JACC: CARDIOVASCULAR INTERVENTIONS VOL. 1, NO. 2, 2008

ISSN 1936-8798/08/$34.00
PUBLISHED BY ELSEVIER INC. DOI: 10.1016/j.jcin.2008.01.007

Head-to-Head Comparison of Coronary Plaque Evaluation Between Multislice Computed Tomography and Intravascular Ultrasound Radiofrequency Data Analysis

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Objectives The purpose of this study was to perform a head-to-head comparison of plaque observations with multislice computed tomography (MSCT) to virtual histology intravascular ultrasound (VH IVUS).

Background The VH IVUS allows in vivo coronary plaque characterization with high spatial resolution. Noninvasively, plaques may be evaluated with MSCT, but limited data are available.

Methods A total of 50 patients underwent 64-slice MSCT followed by VH IVUS. The Agatston score was evaluated on MSCT in coronary segments where IVUS was performed. Plaques were classified on MSCT as noncalcified, mixed, and calcified. Four plaque components (fibrotic, fibro-fatty, and necrotic core tissues and dense calcium) were identified on VH IVUS, and the presence of thin-cap fibroatheroma was evaluated.

Results A moderate correlation was observed between the Agatston score and calcium volume on VH IVUS ($r = 0.69$, $p < 0.0001$). In total, 168 coronary plaques were evaluated (48 [29%] noncalcified, 71 [42%] mixed, 49 [29%] calcified). As compared with calcified plaques, noncalcified plaques contained more fibrotic (60.90 ± 9.21% vs. 54.60 ± 8.33%, $p = 0.001$) and fibro-fatty tissues (28.11 ± 13.03% vs. 21.37 ± 9.75%, $p = 0.006$) on VH IVUS. Mixed and calcified plaques contained more dense calcium (7.61 ± 8.94% vs. 2.68 ± 3.01%, $p = 0.001$; 10.18 ± 6.71% vs. 2.68 ± 3.01%, $p < 0.0001$, respectively). Thin-cap fibroatheromas were most frequently observed in mixed plaques as compared with noncalcified and calcified plaques (32%, 13%, 8%, $p = 0.002$, respectively).

Conclusions A good correlation was observed between calcium quantification on MSCT and VH IVUS. In addition, plaque classification on MSCT paralleled relative plaque composition on VH IVUS, although VH IVUS provided more precise plaque characterization. Mixed plaques on MSCT were associated with high-risk features on VH IVUS. (J Am Coll Cardiol Intv 2008;1:176–82) © 2008 by the American College of Cardiology Foundation

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Manuscript received October 30, 2007; revised manuscript received January 14, 2008, accepted January 24, 2008.

During the last decade, multislice computed tomography (MSCT) coronary angiography has rapidly matured into a technique that could be used as an alternative imaging modality to detect coronary stenoses in patients with suspected coronary artery disease (CAD). Moreover, the technique allows direct visualization of coronary plaques, in contrast to conventional coronary angiography. Accordingly, MSCT may also have the potential to provide information on plaque composition in addition to the degree of stenosis (1–4). Indeed, Schroeder et al. (4) showed that in comparison with grayscale intravascular ultrasound (IVUS), differentiation between noncalcified, intermediate, and calcified plaques is possible on MSCT based on the differences in the average plaque signal intensity. Moreover, MSCT observations may be different among various clinical presentations. For example, a lower prevalence of completely calcified plaques on MSCT was demonstrated in previous studies in patients presenting with acute coronary syndromes (5–7).

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Potentially, more detailed information on plaque composition could be derived from virtual histology IVUS (VH IVUS). This technique has recently been introduced as a novel IVUS modality. This invasive imaging technique allows accurate in vivo evaluation of 4 coronary plaque components, namely fibrotic, fibro-fatty, and necrotic core tissues and dense calcium (8). Indeed, as compared with histopathology, VH IVUS allowed detection of the necrotic core with a predictive accuracy of 88.3%, whereas the accuracy to detect regions of dense calcium, was as high as 96.5% (8). In addition, differences in plaque composition have been demonstrated in different clinical settings using this technique. In patients presenting with acute coronary syndromes, the amount of necrotic core tissue and the density of thin-cap fibroatheromas (TCFA) (features that are associated with high risk of plaque rupture) were shown to be significantly higher as compared with patients with stable CAD (8–10).

As a consequence, VH IVUS could provide more insight into plaque composition on MSCT. In addition, it is unclear which coronary plaques on MSCT may represent lesions with high-risk features. However, no systematic comparisons between MSCT and VH IVUS are currently available. Accordingly, the purpose of the study was to perform a head-to-head comparison of coronary plaque composition as determined by MSCT to VH IVUS. With regard to plaque classification, we expected to demonstrate a fair relation between plaque type (noncalcified, mixed, or calcified) as determined by MSCT versus relative composition as determined by VH IVUS. However due to the higher spatial resolution of VH IVUS, we expected to observe more details on VH IVUS. Finally, noncalcified and mixed lesions on MSCT appear to occur more frequently in unstable conditions, and therefore, we expected noncalcified and mixed plaques to be related to high-risk features on VH IVUS.

Methods

Patient population and study protocol. In total, 50 patients scheduled for conventional coronary angiography based on clinical presentation were prospectively included in the study. All patients underwent 64-slice MSCT coronary angiography, followed by invasive coronary angiography in combination with VH IVUS. Noninvasive and invasive examinations of coronary plaques were performed within 1 month. The clinical history of the patients was evaluated prior to conventional coronary angiography to ensure that no acute coronary events or worsening of angina occurred between examinations.

Only patients without contraindications to MSCT and IVUS were included in the study. Exclusion criteria for MSCT were (supra)ventricular arrhythmias, renal insufficiency (serum creatinine >120 μmol/l), and known allergy to iodine contrast media. Exclusion criteria for IVUS were severe vessel tortuousness or occlusion.

The study protocol was approved by the local ethics committee and informed consent was obtained from all patients.

Abbreviations and Acronyms

CAD = coronary artery disease

MSCT = multislice computed tomography

TCFA = thin cap fibroatheroma

VH IVUS = virtual histology intravascular ultrasound

MSCT

Data acquisition. The 64-slice MSCT coronary angiography was performed using a Toshiba Aquilion (Toshiba Medical Systems, Tokyo, Japan) scanner. First, a coronary calcium scan without contrast was obtained, followed by 64-slice MSCT coronary angiography performed during electrocardiographic gating and the administration of nonionic contrast at 5 ml/s according to the protocol as described previously (11). If the heart rate was ≥65 beats/min, additional oral beta-blockers (metoprolol, 50 or 100 mg, single dose, 1 h prior to the examination) were provided if tolerated. After acquisition, the data were reconstructed and transferred to a remote workstation for post-processing. When extensive coronary calcifications were present, sharp reconstruction algorithms were used to reduce partial volume effects of coronary calcium.

Data analysis. Data were evaluated using a remote workstation with dedicated software (Vitrea 2, Vital Images, Minnetonka, Minnesota, or Advantage, GE Healthcare, Milwaukee, Wisconsin). The MSCT angiograms and calcium scans were evaluated by 2 experienced observers who were unaware of the clinical characteristics and the IVUS findings. Disagreements were immediately resolved in consensus. First,