JACC: CARDIOVASCULAR IMAGING
VOL. 6, NO. 10, 2013
© 2013 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jcmg.2013.04.013

CAD Detection in Patients With Intermediate-High Pre-Test Probability

Low-Dose CT Delayed Enhancement Detects Ischemic Myocardial Scar With Moderate Accuracy But Does Not Improve Performance of a Stress-Rest CT Perfusion Protocol

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OBJECTIVES This study sought to compare computed tomography delayed enhancement (CTDE) against cardiac magnetic resonance (CMR) late gadolinium enhancement (LGE) for detection of ischemic scar and to test the additive value of CTDE as part of a comprehensive multidetector computed tomography (MDCT) stress–rest protocol including computed tomography perfusion (CTP) and computed tomography angiography (CTA) for the diagnosis of significant coronary artery disease (CAD).

BACKGROUND CTDE has been recently described as a promising tool for noninvasive detection of myocardial scar, similarly to CMR-LGE techniques. Despite its theoretical potential as an adjunctive tool to improve MDCT accuracy for detection of CAD, its clinical performance has not been validated.

METHODS One hundred five symptomatic patients with suspected CAD (age 62.0 ± 8.0 years, 67% men) underwent MDCT, CMR, and x-ray invasive coronary angiography. The MDCT protocol consisted of calcium scoring, stress CTP under adenosine 140 µg/kg/min, rest CTP + CTA, and a low-dose radiation prospective scan for detection of CTDE. CMR-LGE was used as the reference standard for assessment of scar. Functionally significant CAD was defined as the presence of ≥90% stenosis/occlusion or fractional flow reserve measurements ≤0.80 in vessels >2 mm.

RESULTS CTDE had good accuracy (90%) for ischemic scar detection with low sensitivity (53%) but excellent specificity (98%). Positive and negative predictive values were 82% and 91%, respectively. On a patient-based model, MDCT protocol without integration of CTDE results had a sensitivity, specificity, and positive and negative predictive values of 90%, 81%, 80%, and 90%, respectively, for the detection of functionally significant CAD. Addition of CTDE results did not improve MDCT performance (90%, 77%, 77%, and 90%, respectively).

CONCLUSIONS CTDE has moderate accuracy for detection of ischemic scar in patients with suspected CAD. Integration of CTDE into a comprehensive MDCT protocol including stress–rest CTP and CTA does not improve MDCT accuracy for detection of significant CAD in intermediate-to-high pre-test probability populations. (J Am Coll Cardiol Img 2013;6:1062–71) © 2013 by the American College of Cardiology Foundation

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Multidetector computed tomography (MDCT) coronary angiography represents the noninvasive gold standard for the assessment of the coronary arterial tree. It is particularly useful for the exclusion of coronary artery disease (CAD) in patients with intermediate/low pre-test probability, largely because of its high negative predictive value (1). However, in patients with higher pre-test probability, its performance is limited because the physiological significance of many lesions cannot be assessed (2). To overcome this limitation,

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MDCT stress–rest myocardial perfusion techniques (computed tomography perfusion [CTP]) have been described (3–6), and integrated protocols, providing both morphological (computed tomography angiography [CTA]) and functional (CTP) information in a single MDCT exam, have been tested (7–13).

MDCT ability to identify myocardial ischemic scar using computed tomography delayed enhancement (CTDE) has also been reported. This technique follows the same principles applied to cardiovascular magnetic resonance (CMR) late gadolinium enhancement (LGE) and could be particularly valuable as part of a MDCT protocol including CTA and CTP. The feasibility of performing such a comprehensive examination has already been shown, but CTDE's potential as an adjunctive tool to improve MDCT accuracy for the detection of CAD has never been validated (14).

The aim of this study was to evaluate the diagnostic performance of low-radiation-dose CTDE for detection of ischemic scar using CMR-LGE as the standard and to test the additive value of CTDE as part of an comprehensive MDCT protocol, including CTA and stress–rest CTP, for the diagnosis of functionally significant CAD, using invasive x-ray coronary angiography (XA) with fractional flow reserve (FFR) evaluation as the reference standard.

METHODS

Population. We prospectively screened 176 consecutive patients with suspected CAD referred by general physicians to our hospital outpatient cardiology clinic from February 2010 to November 2011. Inclusion criteria were age >40 years, symptoms compatible with CAD, and at least 1 of the following: ≥2 risk factors or a positive/inconclusive treadmill test. Exclusion criteria included unstable clinical status, known CAD, valvular heart disease, atrial fibrillation, creatinine clearance ≤60 ml/min, and standard contraindications to CMR, contrast media, and adenosine. A total of 139 eligible patients were tested for exclusion criteria. Figure 1 summarizes the study flow and reasons for exclusions. Characteristics of the final population are summarized in Table 1.

Study design. After informed consent, patients were scheduled for CMR and MDCT in the week before XA. FFR was measured in all major patent epicardial coronary arteries with intermediate diameter stenoses (50% to 90%) as assessed by quantitative coronary angiography (QCA). CMR and MDCT results were fully blinded.

CMR protocol. CMR was performed using established protocols on a 1.5-T Siemens Symphony Tim (Siemens, Erlangen, Germany) using a 12-channel receiver coil (15). Long- and short-axis cine images were obtained using a steady-state free precession breath-hold sequence for volumetric and functional analysis. LGE imaging was performed using a 2-dimensional phase-sensitive inversion-recovery breath-hold sequence ≥10 min after administration of contrast (0.2 mmol/kg). The entire volume of the heart was covered in 8-mm-thick short-axis projections with a gap of 2 mm between slices, and in standard long-axis cardiac planes.

MDCT comprehensive protocol. MDCT stress–rest protocol was performed as previously published, with the addition of a low-radiation scan for CTDE detection (Fig. 2) (8). All scans were performed using a Somatom Sensation 64 scanner (Siemens Medical Solutions, Forchheim, Germany) with no pre-test medication. The comprehensive MDCT protocol included 4 sequential acquisitions: calcium scoring, stress CTP, rest CTP, and CTDE. Table 2

ABBREVIATIONS AND ACRONYMS

CAD = coronary artery disease

CI = confidence interval

CMR = cardiac magnetic resonance

CTA = computed tomography angiography

CTDE = computed tomography delayed enhancement

CTP = computed tomography perfusion

FFR = fractional flow reserve

LGE = late gadolinium enhancement

MDCT = multidetector computed tomography

QCA = quantitative coronary angiography

ROC = receiver-operating characteristic

XA = x-ray invasive coronary angiography

received grant support from the Portuguese Society of Cardiology and the European Society of Cardiology. Dr. Schuster acknowledges grant support from the British Heart Foundation (FS/10/029/28253; RE/08/003) and the Biomedical Research Centre (BRC-CTF 196). Dr. Chiribiri was funded by the Wellcome Trust and Engineering and Physical Sciences Research Council under grant number WT 088641/Z/09/Z; he has received grant support from Philips Healthcare. Dr. Nagel has received grant support from Philips Healthcare and Bayer Healthcare. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received January 16, 2013; revised manuscript received April 5, 2013, accepted April 12, 2013.