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Single-phase coronary artery CT angiography extracted from stress dynamic myocardial CT perfusion on third-generation dual-source CT: Validation by coronary angiography

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ABSTRACT

Background: CT advances allow coronary arterial tree to be entirely covered during one CTP scan. Our aim was to investigate the potential value of single-phase coronary CT angiography (SP-CCTA) extracted from stress dynamic myocardial CT perfusion (CTP) for coronary artery stenosis assessment.
Methods: Consecutive symptomatic patients were prospectively recruited and scanned with an ATP-stress dynamic myocardial CTP and routine CCTA protocol using third-generation DSCT. Noise reduction was applied to optimize image quality (IQ), the CTP phase with the best enhancement of the coronary arteries was selected as the SP-CCTA. IQ was assessed qualitatively. Using coronary angiography (CAG) as the reference standard, the diagnostic performance for stenosis detection was compared for SP-CCTA and routine CCTA.
Results: 56 patients underwent the CTP and CCTA examination, among which 39 patients underwent CAG. The qualitative IQ scores of SP-CCTA were similar to that of routine CCTA ($p > 0.05$). On a per-segment basis, the sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy and area under the receiver-operating-characteristic curve results of SP-CCTA and routine CCTA for diagnosis of stenosis ≥50% exhibited no significant difference (SP-CCTA: 78.1%, 94.9%, 77.4%, 95.1%, 91.6% and 0.935 vs. routine CCTA: 74.7%, 95.3%, 78.0%, 95.3%, 91.6% and 0.937; all $p > 0.05$). The mean effective radiation dose of CTP and routine CCTA plus CTP were 3.92 ± 1.72 mSv and 5.98 ± 2.01 mSv ($p < 0.05$), respectively.
Conclusions: The IQ and diagnostic value of SP-CCTA was equivalent to routine CCTA on third-generation DSCT. SP-CCTA images from CTP may potentially replace a separate routine CCTA, allowing the possibility of "one-stop" cardiac examination for high-risk CAD patients who need myocardial ischemia assessment.
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1. Introduction

Coronary artery disease (CAD) remains a leading cause of mortality and morbidity [1] around the world. Both morphologic and functional information need to be assessed for accurate diagnosis. Coronary CT angiography (CCTA) has been established to exclude CAD morphologically with good sensitivity and excellent negative predictive value [2]. Myocardial CT perfusion (CTP) has been developed as an effective method for assessing myocardial ischemia caused by CAD [3], however previous studies using second-generation dual-source CT (DSCT) suffered from the inability to cover the entire coronary arterial tree during one dynamic CTP scan. Although many studies have demonstrated that the combination of CCTA and CTP (CCTA-CTP) can correctly identify CAD and evaluate potential flow limitation [4], the relatively high radiation dose (8–18 mSv) [5–7] and contrast media (CM) load (100–140 ml) [8,9] of the traditional CCTA-CTP exam have prevented its wide application in clinical practice.

Advances in CT technology now allow the entire coronary arterial tree and myocardium to be covered during one dynamic CTP scan using third-generation DSCT [10]. In our previous clinical work, we found some patients with compromised enhancement of coronary arteries, and we unintentionally found it could be improved by the extracted single-phase

Abbreviations: CM, contrast media; DSCT, dual-source CT; ED, effective radiation dose; IQ, image quality; MBF, myocardial blood flow; RADS, Reporting and Data System; SP-CCTA, single-phase coronary CT angiography.

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images from dynamic CTP scans with good image quality using a multi-frequency band filter for noise reduction, which enables the possibility to evaluate both coronary artery and myocardium in one CTP scan. In this study, we investigate the feasibility of replacing the CCTA scan by single-phase CCTA (SP-CCTA) images extracted from a stress dynamic CTP exam by evaluating the image quality (IQ) and diagnostic value of SP-CCTA compared with coronary angiography (CAG).

2. Methods

2.1. Study design and patients population

The local institutional review board approved this prospective study and written informed consent was obtained from all patients that met inclusion criteria.

Symptomatic patients with known CAD or suspected CAD with high pretest probability, according to Diamond criteria [11] and Appropriate Use Criteria for Cardiac Computed Tomography [12], who were scheduled for CAG in our hospital from April through December 2016 (Fig. 1) were initially included.

Exclusion criteria: contraindications to adenosine stress test [13], contraindication to nitroglycerin administration, age < 30 years, pregnant or nursing women, renal insufficiency (estimated glomerular filtration rate < 60 ml/min/1.73 m^2 or serum creatinine level ≥ 120 mmol/l), history of coronary intervention or coronary bypass grafting or stenting within the prior 6 months.

Patients were instructed to refrain from consuming caffeine containing medications, food and beverages (tea, coffee, etc.), aminophylline, calcium antagonists, ß-adrenergic blocking agents, dipyridamole, or nitrates for at least 24 h before the scan. Those with diabetes were instructed to suspend metformin use for 48 h both before and after the exams.

