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Characterization of Hyperintense Plaque With Noncontrast T_1-Weighted Cardiac Magnetic Resonance Coronary Plaque Imaging

Comparison With Multislice Computed Tomography and Intravascular Ultrasound

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OBJECTIVES This study sought to characterize coronary hyperintense plaques (HIP) using noncontrast T_1-weighted imaging (T1WI) in cardiac magnetic resonance, which was then compared with multislice computed tomography and intravascular ultrasound.

BACKGROUND Carotid plaque components such as intraplaque hemorrhages and/or lipid-rich necrotic cores can be detected as HIP by noncontrast T1WI. Although coronary HIPs have been successfully detected using this technique, the properties of hyperintense signals in coronary plaques have not yet been systematically evaluated.

METHODS Thirty-eight lesions from 37 patients with angina pectoris who demonstrated >70% coronary stenosis on multislice computed tomography were evaluated by noncontrast T1WI using a 1.5-T magnetic resonance imager, and 25 lesions were evaluated by intravascular ultrasound. Signal intensity of coronary plaque to cardiac muscle ratio >1.0 was defined as HIP. We divided 25 lesions into the 2 groups, according to the presence or absence of HIP: HIP (n = 18) and non-HIP (n = 7) groups.

RESULTS In comparison with the non-HIP group, the HIP group demonstrated significantly higher coronary plaque to cardiac muscle ratio (1.7 ± 0.7 vs. 0.9 ± 0.1, $p < 0.01$), higher frequency of positive remodeling as observed by both multislice computed tomography (89% vs. 0%, $p<0.0001$) and intravascular ultrasound (94% vs. 14%, $p < 0.001$) and ultrasound attenuation (100% vs. 14.3%, $p < 0.0001$). The frequency of spotty calcification tended to be higher in HIP (89% vs. 50%, $p = 0.079$). The HIP group also exhibited a significantly lower computed tomography density (–23.2 ± 20.7 Hounsfield units [HU] vs. 9.6 ± 20.5 HU, $p < 0.01$). In addition, the incidence of transient slow-flow phenomena was significantly higher in the HIP group than in the non-HIP group (83% vs. 14%, $p < 0.01$).

CONCLUSIONS The typical HIP case was associated with ultrasound attenuation, positive remodeling, remarkably low computed tomography density, and a high incidence of slow-flow phenomena. Noncontrast T1WI in cardiac magnetic resonance imaging may be useful for the assessment of coronary plaque characterization in patients with coronary artery disease. (J Am Coll Cardiol Img 2009;2:720–8) © 2009 by the American College of Cardiology Foundation

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Cardiac magnetic resonance (CMR) imaging (1–3) and multislice computed tomography (MSCT) (4–7) are attracting attention as new noninvasive imaging techniques for coronary plaque visualization. Noncontrast T_1-weighted imaging (T1WI) in CMR enables the identification of the thickened coronary wall (1–3). In addition, contrast-enhanced CMR allows us to identify areas of delayed enhancement that correlate with the severity of atherosclerosis as measured by MSCT and quantitative coronary angiography (8).

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In carotid plaques, high signals on inversion recovery-based 3-dimensional T1WI are associated with complicated plaques (type VI as proposed by the American Heart Association) (9) and with recent ischemic cerebrovascular events (10,11). Thus, CMR with T1WI is able to successfully identify vulnerable carotid plaques. Although coronary plaque imaging by noncontrast- and contrast-enhanced T1WI has been successfully demonstrated, and coronary plaques can be visualized as hyperintense signal areas, the properties of hyperintense signals in coronary plaques detected by T1WI have not yet been systematically evaluated.

To address this, we sought to characterize hyperintense coronary plaques visualized by noncontrast T1WI in CMR to compare findings obtained by MSCT and intravascular ultrasound (IVUS).

METHODS

Study population. Thirty-seven consecutive angina pectoris patients with a total of 38 lesions were enrolled. In all of these patients, significant coronary stenosis (>70%) was detected on MSCT; all were scheduled for elective percutaneous coronary intervention (PCI) between February 2007 and November 2007. All 38 lesions (37 patients) had been evaluated by noncontrast T1WI in CMR before PCI. Twenty-eight lesions from 27 patients contained areas with hyperintense signals, corresponding to the target lesions on MSCT (defined as hyperintense plaque [HIP]). In contrast, 10 lesions from the remaining 10 patients contained areas without hyperintense signals (defined as non-HIP). We excluded 13 lesions from 13 patients, 10 HIP and 3 non-HIP, who had not undergone IVUS examination during PCI. Thus, 25 lesions from 24 patients (18 HIP and 7 non-HIP) were examined in this study (Fig. 1). Both MSCT and CMR were performed within a month before the IVUS examination. The study protocol was approved by the Institutional Board on Clinical Investigations at Shin-Koga Hospital. Information regarding this study was provided either orally or in written form to all subjects, and written informed consent was obtained from each subject.

CMR coronary plaque imaging. Coronary plaque imaging was obtained with a 1.5-T MR imager (Intera, Philips Medical Systems, Best, the Netherlands) using 5-element cardiac coils. When heart rates were more than 65 beats/min, the rates were adjusted by administration of 20 to 40 mg of metoprolol 30 min before imaging. Nitroglycerin (0.3 mg) was also administered sublingually immediately before taking images to obtain high-quality CMR images. The survey images were focused around the heart, and the reference images were taken under free breathing to improve the sensitivity of parallel imaging. Coronary plaque images were obtained when patients were breathing freely, with the use of a 3-dimensional, T1W inversion-recovery gradient-echo sequence with fat-suppressed and radial k-space sampling (repetition time: shortest ≒ 4.7 ms, echo time: shortest ≒ 1.37 ms, flip angle: 20°, excitations per cardiac cycle: 15 to 45, SENSE factor: 2.5, number of excitations: 2, navigator gating window: 5 mm, no drift correction, field of view: 300 × 270 × 112 mm, acquisition matrices: 224 × 224, reconstruction matrices: 512 × 512 × 140). Spatial resolution was 1.34 × 1.34 × 1.6 mm. The same value was set for the acquisition window as in the coronary CMR. The acquisition window was set, according to the movement of the heart, for the time during the diastolic phase at which the heart moves the least. The movement of the heart was confirmed using cine-MR images that had been taken previously. The cine-MR images were obtained with a steady-state sequence as the patient was free breathing (repetition time: 2.6 ms, echo time: 1.3 ms, flip angle: 60°, field of view: 360 × 324 × 7 mm, acquisition matrix: 192 × 192, cardiac phases: 50, SENSE factor: 3.0, imaging time: 2 s).

A coronary CMR image analysis was performed by 2 technicians who were blinded to the plaque information obtained by MSCT. In the coronary CMR image obtained, if the areas that corre-

ABBREVIATIONS AND ACRONYMS

CMR = cardiac magnetic resonance

HIP = hyperintense plaque

IVUS = intravascular ultrasound

MSCT = multislice computed tomography

PCI = percutaneous coronary intervention

PMR = coronary plaque to cardiac muscle ratio

RI = remodeling index

T1WI = T_1-weighted imaging