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Diagnostic accuracy of 320-slice computed-tomography for detection of significant coronary artery stenosis in patients with various heart rates and heart rhythms compared with conventional coronary-angiography

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ABSTRACT

Purpose: To evaluate the diagnostic accuracy of 320-slice CT for detection of significant coronary artery stenosis in patients with various heart rates (HR) and heart rhythms, including tachycardia and chronic atrial-fibrillation (CAF) compared with conventional-coronary-angiography (CAG).

Materials and methods: One-hundred-six consecutive patients underwent both 320-slice CT and CAG within 3 months (normal-sinus-rhythm [NSR] 91.5%, CAF 8.5%, mean HR 65 ± 15 beats/min). There were no cardiac events between the 2 procedures. Patients were divided in 2 groups: Group 1 (HR <65 with NSR at CT scan, n = 62), and Group 2 (HR >64 with NSR or heart rhythm irregularities at CT scan, n = 44). Patients with >50% or >75% luminal stenosis on CT were compared with those with >50% or >75% stenosis on CAG, respectively.

Results: In a segment-by-segment analysis, in all patients, sensitivity, specificity, positive (PPV) and negative predictive value (NPV) of >50% stenosis on CT for predicting >50% stenosis on CAG were 69, 98, 78, and 97%, respectively, and those of >75% stenosis on CT for predicting >75% stenosis on CAG were 78, 98, 64, and 99%, respectively. Sensitivity, specificity, PPV, and NPV of >50% and 75% stenosis on CT for predicting >50% and >75% stenosis, respectively, on CAG were comparable. Diagnostic accuracy was essentially the same in both groups.

Conclusion: 320-slice CT had high diagnostic accuracy for the detection of significant coronary artery stenosis compared with CAG. Even though the numbers were small, patients with high HR or heart rhythm irregularities might have essentially equivalent results to those with low HR with NSR.

1. Introduction

Recently, multislice computed tomography (CT) has been developed extensively and it has been established as a promising noninvasive method to examine the lumen of coronary arteries [1,2]. Many previous studies have shown that 16-slice CT and 64-slice CT have high sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for detecting significant coronary artery stenosis [1–5]. These studies suggest that due to its high diagnostic accuracy for detecting significant coronary arterial stenosis, coronary CT angiography (CCTA) may be an alternative method to conventional coronary angiography (CAG) for evaluating coronary artery disease. Also its high NPV indicates that this method is suitable for patients who have a low to intermediate pretest probability for coronary artery disease to rule out presence of significant coronary artery stenosis. But many previous studies limited the procedure to patients who have normal sinus rhythms (NSR) and low heart rate (HR). High HR would lead to impaired temporal resolution on CT. The images of coronary arteries of patients with arrhythmia would also make it difficult to evaluate the entire coronary arterial tree due to presence of banding artifacts, which produce discontinuous images of coronary arteries to the through plane [6].

320-slice CT may have the potential to evaluate coronary arteries with high image quality even in patients with arrhythmias such as atrial fibrillation (AF) and high HR. The main characteristic of this scanner is its wide coverage (0.5 mm × 320 slice = 16 cm) to the through plane with which whole heart images can be obtained with only a single rotation scanning. When the scanning is completed in a single heart beat, data and images are reconstructed using half reconstruction and a suitable cardiac phase in which coronary arteries appear static. This results in clear images without banding and motion artifacts. For high HR with NSR, by acquiring plural heart beat data, we can create multisector reconstruction to improve the temporal resolution. For arrhythmia such as AF, after acquiring plural heart beat data, we can select single heart beat data with the longest R-to-R interval on electrocardiogram (ECG) and images are reconstructed using half reconstruction. This results in clear coronary arterial imaging for the CT (Fig. 1). We have already demonstrated that

