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Original article

Diagnostic advantage of stress computed tomography myocardial perfusion over single-photon emission computed tomography for the assessment of myocardial ischemia

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ABSTRACT

Background: This study compared adenosine stress computed tomography myocardial perfusion (CTP) with single-photon emission computed tomography (SPECT) in the diagnosis of functionally significant coronary artery stenosis using fractional flow reserve (FFR) as reference standard.
Methods: We included a total of 93 coronary arteries from 31 patients in whom at least one vessel with ≥50% stenosis was detected with computed tomography coronary angiography. All patients underwent both SPECT and adenosine stress CTP, followed by invasive coronary angiography (ICA) and FFR. Diagnostic accuracy between CTP and SPECT was compared according to positive findings of either ≥99% stenosis on ICA or FFR ≤0.8.
Results: Among 78 vessels eligible for the quantitative analyses, significant coronary artery disease (CAD) was diagnosed in 22 vessels of 19 patients. Comparison of CTP vs. SPECT for sensitivity, specificity, positive predictive value (PPV), negative predictive value, and accuracy in detecting significant CAD were 59% vs. 18%, 96% vs. 93%, 87% vs. 50%, 86% vs. 74%, and 86% vs. 72%, respectively.
Conclusions: CTP demonstrated a significant diagnostic advantage over SPECT in the identification of significant CAD, especially in terms of sensitivity and PPV. Adenosine stress CTP is useful for the noninvasive diagnosis of functionally significant CAD.

Introduction

Computed tomography angiography (CTA) has clinical advantages including high sensitivity and high negative predictive value (NPV), and thus has been utilized to exclude the presence of coronary artery disease (CAD) [1,2]. Recent advances in high-resolution CT technology allow evaluation of myocardial perfusion during pharmacologically induced maximal coronary vasodilation. The advantages of stress computed tomography myocardial perfusion (CTP) include simultaneous assessment of the degree of stenosis and functional significance of CAD. The clinical utility of single-photon emission computed tomography (SPECT) has been well established in the diagnosis of myocardial ischemia [3–5]. SPECT exhibits a high NPV for future cardiac events and high sensitivity (up to 90%) for the identification of significant CAD [6]. However, its accuracy is limited in patients with multivessel and/or left main disease [7].

The diagnostic accuracies of adenosine stress CTP, SPECT, and cardiac magnetic resonance myocardial perfusion imaging have

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been compared by using invasive coronary angiography (ICA) [8–11]. The nonfunctional assessment of ICA images, however, may overestimate or underestimate the hemodynamic significance [12]. Notably, a limited number of studies on myocardial perfusion imaging have referred to fractional flow reserve (FFR) [11,13,14]. FFR has been established as a gold standard to evaluate the functional severity of coronary artery stenosis, and FFR-guided revascularization improves clinical outcomes of patients with CAD [15,16].

To the best of our knowledge, no reports have established a side-by-side comparison between CTP and SPECT in the diagnosis of functionally significant coronary artery stenosis. The aim of this study was to compare the diagnostic accuracy between CTP and SPECT for the assessment of functionally significant CAD determined by ≥99% stenosis on ICA or FFR ≤0.8 as a reference standard.

Methods

Study design and patients

Participants of this study were recruited from 244 subjects who were referred to our cardiology outpatient clinic for the assessment of CAD. Inclusion criteria were the presence of ≥50% visual stenosis in at least one vessel detected by CTA in a major epicardial artery, which was considered for non-urgent revascularization. Exclusion criteria were as follows: age <40 years, atrial fibrillation or uncontrolled tachyarrhythmia, advanced atrioventricular block, sinus bradycardia (fewer than 40 beats per minute), acute coronary syndrome, moderate or severe aortic stenosis, advanced heart failure (New York Heart Association class III or IV), previous coronary artery bypass grafting or other cardiac surgery, presence of chronic total occlusion, left main disease, history of allergic reaction to iodinated contrast media or contrast-induced nephropathy, elevated serum creatinine (>1.5 mg/dL) or calculated creatinine clearance of <60 mL/min (using the Cockcroft-Gault formula), and known or suspected intolerance or contraindication to beta-blockers.

A total of 63 patients provided written informed consent, and were prospectively enrolled between November 2012 and March 2014. All patients underwent both CTP and SPECT within 90 days of CTA. Participants had stable symptom and hemodynamic status, and received no additional intervention or treatment during the study period. This study was approved by our institutional ethics committee and performed in accordance with the Declaration of Helsinki.

