Quantitative Analysis of Coronary Plaque Composition by Dual-Source CT in Patients with Acute Non–ST-Elevation Myocardial Infarction Compared to Patients with Stable Coronary Artery Disease Correlated with Virtual Histology Intravascular Ultrasound

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Rationale and Objectives: To quantitatively assess coronary atherosclerotic plaque composition in patients with acute non–ST elevation myocardial infarction (NSTEMI) and patients with stable coronary artery disease (CAD) by coronary computed tomography angiography (cCTA) correlated with virtual histology intravascular ultrasound (VH-IVUS).

Materials and Methods: Sixty patients (35 with NSTEMI) were included. Corresponding plaques were assessed by dual-source cCTA and VH-IVUS regarding volumes and percentages of fatty, fibrous, and calcified component; overall plaque burden; and maximal percent area stenosis. Possible differences between patient groups were investigated. Concordance between cCTA and VH-IVUS measurements was validated by Bland–Altman analysis.

Results: Forty corresponding plaques (22 of patients with NSTEMI) were finally analyzed by cCTA and VH-IVUS. cCTA plaque analysis revealed no significant differences between plaques of patients with NSTEMI and stable CAD regarding absolute and relative amounts of any plaque component (fatty: 20 mm^3/13% versus 17 mm^3/14%; fibrous: 81 mm^3/63% versus 80 mm^3/53%; calcified: 16 mm^3/14% versus 26 mm^3/26%; all $P > .05$) or overall plaque burden (153 mm^3 versus 165 mm^3; $P > .05$), nor did VH-IVUS plaque analysis. VH-IVUS measured a higher area stenosis in patients with NSTEMI compared to patients with stable CAD (76% versus 68%, $P = .01$; in cCTA 69% versus 65%, $P = .2$). Volumes of fatty component were measured systematically lower in cCTA, whereas calcified and fibrous volumes were higher. No significant bias was observed comparing volumes of overall noncalcified component and overall plaque burden.

Conclusion: Plaques of patients with acute NSTEMI and of patients with stable CAD cannot be differentiated by quantification of plaque components. cCTA and VH-IVUS differ in plaque component analysis.

Key Words: Dual-source computed tomography angiography; intravascular ultrasound; coronary artery disease; plaque composition; non–ST-elevation myocardial infarction.

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Coronary CT angiography (cCTA) has been proved to reliably exclude presence of coronary artery disease (CAD) and is increasingly used to assess CAD and further characterize atherosclerotic lesions as well (1). Histopathology studies have assessed characteristics of stable and instable plaques (2). The likeliness of a plaque to rupture—its vulnerability—and to subsequently cause vessel obstruction and myocardial infarction is known to be largely dependent on its composition, and strong efforts are made to reliably risk-stratify plaques and patients. The invasive reference standard for plaque composition imaging is intravascular ultrasound (IVUS) (3,4). The search for accurate noninvasive plaque imaging modalities is ongoing. With further improvement of temporal and spatial resolution, cCTA continues to emerge as a promising technique in the quest for a noninvasive plaque imaging reference standard (5).

Plaque analysis with cCTA was previously evaluated in mostly select plaque and patient samples concerning, for example, proximal lesion localization, nonobstructive CAD, absence of arrhythmias, or low Agatston score with the goal of achieving optimal CT image quality (6–8). The parameters most frequently studied were stenosis grading, overall plaque burden, and classification into calcified and noncalcified plaques and plaque components. Data about the performance of cCTA with regard to further differentiation and quantification of plaque components in correlation to virtual histology IVUS (VH-IVUS) are limited. To our knowledge, Brodoefel et al were the first to differentiate and quantitatively assess fatty, fibrous, and calcified components using dual-source CT in plaques of patients with stable CAD (9).

Because reliable risk-stratification of lesions and patients is a major goal in the workup of CAD, comparative analysis of plaques of patients with stable CAD and of patients presenting with acute coronary syndrome (ACS) as the clinical manifestation of an unstable state of CAD is of major interest (10–13). Patients with ACS can be further categorized into patients suffering from ST-elevation myocardial infarction (STEMI), non–ST-elevation myocardial infarction (NSTEMI) and unstable angina (14). Out of the ACS group, patients with NSTEMI are most suitable for a prospective study involving cCTA and invasive plaque imaging techniques in comparison to patients with stable CAD for several reasons: First, in the workup of patients with NSTEMI, the use of diagnostic cCTA before invasive coronary angiography (ICA) is appropriate, while patients with STEMI immediately have to undergo ICA treatment due to their high-risk profile (1). In addition, from a solely technical point of view, intravascular plaque imaging would fail in most cases with STEMI due to subtotal or complete vessel occlusion being present in those patients. Third, in contrast to patients with unstable angina, in patients with NSTEMI noncardiac causes for chest pain can be ruled out as less likely at an earlier time point during clinical workup due to elevation of troponin levels.

Therefore, our goal was to quantitatively assess in patients with acute NSTEMI compared to patients with stable CAD the amount of fatty, fibrous, and calcified plaque components in coronary plaques by means of dual-source CT in comparison to VH-IVUS. We investigated for possible differences in the amount of the plaque components between the two patient groups and correlated cCTA and VH-IVUS measurements.

MATERIALS AND METHODS

Ethics Statement

This study was conducted according to the principles expressed in the Declaration of Helsinki of 1975, as revised in 1983. The study protocol of this prospective single-center study was approved by the Federal Office for Radiation Protection in Germany (BfS) and our institutional ethics committee. All patients included in the study gave written informed consent prior to data acquisition.

Study Population

Patients presenting to our emergency department with ACS, absence of ST-segment elevation on electrocardiography (ECG), elevation of troponin I to greater than 0.5 μg/L or elevation of high-sensitive troponin I to greater than 0.045 ng/mL (as high-sensitive troponin I was implemented in our clinic during the course of the study), and hemodynamic stability were prospectively assigned to the NSTEMI group. Patients electively scheduled for diagnostic ICA due to suspected CAD or suspected progression of previously diagnosed CAD were prospectively assigned to the stable CAD group. For detailed study inclusion and exclusion criteria, see the supplementary information. We included patients with acute NSTEMI and patients with stable CAD scheduled for ICA who underwent additional cCTA in the course of the study within 24 hours for the patients with NSTEMI and within 3 days for the patients with stable CAD.

cCTA

Image acquisition. All cCTA examinations were performed on a 64-slice dual-source CT system (SOMATOM Definition; Siemens Healthcare Sector, Forchheim, Germany).

Acquisition technique was chosen individually for each patient depending on heart rate, heart rhythm, and body mass index (BMI), with the overall goal of minimizing radiation dose. Scan techniques included retrospective ECG-gating with default use of ECG-dependent tube current modulation as well as prospective ECG-triggering. Acquisition parameters were as follows: detector collimation, $2 \times 32 \times 0.6$ mm; gantry rotation time, 330 ms; and reference tube current–time product per rotation, 320 mAs. The tube potential was 120 kV in patients with a