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CT Angiography for the Prediction of Hemodynamic Significance in Intermediate and Severe Lesions

Head-to-Head Comparison With Quantitative Coronary Angiography Using Fractional Flow Reserve as the Reference Standard

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ABSTRACT

OBJECTIVES The goal of this study was to compare the diagnostic performance of coronary computed tomography angiography (CTA) versus quantitative coronary angiography (QCA) for the detection of lesion-specific ischemia using fractional flow reserve (FFR) as the gold standard.

BACKGROUND Coronary CTA has emerged as a noninvasive method for accurate detection and exclusion of high-grade coronary stenoses. FFR is the gold standard for determining lesion-specific ischemia and has been shown to improve clinical outcomes when guiding revascularization.

METHODS A total of 252 patients from 5 countries were prospectively enrolled (mean age 63 years; 71% male). Patients underwent coronary CTA and invasive coronary angiography (ICA) with FFR in 407 lesions. Coronary CTA, QCA, and FFR were interpreted by independent core laboratories. Stenosis severity according to coronary CTA and QCA were graded as 0% to 29%, 30% to 49%, 50% to 69%, and 70% to 100%; stenosis ≥50% was considered anatomically obstructive. Lesion-specific ischemia was defined according to FFR ≤0.8, whereas QCA and coronary CTA stenosis ≥50% were considered obstructive. Diagnostic accuracy and areas under the receiver-operating characteristics curve (AUC) for lesion-specific ischemia was assessed.

RESULTS According to FFR, ischemia was present in 151 (37%) of 407 lesions. Diagnostic accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were 69%, 79%, 63%, 55%, and 83% for coronary CTA; and 71%, 74%, 70%, 59%, and 82% for QCA. AUC for identification of ischemia-causing lesions was similar: 0.75 for coronary CTA and 0.77 for QCA ($p = 0.6$). No differences between CTA and QCA existed for discrimination of ischemia within the left anterior descending artery (AUC 0.71 vs. 0.73; $p = 0.6$), left circumflex artery (AUC 0.78 vs. 0.85; $p = 0.4$), and right coronary artery (AUC 0.80 vs. 0.83; $p = 0.6$).

CONCLUSIONS CTA and ICA exhibited similar diagnostic performance for the detection and exclusion of lesion-specific ischemia. Using a true reference standard to determine appropriate revascularization targets, 3-dimensional coronary CTA performed as well as 2-dimensional ICA. (J Am Coll Cardiol Img 2016;9:559–64) © 2016 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

AUC = area under the curve

CAD = coronary artery disease

CT = computed tomography

CTA = computed tomography angiography

FFR = fractional flow reserve

FFR_{CT} = fractional flow reserve by computed tomography

ICA = invasive coronary angiography

NPV = negative predictive value

PPV = positive predictive value

QCA = quantitative coronary angiography

Measurement of fractional flow reserve (FFR) provides hemodynamic assessment of coronary artery lesions, facilitating clinical decision-making regarding coronary artery revascularization (1–3). Decisions based on specific FFR values significantly affect patient morbidity and mortality, resulting in the incorporation of FFR-guided intervention for intermediate stenoses in interventional guidelines with a Class IIa, Level of Evidence A, recommendation (4). Until recently, invasive angiography has been considered a gold standard for obstructive disease and need for revascularization, but these intervention trials clearly show that functional ischemia, as defined by FFR, improves outcomes. Coronary computed tomography angiography (CTA) has been shown to be a highly diagnostic test that results in better cardiovascular outcomes than functional testing (5,6) but has been perpetually compared with invasive angiography as a reference standard for diagnostic accuracy (7,8). The development of fractional flow reserve derived from resting computed tomography (FFR_{CT}) has led to studies being performed to evaluate the diagnostic accuracy of FFR_{CT} compared with invasive FFR (9). This approach allows for a large cohort of patients with coronary CTA and invasive coronary angiography (ICA) to be compared with invasive FFR to identify physiologically significant lesions that would benefit from revascularization.

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The objective of the present study was to compare the diagnostic accuracy of quantitative coronary angiography (QCA) and coronary CTA versus invasive FFR measurements. To the best of our knowledge, QCA- and coronary CTA-derived stenosis measurements have not previously been compared head-to-head for the prediction of ischemia as categorized by FFR in a large multicenter cohort.

METHODS

The rationale, design, and overall results of the DeFACTO (Determination of Fractional Flow Reserve by Anatomic Computed Tomographic Angiography) study have been reported previously (9,10). Briefly, DeFACTO was designed to evaluate the accuracy of FFR_{CT} in diagnosing hemodynamically significant coronary artery disease (CAD), as defined by an invasive FFR reference standard, in a targeted population of subjects with suspected CAD who were referred for clinically indicated ICA. Patients with prior revascularization were excluded, and the final population consisted of 252 patients with 407 vessels. The DeFACTO study was conducted at 17 centers in 5 countries.

All patients provided written informed consent. The study was consistent with the principles of the Declaration of Helsinki. Coronary CTA, ICA, FFR, and FFR_{CT} were interpreted in a blinded fashion by independent core laboratories as previously described (9).

CORONARY CTA IMAGE ACQUISITION AND ANALYSIS. Coronary CTA was performed on ≥64 detector row scanners with prospective or retrospective electrocardiographic gating in accordance with Society of Cardiovascular Computed Tomography guidelines (11,12). Computed tomography (CT) angiograms were interpreted at the central CT core laboratory (Los Angeles Biomedical Center, Torrance, California) for blinded interpretation by using an 18-segment coronary model. Investigators evaluated CT scans by visual assessment for maximal patient- and vessel-diameter stenosis, which was categorized as 0%, 1% to 29%, 30% to 49%, 50% to 69%, and >70% stenosis, or totally (100%) occluded. Per-patient and per-vessel CAD stenosis were the maximal stenoses identified in all segments or in all segments within a vessel distribution, respectively. Use of beta-blockers and nitroglycerin was left to individual site practices.

ICA IMAGE ANALYSIS. Invasive coronary angiograms were transferred to a central angiographic core laboratory (University of British Columbia, Vancouver, British Columbia, Canada) for blinded QCA of all vessels using commercially available software (Discovery System, Quinton, Bothell, Washington). The angiographic core laboratory visualized each coronary artery by multiple projections. QCA measurements were performed of every lesion ≥30% in coronary segments ≥1.5 mm in diameter.

FRACTIONAL FLOW RESERVE. FFR was performed at the time of ICA (PressureWire Certus, St. Jude

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