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iREVIEWS

STATE-OF-THE-ART PAPER

Quantification of Coronary Arterial Stenoses by Multidetector CT Angiography in Comparison With Conventional Angiography

Methods, Caveats, and Implications

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Multidetector computed tomography (MDCT) is a rapidly evolving technology for performing noninvasive coronary angiography. Despite good sensitivity and specificity for detecting significant coronary artery disease in patients, disagreement on individual coronary arterial stenosis severity is common between MDCT and the current gold standard, conventional angiography. The reasons for such disagreement are numerous, but are at least partly inherent to MDCT's modest spatial and temporal resolution at present. Less well acknowledged, however, is the fact that MDCT and conventional angiography are fundamentally different technologies, rendering good agreement on the degree of lumen narrowing rather unrealistic, given both of their respective limitations. Discrepant stenosis assessment by MDCT and conventional angiography receives remarkable attention, whereas its significance for patient outcome is less certain. On the other hand, the ability to noninvasively assess coronary arterial plaque characteristics and composition in addition to lumen obstruction shows strong promise for improved risk assessment and may at last enable us to move beyond mere coronary stenosis assessment for the management of patients with coronary artery disease. (J Am Coll Cardiol Img 2011;4:191–202) © 2011 by the American College of Cardiology Foundation

Coronary angiography using multidetector computed tomography (MDCT) is used increasingly for the evaluation of coronary artery disease (CAD). Numerous clinical studies have documented high diagnostic accuracy of current-generation MDCT. For detection of obstructive CAD, areas under the receiver-operator characteristic curve average 0.98 for single-center studies and range between 0.93 and 0.96 for multicenter studies (1–6). Currently, MDCT is predominantly being used for ruling out obstructive CAD in symptomatic patients with low to intermediate pre-test probability of disease. This indication, for which there is broad endorsement from major societies (7,8), is supported by consistently high negative predictive values for detecting obstructive CAD.

In the most common scenario for the application of MDCT, the study is negative for obstructive CAD, and the management is fairly straightforward. The situation is more cumbersome if the MDCT study is suggestive of significant CAD. Although the negative pre-

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dictive values have been remarkably consistent among studies, the positive predictive values have not, ranging from 64% to 91% on a patient-level analysis among the 3 major multicenter studies (4–6). Variations in disease prevalence partly explain the differences. However, when applied to the low- to intermediate-risk population for which MDCT is advocated, a false positive rate of up to 35% per patient (9) is common even in experienced centers and may be even higher at sites with less expertise. Careful assessment of stenosis severity is a prerequisite to minimize misinterpretation in coronary computed tomography (CT) angiography. This report reviews the methods for coronary stenosis quantification by MDCT as well as conventional angiography and discusses the reasons and implications for discrepant findings among these modalities for coronary arterial lesion assessment.

ABBREVIATIONS AND ACRONYMS

CAD = coronary artery disease

CT = computed tomography

IVUS = intravascular ultrasound

MDCT = multidetector computed tomography

MLA = minimum lumen area

MLD = minimum lumen diameter

QCA = quantitative coronary angiography

SPECT = single-photon emission computed tomography

Coronary Arterial Stenosis Assessment by MDCT

General considerations. There are multiple ways of assessing coronary artery lumen for stenosis. Most commonly, an estimate of luminal diameter stenosis is used, less frequently, area stenosis, minimum lumen diameter (MLD), or minimum lumen area (MLA) is considered. When correlating with hemodynamic evaluation, i.e., coronary flow or myocardial perfusion assessment, estimating lumen area appears preferable to diameter evaluation (10–12). This is intuitive when considering irregular arterial lumen shapes for which diameter assessment is difficult (13). Since irregular lumen shapes are not uncommon at lesion sites, diameter assessment may misrepresent true lumen narrowing in many instances (14,15). Absolute assessment, i.e., MLA, also eliminates an important error source, the selection of an appropriate reference segment, and thus, appears attractive in several ways. However, almost all clinical studies for the evaluation of coronary arterial stenoses used diameter assessment since the gold standard, i.e., invasive coronary angiography, typically employs diameter measurements for its evaluation. For the same reason, coronary assessment is based on diameter evaluation in clinical practice. Diameter assessment by MDCT, therefore, will be the preferred lumen evaluation for the near future, whereas lumen area assessment may be used more frequently once its feasibility and superiority have been conclusively shown in clinical practice.

Stenosis evaluation. VISUAL STENOSIS ESTIMATE. Because of its convenience and speed, visual stenosis estimation is the most commonly performed coronary lumen assessment in clinical practice, both for coronary CT angiography as well as for invasive coronary angiography. The observer interrogates the lesion in multiple views and identifies the MLD. The observer then compares the MLD to an arterial diameter at an appropriate reference site, i.e., a nondiseased arterial segment in closest proximity to the lesion, preferably with no branch vessels in between (Fig. 1). Maximum diameter stenosis severity can be graded using either a qualitative or semiquantitative stenosis grading system, for example, mild, moderate, severe, or 1% to 24%, 25% to 49%, and so on (16–18). Tables 1 and 2 provide the stenosis grading recommended by the Society of Cardiovascular Computed Tomography.

QUANTITATIVE STENOSIS ESTIMATE. Most cardiac CT workstations allow quantification of coronary arterial stenoses. Measurements of lumen dimensions can be performed manually or semiautomatically. For manual assessment, the reader uses an internally calibrated ruler or caliper, and determines luminal diameters guided by visual assessment. The diameters can be drawn using cross-sectional or longitudinal lumen display (Figs. 2 and 3), both appear similarly accurate when compared with quantitative coronary angiography (QCA) (18). Drawing the diameters on a cross-sectional display has the advantage of assessing all lumen borders in 1 view, whereas longitudinal views only allow the evaluation from 1 particular viewing angle, requiring the assessment of multiple views to ascertain the most adequate display. One important caveat for quantitative stenosis assessment by MDCT is that window and level settings may influence the displayed luminal diameter and area (17).

SEMIAUTOMATED ARTERIAL CONTOUR DETECTION. In addition to manual measurements, most workstations also offer semiautomatic lumen contour detection for coronary CT angiography (Fig. 4). While these contour detection algorithms have not been adequately validated, initial data are encouraging, as similar accuracies for automated and manual assessments are being reported (19,20). Of note, semiautomatically generated lumen assessment by MDCT resulted in better positive predictive values for diagnosing CAD than visual assessment in comparison to