2.2. Image data acquisition

2.2.1. Cardiac CT: CT perfusion and CTA

Each enrolled patient underwent a combined ATP-stress dynamic myocardial CTP and CCTA imaging protocol using a third-generation DSCT (SOMATOM Force; Siemens Healthineers, Forchheim, Germany). Both automated tube voltage selection [14] and attenuation-based tube current modulation were enabled (reference tube voltage and current: 80 kV, 300 mAs).

CT perfusion was performed using a prospectively ECG-triggered table shuttle mode. Two 20-gauge intravenous lines were placed: one in the right antecubital vein for CM administration and the other in left antecubital vein for delivering ATP. The CM was injected using a dual-syringe power injector (DUAL SHOT GX, Nemoto-Kyorindo, Tokyo, Japan), with at least 8 second injection duration and an iodine delivery rate of 2.0 g/s. The CM

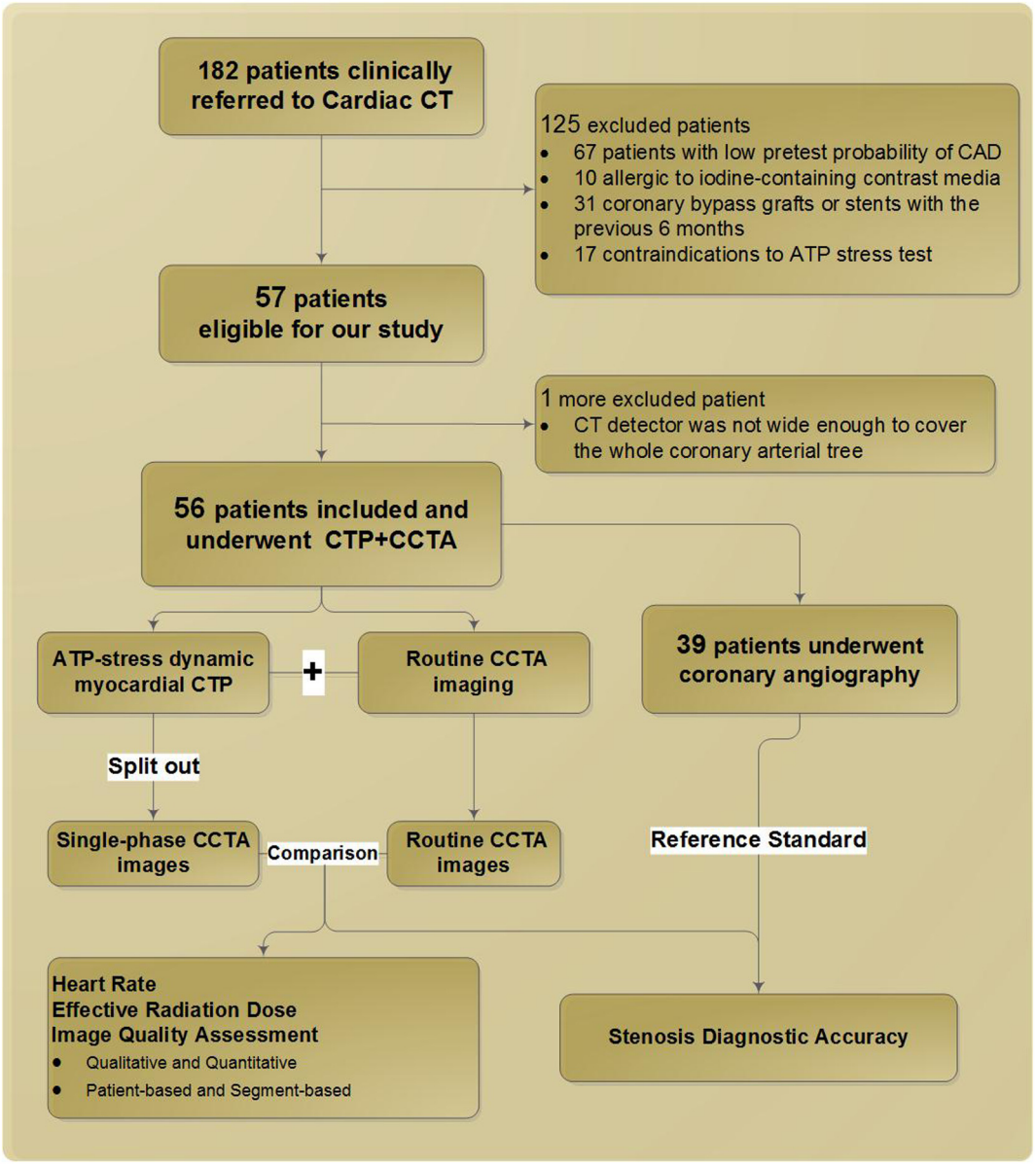

Fig. 1. Flowchart of subject enrolment and study design. Based on the predefined inclusion and exclusion criteria, 56 patients successfully underwent myocardial CTP and routine CCTA examination. The image quality and diagnostic performance were compared between CCTA from CTP and routine CCTA using on coronary angiography as the gold standard. CCTA = coronary CT angiography; ATP = adenosine triphosphate; CTP = CT perfusion.

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