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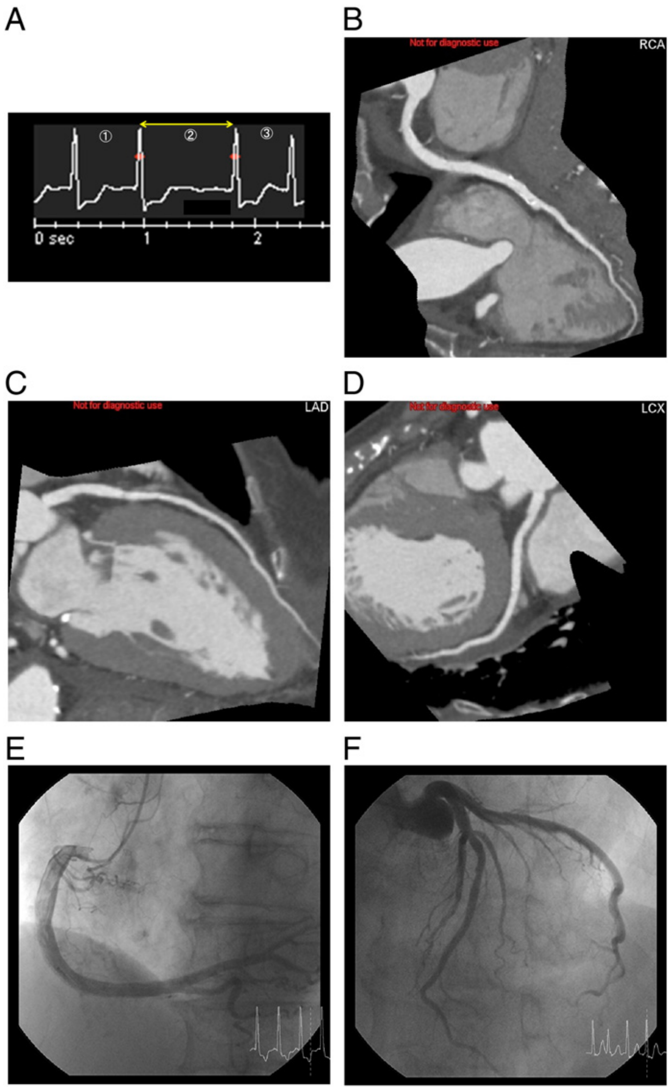

Fig. 1. Typical images acquired with 320-slice CT and by conventional coronary angiography (CAG) of a patient with chronic atrial fibrillation (CAF). A: ECG acquired at CT examination. Three consecutive heart beat data (①—③) were acquired and as the R-to-R intervals were different from each other, we selected only one heart beat data with the longest R-to-R interval (in this case 865 ms ②) and CT images were reconstructed by half reconstruction. B–D: Typical images of coronary arteries using enhance 320-slice CT. As shown in panel A, after acquiring plural heart beat data, the longest R-to-R interval data was manually selected and data were reconstructed by half reconstruction. Curved planar reformation images of the right coronary artery (RCA) (B), left anterior descending branch (LAD) (C), and left circumflex branch (LCX) (D). Even though this patient had CAF, there are no banding artifacts and image quality was excellent. There was no significant stenosis in any of the vessels on CT. E–F: Images of CAG of the RCA (E), and the left coronary artery (F), acquired from the same patient as in panels B–D. There was also no significant stenosis found on CAG as seen on CT images shown in panels B–D.

quality of coronary artery images acquired by 320-slice CT obtained in patients with chronic AF (CAF) was comparable to that in patients with NSR [7,8] and the quality of coronary artery images acquired by 320-slice CT obtained in patients with CAF was significantly superior to those previously acquired by 16-slice CT obtained in the same patients with CAF [9].

The aim of this study was therefore to evaluate the diagnostic accuracy of 320-slice CT for detection of significant coronary artery stenosis in patients with various HR and heart rhythms including patients with high HR and CAF compared with those obtained with CAG.

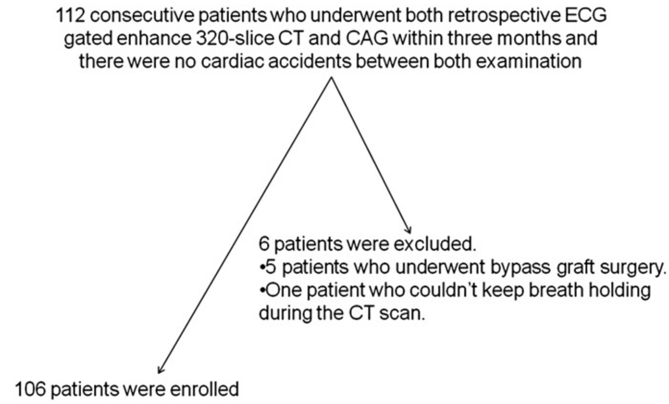

Fig. 2. Schema of enrolled patients. ECG and CAG indicate electrocardiogram and conventional coronary angiogram, respectively.

