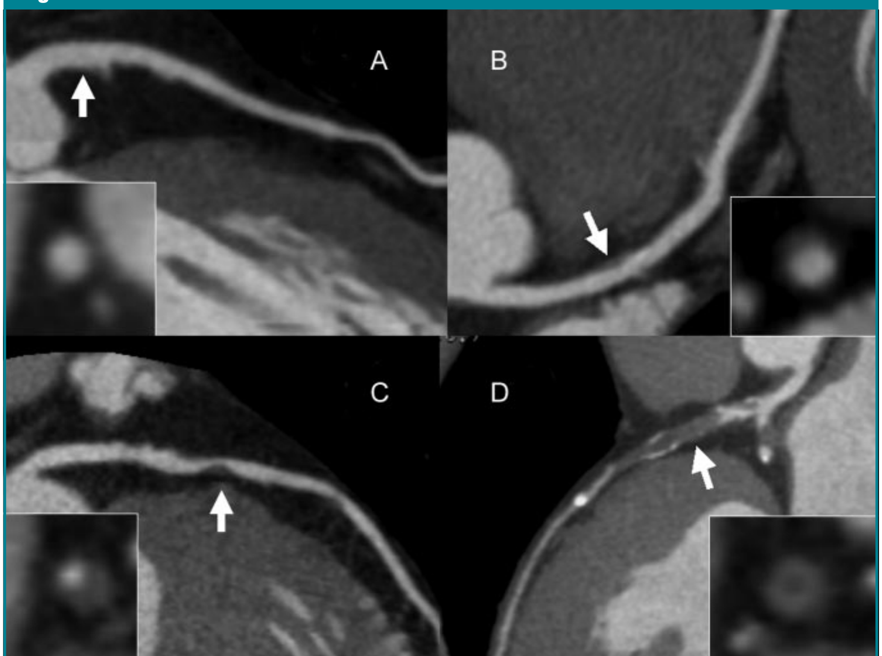

Figure 4: CT angiograms show grading of coronary artery stenosis. In, *A*, no stenosis (0% occlusion) is seen. In, *B*, 1%–49% occlusion is visible. In, *C*, 50%–75% occlusion can be seen. In, *D*, there is more than 75% occlusion. Arrows = stenotic lesions. The magnified areas show cross-sectional views of targeted areas.

Coronary Artery Stenoses

Coronary artery segments with acceptable image quality were assessed for the presence of stenoses and placed into the following categories: category 1, no (0%) occlusion; category 2, 1%–49% occlusion; category 3, 50%–75% occlusion; and category 4, more than 75% occlusion (Fig 4). The degree of coronary artery stenosis seen with prospective CT angiography was compared with that seen with retrospective CT angiography on both a per-segment basis and a per-patient basis. (The highest degree of stenosis was used for analysis.)

Radiation Dose

The dose-length product (measured in milligray-centimeters) was displayed on the dose report on the CT scanner and recorded. A reasonable approximation of the effective dose *(E)* can be obtained by using the following equation (11): $E = k \cdot \mathrm{DLP}$, where k is equal to 0.017 $\mathrm{mSv} \cdot \mathrm{mGy}^{-1} \cdot \mathrm{cm}^{-1}$ and DLP is the dose-length product. This value is applicable for chest examinations and is the average between male and female models.

Statistical Analysis

Statistical analysis was performed by using statistical software (StatView for Windows, version 5.0; SAS Institute, Cary, NC). Interobserver or interprotocol agreements and 95% confidence intervals (CIs) were expressed as Cohen κ statistics (12), in which a κ

