To evaluate the feasibility and diagnostic accuracy of adenosine-stress dual-energy computed tomography (DECT) for detecting hemodynamically significant stenosis causing reversible myocardial perfusion defect (PD) compared with stress perfusion magnetic resonance imaging (SP-MRI) and conventional coronary angiography (CCA).

Purpose

Patients. This study was conducted prospectively, enrolling 50 consecutive patients (20 women, 30 men; mean age 64.6 ± 9 years; range 46-75 years) with documented coronary artery disease (CAD) that was diagnosed by using DSCT coronary angiography (CA). Reasons for DSCT-CA examination were typical or atypical chest pain, pathological treadmill test, or dyspnea. All patients were scheduled for CCA and were referred for adenosine-stress delayed enhancement CTA (DECT) using SYMRI to further evaluate the stress DECT results in the context of known CAD.

Adenosine-stress delayed enhancement CTA. Beta-blockers and nitroglycerin were not used to avoid impact on myocardial perfusion. All CTA examinations were performed on a DSCT scanner (Somatom Definition, Siemens Medical Solutions, Forchheim, Germany) in dual-energy mode. DECT was performed using the following scanning parameters: 330 ms gantry rotation time, heart rate adaptive pitch of 0.2-0.6, 32 × 2.0-3.4-mm collimation with z-flying focal spot technique and 165 ms temporal resolution. One tube of the DSCT was operated with 60 mAs at 140 kV, the second tube with 164 mAs in 40 kV. Adenosine infusion was started at a constant rate of 140 μg/kg/min over 6 min. A retrospectively gated scan with electrocardiography (ECG)-based current modulation (Modino) and pitch adaptation was obtained 4 min after the initiation of the adenosine infusion. For all CT examinations, a dual-head power injector (Stellant D; Medrad, Indiana, PA, USA) was used to administer a three-phase bolus at a rate of 4.5 mL/s. The data sets for the assessment of myocardial perfusion were reconstructed during the mid diastolic phase, with reconstruction windows set at 60% to 75% of the R-R interval. For the reconstruction of axial images, we used a slice thickness of 0.75 mm and a slice increment of 0.4 mm with dedicated dual-energy convolution kernel (DSD). Cardiac MRI. Among the 50 study participants, 36 underwent rest and stress-perfusion MRI. All cardiac MRI studies were performed with a 1.5 T whole-body system (Signa HD, GE Medical System, Milwaukee, USA) using an 8-element phased array surface coil. Adenosine was administered intravenously at an average rate of 140 μg/kg/min over 6 min in 60% of the LV myocardium. Dual energy CT based iodine map during adenosine infusion (c) reveals a perfusion defect in the mid anterior and anteroseptal LV myocardium (arrows). Findings in good correlation with cardiac MRI acquired at rest (d) and stress (e), which reveal persisting perfusion defects in the same myocardial area. In total, 41 patients had myocardial perfusion defects on stress DECT and cardiac MRI.

Conclusions

Our initial experience of stress DECT demonstrated feasibility and good diagnostic accuracy in detecting functionally relevant coronary stenoses causing stress-induced myocardial PDs in comparison with SP-MRI and CCA in patients with known CAD. Adenosine stress DECT has the potential to become a promising imaging modality for evaluation of myocardial perfusion and can be used as an alternative to other MPI techniques. However, we recommend cautious clinical application of the results to low CAD prevalence populations. Larger multicenter studies are required to explore the growing value of this imaging technique.

Results

Adenosine-stress delayed enhancement CTA. Stress DECT was performed for all 41 patients within 215 ± 21 days after DSCT-CA imaging. With the use of adenosine, the average HR increased from 61 ± 8 bpm at rest to 70 ± 11 bpm at stress. The average effective radiation dose for the stress perfusion DECT was 5.8 ± 0.6 mSv. Reversible myocardial PDs on DECT were found for 38 out of 41 patients (92.2%), 35 out of 69 myocardial segments (43.2%), and 72 of 123 vascular territories (58.5%). Cardiac MRI. Cardiac MRI data were analyzed in 28 of 36 patients because 5 patients were excluded in the study population and 3 patients had poor image quality related to breathing artifact and dark rim artifacts. All 28 cardiac MRI scans were of diagnostic image quality and obtained within 2.2 ± 0.9 days after stress DECT. On cardiac MRI, 25 of 28 patients (89.3%) 18% of 448 myocardial segments (41.3%), and 45 of 84 vascular territories (53.6%) had reversible perfusion abnormalities.

On CCA, 37 (90%) patients had significant coronary stenosis (>50% lumen reduction), of whom 18 had significant stenosis in the right coronary artery territory. 30 in the left anterior descending artery territory, and 17 in the left circumflex artery territory. Of these 37 patients, 15 (40.6%) patients had single-vessel disease, 14 (37.8%) had double-vessel disease, and 8 (21.6%) had triple-vessel disease. Adenosine-stress perfusion DECT and cardiac MRI. Of the 222 segments with abnormal DECT stress perfusion, 164 were detected on SP-MRI (Figs. 1 and 2) but 58 were mismatched with SP-MRI (Fig. 3). Twenty-one segments with perfusion abnormalities on SP-MRI were mismatched with stress DECT. On a per-segment basis, stress DECT had a sensitivity of 89%, specificity of 79%, accuracy of 82%, PPV of 74%, and NPV of 91% for the detection of segments with reversible myocardial PDs seen on SP-MRI. Of the 52 vascular territories with abnormal DECT stress perfusion, 41 were matched with SP-MRI but 11 were not detected on SP-MRI. Four territories with reversible PDs on SP-MRI were not detected on stress DECT. On a per-vascular territory basis, stress DECT had a sensitivity of 91%, specificity of 72%, accuracy of 83%, PPV of 81%, and NPV of 92% for the detection of vascular territories with ischemic PDs that were supplied by a significant coronary stenosis compared with CCA. Of the 38 patients with perfusion abnormalities, 36 had significant coronary stenosis (Figs. 1-3) but 2 did not have significant stenosis on CCA. One patient with significant stenosis did not show reversible myocardial PD on stress DECT. On a per-patient basis, sensitivity for the classification of patients with or without hemodynamically relevant CAD using stress DECT was 97%, specificity was 50%, accuracy 93%, PPV was 95%, and NPV was 95% in comparison with CCA.