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Impact of Coronary Plaque Composition on Cardiac Troponin Elevation After Percutaneous Coronary Intervention in Stable Angina Pectoris

A Computed Tomography Analysis

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Objectives The authors used multidetector computed tomography (MDCT) to study the relation between culprit plaque characteristics and cardiac troponin T (cTnT) elevation after percutaneous coronary intervention (PCI).

Background Percutaneous coronary intervention is often complicated by post-procedural myocardial necrosis manifested by elevated cardiac biomarkers.

Methods Stable angina patients ($n = 107$) with normal pre-PCI cTnT levels underwent 64-slice MDCT before PCI to evaluate plaque characteristics of culprit lesions. Patients were divided into 2 groups according to presence (group I, $n = 36$) or absence (group II, $n = 71$) of post-PCI cTnT elevation ≥3 times the upper limit of normal (0.010 ng/ml) at 24 h after PCI.

Results Computed tomography attenuation values were significantly lower in group I than in group II (43.0 [26.5 to 75.7] HU vs. 94.0 [65.0 to 109.0] HU, $p < 0.001$). Remodeling index was significantly greater in group I than in group II (1.20 ± 0.18 vs. 1.04 ± 0.15, $p < 0.001$). Spotty calcification was observed significantly more frequently in group I than in group II (50% vs. 11%, $p < 0.001$). Multivariate analysis showed presence of positive remodeling (remodeling index >1.05; odds ratio: 4.54; 95% confidence interval: 1.36 to 15.9; $p = 0.014$) and spotty calcification (odds ratio: 4.27; 95% confidence interval: 1.30 to 14.8; $p = 0.016$) were statistically significant independent predictors for cTnT elevation. For prediction of cTnT elevation, the presence of all 3 variables (CT attenuation value <55 HU; remodeling index >1.05, and spotty calcification) showed a high positive predictive value of 94%, and their absence showed a high negative predictive value of 90%.

Conclusions MDCT may be useful in detecting which lesions are at high risk for myocardial necrosis after PCI. (J Am Coll Cardiol 2012;59:1881–8) © 2012 by the American College of Cardiology Foundation

Percutaneous coronary intervention (PCI) may be complicated by post-procedural myocardial injury/infarction as manifested by elevated cardiac biomarkers such as creatine kinase-myocardial band or troponin T. The occurrence of post-procedural myocardial injury/infarction has been shown to be associated with worse short- and long-term clinical outcome (1,2), and even mild elevation of cardiac troponin after PCI has been related to a worse prognosis (3). Intravascular ultrasonography (IVUS) has shown that post-procedural myocardial injury/infarction is caused by lesions with ruptured plaques and/or those with a greater plaque burden (4). Virtual histology IVUS also has shown that post-PCI cardiac troponin (cTnT) elevation occurs in lesions with a large necrotic core area and positive remodeling (PR) of the vessel (5).

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Multidetector computed tomography (MDCT) is a promising technique for noninvasive coronary angiography. With the development of MDCT, it is possible not only to detect coronary artery stenosis (6,7) but also to evaluate coronary plaque quality and quantity such as can be done with IVUS (8,9). Motoyama et al. (10) showed that the

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Abbreviations and Acronyms

ACS = acute coronary syndrome(s)
CSA = cross-sectional area
CT = computed tomography
cTnT = cardiac troponin T
EEM = external elastic membrane
IVUS = intravascular ultrasonography
MDCT = multidetector computed tomography
NPV = negative predictive value
PCI = percutaneous coronary intervention
PPV = positive predictive value
PR = positive vessel remodeling
RI = remodeling index
SAP = stable angina pectoris

computed tomography (CT) characteristics of culprit lesions in acute coronary syndrome (ACS) included PR, low-attenuation plaques, and spotty calcification, and that the patients with these 2 plaque characteristics of PR and low-attenuation plaques on CT angiography were at a higher risk of developing ACS than were patients without these characteristics during follow-up (11). Recently, Uetani et al. (12) reported that post-procedural myocardial injury/infarction was associated with the volume and fraction of low-attenuation plaques detected by MDCT. However, a previous study exploring potential prognostic predictors of cardiovascular events on MDCT showed that mixed lesions were associated with adverse events on follow-up (13). Thin-cap fibroatheromas on virtual histology IVUS were most prevalent in mixed plaques, suggesting a higher degree of vulnerability of these mixed plaques on MDCT (14).

