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Low-Dose Dual-Source CT Angiography With Iterative Reconstruction for Coronary Artery Stent Evaluation

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OBJECTIVES The purpose of this study was to evaluate the image quality and diagnostic accuracy of very low-dose, dual-source computed tomography (DSCT) angiography for the evaluation of coronary stents.

BACKGROUND Iterative reconstruction (IR) leads to substantial reduction of image noise and hence permits the use of very low-dose data acquisition protocols in coronary computed tomography angiography.

METHODS Fifty symptomatic patients with 87 coronary stents (diameter 3.0 $\pm$ 0.4 mm) underwent coronary DSCT angiography (heart rate, 60 $\pm$ 6 beats/min; prospectively electrocardiography-triggered axial acquisition; 80 kV, 165 mA, 2 $\times$ 128 $\times$ 0.6-mm collimation; 60 ml of contrast at 6 ml/s) before invasive coronary angiography. DSCT images were reconstructed using both standard filtered back projection and a raw data–based IR algorithm (SAFIRE, Siemens Healthcare, Forchheim, Germany). Subjective image quality (4-point scale from 0 [nondiagnostic] to 3 [excellent image quality]), image noise, contrast-to-noise ratio as well as the presence of in-stent stenosis >50% were independently determined by 2 observers.

RESULTS The median dose-length product was 23.0 (22.0; 23.0) mGy·cm (median estimated effective dose of 0.32 [0.31; 0.32] mSv). IR led to significantly improved image quality compared with filtered back projection (image quality score, 1.8 $\pm$ 0.6 vs. 1.5 $\pm$ 0.5, $p < 0.05$; image noise, 70 Hounsfield units [62; 80 Hounsfield units] vs. 96 Hounsfield units [82; 113 Hounsfield units], $p < 0.001$; contrast-to-noise ratio, 11.0 [9.6; 12.4] vs. 8.0 [6.2; 9.3], $p < 0.001$). To detect significant coronary stenosis in filtered back projection reconstructions, the sensitivity, specificity, positive predictive value, and negative predictive value were 97% (32 of 33), 53% (9 of 17), 80% (32 of 40), and 90% (9 of 10) per patient, respectively; 89% (43 of 48), 79% (120 of 152), 57% (42 of 74), and 96% (121 of 126) per vessel, respectively; and 85% (12 of 14), 69% (51 of 73), 32% (11 of 34), and 96% (51 of 53) per stent, respectively. In reconstructions obtained by IR, the corresponding values were 100% (33 of 33), 65% (11 of 17), 85% (33 of 39), and 100% (11 of 11) per patient, respectively; 96% (46 of 48), 84% (129 of 152), 66% (47 of 71), and 98% (127 of 129) per vessel, respectively; and 100% (14 of 14), 75% (55 of 73), 44% (14 of 32), and 100% (55 of 55) per stent, respectively. These differences were not significant.

CONCLUSIONS In selected patients, prospectively electrocardiography-triggered image acquisition with 80-kV tube voltage and low current in combination with IR permits the evaluation of patients with implanted coronary artery stents with reasonable diagnostic accuracy at very low radiation exposure. (J Am Coll Cardiol Img 2013;6:458–65) © 2013 by the American College of Cardiology Foundation

Temporal and spatial resolution of computed tomography (CT) has improved substantially during the past decade. Although applications of coronary CT angiography have become more widespread, the clinical utility of coronary CT angiography to identify in-stent stenosis remains questionable. This is partly due to the wide range of sensitivity (between 86% and 95% in recent studies) and specificity (between 84% and 98%) as well as the often low positive predictive value in published comparisons between CT angiography and invasive coronary angiography (1–6). In addition, the radiation exposure associated with coronary CT angiography remains of concern (7,8). New image acquisition protocols, such as the use of prospectively triggered axial acquisition, and advanced iterative image reconstruction techniques permit substantial reductions in radiation exposure (9–13). Iterative reconstruction (IR) may furthermore improve image quality (14–16).

Low-dose coronary CT angiography with IR has been demonstrated to allow high accuracy for the detection of coronary artery stenoses, but its value for the identification of in-stent stenosis has so far not been assessed. We therefore investigated a series of 50 patients with previously implanted coronary artery stents, scheduled for invasive coronary angiography, who underwent dual-source CT (DSCT) coronary angiography before invasive catheterization.

METHODS

Patient population. Fifty consecutive patients with previous coronary stent implantation (87 stented lesions) referred for invasive coronary angiography due to suspected progression of coronary artery disease were included in the study.

Patients with impaired renal function (serum creatinine >1.5 mg/dl), with known allergy to a contrast agent, or who were possibly pregnant as well as patients in non–sinus rhythm or acute coronary syndromes were not included in the study. Stent-specific exclusion criteria were previous stent-in-stent implantation and previous stent implantation in bifurcation lesions or bypass grafts. All included patients gave written informed consent, and the study was approved by the institutional review board.

All patients with a heart rate >65 beats/min received 100 mg of atenolol orally 45 to 60 min before the DSCT examination. If the heart rate in inspiration remained >65 beats/min at the time of the scan, as many as 4 doses of 5 mg metoprolol were given intravenously to reach a target heart rate <60 beats/min. Patients who did not reach the target heart rate were not excluded. All patients received 0.8-mg isosorbide dinitrate sublingually before DSCT examination.

DSCT data acquisition. All patients were examined while in the supine position during inspiratory breath-hold using a DSCT system (Somatom Definition Flash, Siemens Healthcare, Forchheim, Germany) with a gantry rotation time of 0.28 s. Tube voltage was set to 80 kV, and tube current was 165 mA. DSCT datasets were simultaneously acquired in 2 × 128 slices with 0.6-mm collimation. Scan direction was craniocaudal, and the scan volume ranged from the mid pulmonary artery to below the diaphragmatic face of the heart. In all patients, a prospectively electrocardiography (ECG)-triggered axial scan mode was used, triggered at 70% of the R-R interval, with no "padding," which would allow for reconstruction of datasets at other time points within the cardiac cycle.

After placing an 18-gauge intravenous access antecubitally for all patients, contrast agent circulation time (iopromide, 370 mg iodine/ml, Schering, Berlin, Germany) was assessed by application of a test bolus of 10 ml followed by a saline flush of 50 ml at a flow rate of 6 ml/s using a dual-head power injector (CT Stellant, Medrad Inc., Indianola, Pennsylvania). The circulation time was defined by the time between the start of the contrast agent injection and the maximal enhancement in the ascending aorta above the coronary ostia. For angiographic CT data acquisition, a delay that was 2 s longer than the circulation time was used. The

ABBREVIATIONS AND ACRONYMS

CT = computed tomography

DSCT = dual-source computed tomography

ECG = electrocardiography

FBP = filtered back projection

IR = iterative reconstruction

LAD = left anterior descending

LCX = left circumflex

LM = left main

RCA = right coronary artery

ROI = region of interest

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