Table 1

Quality of Coronary Artery Images

Segment	Grade 1		Grade 2		Grade 3		Grade 4		*P* Value*
	Prospective CT Angiography	Retrospective CT Angiography	Prospective CT Angiography	Retrospective CT Angiography	Prospective CT Angiography	Retrospective CT Angiography	Prospective CT Angiography	Retrospective CT Angiography	
1	85 (51/60)	85 (51/60)	5 (3/60)	3 (2/60)	3 (2/60)	2 (1/60)	7 (4/60)	10 (6/60)	.964
2	67 (40/60)	65 (39/60)	22 (13/60)	22 (13/60)	5 (3/60)	5 (3/60)	7 (4/60)	8 (5/60)	.842
3	87 (52/60)	90 (54/60)	3 (2/60)	5 (3/60)	7 (4/60)	3 (2/60)	3 (2/60)	2 (1/60)	.729
4									
Atrioventricular	98 (55/56)	100 (56/56)	2 (1/56)	0 (0/56)	0 (0/56)	0 (0/56)	0 (0/56)	0 (0/56)	.871
Posterior descending	97 (58/60)	98 (53/54)	2 (1/60)	2 (1/54)	0 (0/60)	0 (0/54)	2 (1/60)	0 (0/54)	.889
5	98 (59/60)	100 (60/60)	2 (1/60)	0 (0/60)	0 (0/60)	0 (0/60)	0 (0/60)	0 (0/60)	.875
6	88 (53/60)	97 (58/60)	5 (3/60)	0 (0/60)	3 (2/60)	3 (2/60)	3 (2/60)	0 (0/60)	.434
7	92 (55/60)	85 (51/60)	3 (2/60)	8 (5/60)	3 (2/60)	2 (1/60)	2 (1/60)	5 (3/60)	.532
8	97 (58/60)	97 (57/59)	2 (1/60)	3 (2/59)	2 (1/60)	0 (0/59)	0 (0/60)	0 (0/59)	>.99
9	100 (55/55)	98 (54/55)	0 (0/55)	2 (1/55)	0 (0/55)	0 (0/55)	0 (0/55)	0 (0/55)	.869
10	100 (3/3)	67 (2/3)	0 (0/3)	33 (1/3)	0 (0/3)	0 (0/3)	0 (0/3)	0 (0/3)	.513
11	93 (55/59)	92 (55/60)	5 (3/59)	2 (1/60)	2 (1/59)	3 (2/60)	0 (0/59)	3 (2/60)	.857
12									
High lateral	88 (15/17)	95 (19/20)	0 (0/17)	5 (1/21)	12 (2/17)	0 (0/21)	0 (0/17)	0 (0/21)	.421
Obtuse marginal	100 (44/44)	93 (38/41)	0 (0/45)	7 (3/41)	0 (0/45)	0 (0/41)	0 (0/45)	0 (0/41)	.694
13	93 (55/59)	90 (54/60)	3 (2/59)	8 (5/60)	3 (2/59)	0 (0/60)	0 (0/59)	2 (1/60)	.774
14	97 (57/59)	100 (59/59)	2 (1/59)	0 (0/59)	2 (1/59)	0 (0/59)	0 (0/59)	0 (0/59)	.999
15	100 (1/1)	100 (1/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	0 (0/1)	>.99
All segments	91.9 (761/828)	92.0 (766/833)	4.6 (38/828)	4.0 (33/833)	2.2 (18/828)	2.4 (20/833)	1.3 (11/828)	1.7 (14/833)	.992

Note.—Data are percentages, and data in parentheses were used to calculate the percentages.

* The Mann-Whitney *U* test was used to determine the difference between prospective ECG-triggered CT angiography and retrospective ECG-gated CT angiography.

value of less than 0.20 implied poor agreement; a κ value of 0.21–0.40, fair agreement; a κ value of 0.41–0.60, good agreement; a κ value of 0.61–0.80, very good agreement; and a κ value of 0.81–1.00, excellent agreement. Possible correlations between segments within patients were considered by using the generalized estimation equation model for binomial data. Interobserver and interprotocol agreements per segment were evaluated with κ statistics for grade 1–3 (acceptable) image quality versus grade 4 (unacceptable) image quality (13) and insignificant (<50% occlusion) versus significant (≥50% occlusion) stenoses (14). The Student *t* test was used for continuous variables, and the Mann-Whitney *U* test was used for categorical data. In case data were not normally distributed, they were transferred into a logarithmic scale to reduce skew. $P < .05$ indicated a significant difference.