2. Materials and methods

2.1. Patients

Between December 2008 and July 2010, 112 consecutive patients who underwent both ECG gated enhanced 320-slice CT (Aquilion One, Toshiba Medical) and CAG within 3 months in our institute were recruited for the study. There were no cardiac events between the 2 examinations for any of the patients. Five patients who underwent bypass graft surgery and 1 patient who could not hold breath during the CT scan were excluded; the remaining106 patients were included in this study (Fig. 2).

Eighty two patients underwent CCTA primarily for the purpose of evaluating their coronary arteries because of suspected angina symptoms or changes in ECG with low or intermediate risk for coronary arteries according to the Appropriate Use Criteria for Cardiac CT [20]. The remaining 24 patients had some cardiac dysfunction and to rule out ischemic cardiomyopathy they underwent CCTA. After CCTA, all 106 patients underwent CAG within 3 months, because of suspected coronary artery disease on CCTA, or the need for cardiac catheter test such as cardiac biopsy to diagnose the cause of heart failure.

Patients who had allergy to iodinated contrast, renal insufficiency (serum creatinine≧1.5 mg/dL) were not included in this study. Known history of coronary artery disease and those who had previously underwent percutaneous coronary intervention were included. However, as noted above, those who underwent coronary artery bypass surgery were excluded. Patients with severe coronary calcification, high HR with NSR or heart rhythm irregularities such as any arrhythmia during the scanning were included in this study.

Each patient provided written informed consents before CT examinations.

2.2. Protocol for 320-slice CT

Retrospective ECG gated conventional enhanced 320-slice CT was performed with a slice thickness of 0.5 mm, tube voltage of 120 kV, and a tube current maximum of 580 mA. Contrast material was administered via a 20- or 22-gauge needle into the right antecubital vein. All patients received 10 mg of propranolol prior to scanning, except for those who had severe heart failure, bronchial asthma, hypotension, or bradycardia due to conditions such as atrioventricular block or sick sinus syndrome. Just prior to the scanning procedure patients were administered 2 doses of isosorbide dinitrate sublingually to facilitate dilation of coronary arteries and enable acquisition of clear images even in the small branches of coronary arteries.

We used a HeartNAVI® system which is a standard CT scanner protocol developed by Toshiba Medical Company. This system provides the best temporal resolution that can be optimized according to the HR during scanning. In this system, before performing actual acquisition, rehearsal of breath holding was carried out, and HR during scanning was estimated. Concerning the number of acquired heart beat data, based on the estimates of HR, the following scanning conditions were established: When the estimated HR (beat per minute) was <66, 1 heart beat of data was acquired and half reconstruction was performed; when the estimated HR was 66–79, 2 heart beats of data were acquired and 2 sector reconstruction was performed; when the estimated HR was 80–117, 3 heart beats of data were acquired and 3 sector reconstruction was performed; when the estimated HR was 118–155, 4 heart beats of data were required and 4 sector reconstruction was performed; if the estimated HR was > 156, 5 heart beats of data were acquired and 5 sector reconstruction was performed to obtain the best temporal resolution. If HR varied during the rehearsal of breath holding such as CAF or frequent premature beats, 1 extra heart beat of data were acquired. Similarly, if there was no arrhythmia in the rehearsal of breath holds, but unexpected heart beats occurred during the actual scanning, 1 extra heart beat of data was also acquired.

Concerning the rotation speed, based on the estimated HR during the rehearsal of breath holds, in order to obtain the best temporal resolution, 4 kinds of rotation speeds were used, which were automatically selected from 0.35, 0.375, 0.40, and 0.45 s per rotation in combination with the number of the acquired heart beat data. Furthermore, if