Image acquisition, processing, and interpretation

Computed tomography protocol

The acquisition and analysis of CT images followed the CORE 320 study [17]. In brief, patients received 20 mg of metoprolol orally at 1 h before scan, followed by intravenous administration of 2–4 mg of propranolol if resting heart rate was ≥65 beats per minute. We performed CTA and stress CTP by either a 1-day standard protocol (n = 13, Fig. 1A) or a novel 2-day protocol (n = 18, Fig. 1B) in which stress CTP images were obtained within 90 days after CTA. The 2-day protocol was suitable for patients with stable CAD or angina-free patients who could wait for the next visit to acquire CTA images. Electrocardiograph and blood pressure were monitored, and patients received sublingual nitrates. CT scanograms, CTA, and rest CTP images were simultaneously acquired using a 320-row CT scanner (Aquilion™ ONE, Toshiba Medical Systems, Tokyo, Japan) with the following settings: 0.5-mm detector width, peak tube voltage of 120 kV, gantry rotation time of 0.350–0.375 s, and prospective electrocardiograph triggering. Contrast volume was adjusted for patients' body weight (50–70 mL of iopamidol, 370 mg iodine/mL), and was injected using a triphasic protocol as follows: 100% contrast; 30% contrast, 70% saline mix; and finally 100% saline. Real-time bolus tracking in the descending aorta started 5 s after the beginning of contrast injection. The triggering threshold was set at 300 HU, when CTA was initiated in the next one to two heartbeats.

In the 1-day protocol for stress CTP, intravenous adenosine triphosphate (0.15 mg/kg/min) was administered at 20 min after the rest scan (Fig. 1A). Approximately 3 min after adenosine triphosphate infusion, iopamidol was administered at a flow rate of 4–5 mL/s. The effective radiation dose was estimated from the dose-length product provided by the scanner [18]. CT angiographic

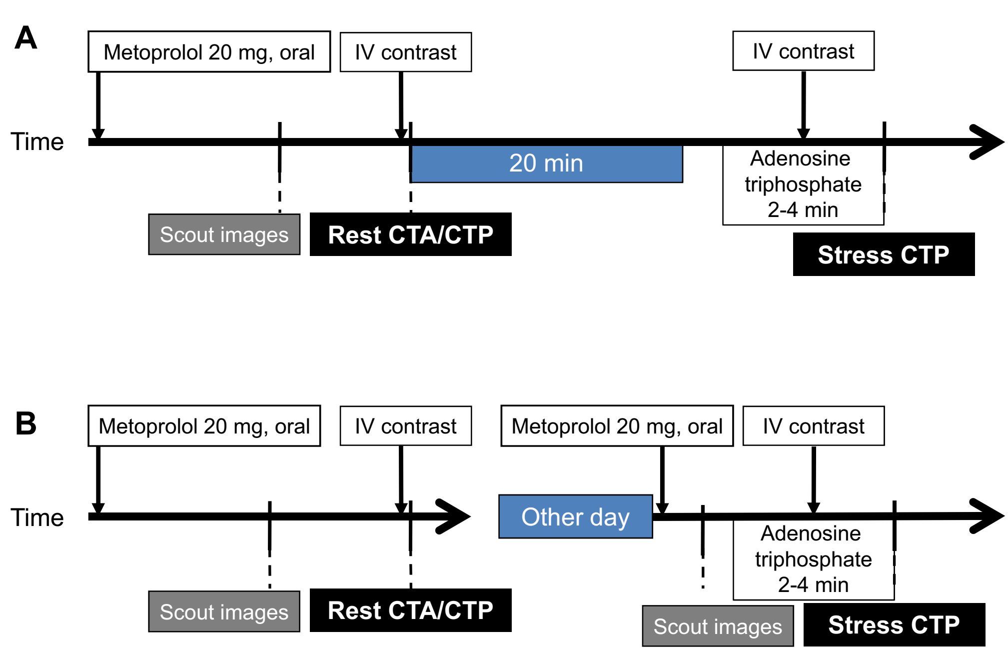

Fig. 1. Protocols for computed tomography coronary angiography (CTA) and stress computed tomography myocardial perfusion imaging (CTP). CTA and CTP were performed on the same day (A) or two separate days (B). In the 2-day protocol, CTP images could be acquired after referring to prior CTA images.