Results

The 60 patients with a heart rate of less than 75 beats per minute during both examinations had a mean body weight of 62 kg ± 12 (range, 38–90 kg). The mean total volume of contrast material administered (test bolus examination, prospective and retrospective CT angiography) was 85 mL ± 15 (range, 56–118 mL). Mean data acquisition time was 5.6 seconds ± 1.1 (median, 6.0 seconds; 95% CI: 5.1 seconds, 6.0 seconds) for prospective CT angiography and 6.7 seconds ± 1.1 (median, 7.0 seconds; 95% CI: 6.8 seconds, 7.2 seconds) for retrospective CT angiography ($P < .01$). The mean heart rate during data acquisition was 57.1 beats per minute ± 7.8 (range, 42–73 beats per minute) for prospective CT angiography and 57.7 beats per minute ± 7.1 (range, 41–74 beats per minute) for retrospective CT angiography ($P = .33$).

Image Quality

In 1520 (91.5%) of the 1661 coronary segments, immediate agreement between observers regarding image quality was achieved. In the remaining 141 segments (8.5%), consensus reading was needed to discriminate between image quality scores 1 and 2 ($n = 91$, 64.5%) and between scores 2 and 3 ($n = 50$, 35.5%). Interobserver agreement for grading of image quality in binomial fashion (ie, acceptable vs unacceptable) was perfect (κ = 1.000). Acceptable image quality (scores 1–3) was achieved in 819 (98.9%) of 828 coronary segments with prospective CT angiography and in 811 (97.4%) of 833 segments with retrospective CT angiography, with excellent agreement between the methods (κ = 0.882; 95% CI: 0.842, 0.923). There was no significant difference in image quality score for the total segments between prospective CT angiography and retrospective CT angiography (1.15 vs 1.13, respectively; $P = .992$) (Table 1).

Coronary Artery Stenoses

We excluded 21 pairs of 1661 segments, all 21 of which had an image quality score of 4. In 754 (93.1%) of the 810 coronary segments, immediate agreement between both observers was achieved. In the remaining 56 segments (6.9%), consensus reading was required to discriminate between *(a)* coronary artery stenoses with 0% occlusion and those with 1%–49% occlusion ($n = 16$, 29%), *(b)* those with 1%–49% occlusion and those with 50%–75% occlusion ($n = 31$, 55%), and *(c)* those with 50%–75% occlusion and those with more than 75% occlusion ($n = 9$, 16%). Interobserver agreement for detection of significant coronary artery stenoses was excellent (κ = 0.882; 95% CI: 0.841, 0.923). Assessment of coronary artery stenoses on a per-patient basis had an excellent κ value of 0.829 (95% CI: 0.713, 0.945) (Table 2).

Radiation Dose

There was a significant difference between dose-length products for prospective CT angiography (mean, 240 mGy · cm ± 105; median, 191 mGy · cm; 95% CI: 205 mGy · cm, 267 mGy · cm) and retrospective CT angiography (mean, 1175 mGy · cm ± 205; median, 1146 mGy · cm; 95% CI: 1113 mGy · cm, 1239 mGy · cm) ($P < .001$). There was also a significant difference between calculated effective doses for prospective CT angiography (mean, 4.1 mSv ± 1.8; median, 3.2 mSv; 95% CI: 3.5 mSv, 4.5 mSv) and retrospective CT angiography (mean, 20.0 mSv ± 3.5; median, 19.5 mSv; 95% CI: 18.9 mSv, 21.1 mSv) ($P < .001$). The radiation dose of prospective CT angiography was reduced by 79% compared with that of retrospective CT angiography.

Discussion

To our knowledge, our study is the first to show that prospective CT angiography has a diagnostic performance, in terms of image quality and ability to assess stenoses, that is comparable to that of retrospective CT angiography in patients with a heart rate of less than 75 beats per minute. Most importantly, effective radiation dose in prospective CT angiography is dramatically reduced to approximately 4.4 mSv, which is far less than that of retrospective CT angiography with dose modulation in the present study and in previous studies (2–4) and is near that reported for diagnostic coronary angiography (ie, 2–3 mSv) (11, 15). The lower tube voltage reduces the radiation dose for retrospective CT angiography performed on a 64-detector scanner (16,17); however, lower tube voltage and tube current are needed to further assess how radiation exposure can be decreased with prospective CT angiography.