Therefore, we hypothesized that the plaque with MDCT characteristics of low attenuation plaques, PR, and spotty calcification has the potential to predict an elevation of cTnT after PCI. The aim of this study was to investigate the clinical value of PR and spotty calcification in conjunction with low-attenuation plaques on MDCT to predict post-PCI cTnT elevation.

Methods

Study population. The study population comprised 107 patients who were diagnosed as having stable coronary artery disease by 64-slice MDCT before PCI from April 2009 to August 2010 at our institution. We included patients with stable angina pectoris (SAP) with normal pre-PCI cTnT levels (15) and excluded patients with ST-segment elevation myocardial infarction and unstable AP. We also excluded patients with severely calcified lesions, motion artifacts, previously stented lesions, and chronic total occlusions, for which coronary plaque quantity and degree of stenosis are difficult to evaluate by MDCT.

Study protocol. All patients underwent 64-slice MDCT to evaluate coronary plaque characteristics of the culprit lesion before PCI and serial measurements of cTnT before PCI and at 24 h post-procedure. According to cTnT blood test results, the patients were divided into 2 groups according to the presence (group I, n = 36) or absence (group II, n = 71) of post-PCI TnT elevation ≥3 times the upper limit of normal (0.010 ng/ml) at 24 h after PCI.

MDCT protocol. Scanning was performed with a Philips Brilliance-64 scanner (Philips Medical Systems, Cleveland, Ohio) with 64 × 0.625-mm detector configuration. Scanning was performed at 120 kV and 600 to 1,050 mA, 0.2 pitch, and with standard or sharp filters. Estimated effective radiation dose was 11 mSv. Reconstruction was routinely performed using a window centered at 75% of the R-R interval to coincide with left ventricular diastasis. A volume of 60 ml of contrast agent (iopamidol 370 mg/ml; Schering AG, Berlin, Germany) was injected intravenously at a rate of 4 ml/s. As soon as the signal density level in the ascending aorta reached a pre-defined threshold of 100 Hounsfield units (HU), acquisition of CT data and an electrocardiogram trace were automatically started during a 7-s to 9-s breath-hold. The patients were given oral metoprolol (20 mg) 1 h before the scheduled scan if their heart rate was >70 beats/min, and all patients received sublingual nitroglycerin (0.3 mg) 5 min before the scan.

MDCT analysis. Analysis of the scans was performed using a Brilliance Workspace 3-D workstation (Philips Medical Systems). Images were initially reconstructed at mid-diastolic phase (75% of R-R interval) of the cardiac cycle. In some cases, additional reconstructions were made at different time points of the R-R interval. Each scan was analyzed independently by 2 experienced readers unaware of the patient's identity, clinical presentation, biomarker analysis, and PCI procedure. Image display settings for lumen and plaque quantification were determined according to previously published data (16).

We measured the vessel diameter and lesion length, the cross-sectional area (CSA) of the external elastic membrane (EEM) and target lesion, and the lumen CSA of the proximal and distal vessel references using axial images and multiplanar reconstruction images. The CT density values of the culprit plaque were measured from at least 3 points, and averaged this. Remodeling index (RI) was defined as the EEM CSA of the target lesion divided by the average of the EEM CSAs of the proximal and distal references. We assessed adherent calcium deposits in or adjacent to each plaque by determining their presence or absence and morphology as follows according to previously described methods: diffuse, length of calcium burden ≥3/2 of vessel diameter and width ≥2/3 of vessel diameter; medium, length ≥3/2 of vessel diameter and width <2/3 of vessel diameter or length <3/2 of vessel diameter and width ≥2/3 of vessel diameter; and spotty, length <3/2 of vessel diameter and width <2/3 of vessel diameter (17). We classified the plaque into 3 types, namely, noncalcified, calcified, and mixed plaque (18). A ringlike enhancement was defined as either the presence of a ring of high attenuation around certain coronary artery plaques or the CT attenuation of a ring presenting higher than those of the adjacent plaque and no greater than 130 HU (19).

PCI procedures. All patients received treatment with aspirin (200 mg/day) and clopidogrel (75 mg/day) at least 24 h before the procedure. A glycoprotein IIb/IIIa receptor