We showed that image quality was comparable between prospective CT angiography and retrospective CT angiography. One potential reason for this was that we did not include patients with a high heart rate. Increased heart rate shortens the rest period at diastole; therefore, the best image quality may shift from diastole to systole during 64-detector CT examinations (18,19). The 175-msec temporal resolution (half of gantry rotation speed) in prospective CT angiography on fixed end-diastolic phase reconstruction was not suited for these patients, especially for delineation of the fast-moving right coronary artery. We believe that examinations in patients with an unstable heart rate are difficult to manage with prospective CT angiography and are suited for retrospective CT angiography with ECG editing (ie, by arbitrarily modifying the position of the temporal windows within the cardiac cycle to correct and compensate for part or all of the artifacts produced by mild heart rhythm irregularities) (20).

In a recent review (21), Kroft et al comprehensively described the technical causes of various artifacts seen on multidetector coronary CT angiograms. Respiratory and postural motions are causes for blurring artifacts (volume averaging due to motion) or subtle discontinuities and missing data. Reduced acquisition time for 64-detector CT data, especially with use of prospective CT angiography, has the potential to minimize these artifacts. The axial direction of data acquisition with prospective CT angiography also has the potential to avoid rod artifacts, which are also referred to as "windmill" artifacts (ie, hypo- or hyperattenuation structures around high- or low-attenuation structures caused by the spiral interpolation process of high-contrast structures that are obliquely oriented along the z-axis scanning plane) (21).

We found that prospective CT angiography and retrospective CT angiography have a similar diagnostic performance in the assessment of luminal obstructions in patients with heart rates of less than 75 beats per minute. Analysis of coronary artery segments revealed that absence of stenoses was observed at both prospec-

Table 2

Per-Patient Assessment of Coronary Artery Stenosis

	Retrospective CT Angiography			
Prospective CT Angiography	0%	1%–49%	50%–75%	More than 75%
0%	10*	1	. . .	. . .
1%–49%	1	6*	1	. . .
50%–75%	. . .	1	10*	. . .
More than 75%	. . .	. . .	3	27*

Note.—Data are numbers of sites of stenosis.

* Segment with complete agreement between prospective CT angiography and retrospective CT angiography.

tive CT angiography and retrospective CT angiography in 591 segments, whereas discrepancy between the protocols (positive vs negative findings) was seen in only 31 segments. This suggests that prospective CT angiography preserves the high negative predictive value for coronary artery stenoses, which is one of the most vital functions of 64-detector coronary CT angiography.

The advantages of retrospective CT angiography over prospective CT angiography include the improved temporal resolution with multisector reconstruction, the ability to acquire systolic phase information, the chance to assess ventricle motion and aortic valve motion, and the potential for ECG editing. Patients with a low probability of myocardial infarction and no previous history of coronary heart disease who were examined to rule out coronary artery disease might reap the most benefits from the large radiation dose reduction that accompanies prospective CT angiography, since the advantages of retrospective CT angiography are typically not needed in this group.

Blooming artifacts (ie, small high-contrast objects that appear larger than they are) (21) are known to be a factor in the overestimation of stenoses near calcified plaque. Thus, in patients with calcified plaque, both prospective CT angiography and retrospective CT angiography may have shown a high grade of stenosis, while the actual stenosis belonged to a lesser grade. This problem, which is inherent to the currently available 64-detector CT scanners, may be overcome by the next generation of thin-section (approximately 0.3-mm collimation) 64-detector CT scanners (22).

One limitation of this study was that we did not correlate prospective CT angiography findings with coronary angiography findings. A comparative study with angiography will elucidate how much prospective CT angiography results in the overestimation of severity of stenoses near calcified plaque. A second limitation was that we did not include patients with a high heart rate; therefore, we did not investigate the robustness of prospective CT angiography in patients with a high heart rate. A third limitation was that a low helical pitch (0.16–0.22) was used, resulting in a high radiation dose at retrospective CT angiography (20.0 mSv ± 3.5). The fourth and final limitation was that this was a single-institution study, and the body habitus of these participants (mean weight, 62 kg ± 12) was smaller than the typical body habitus of patients in the United States; therefore, the optimization of radiation dose for prospective CT angiography needs further verification.

In conclusion, prospective ECG-triggered coronary CT angiography can reduce radiation dose below that of retrospective ECG-gated coronary CT angiography with dose modulation, while maintaining image quality and the ability to assess luminal obstructions in patients with heart rates of less than 75 beats per minute.

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