High-Risk Plaque Features on Coronary CT Angiography

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CORONARY COMPUTED TOMOGRAPHIC ANGIOGRAPHY (CTA) HAS BECOME AN ACCEPTED TOOL FOR THE evaluation of obstructive coronary artery disease, with high accuracy and proven prognostic implications. Although detailed information regarding plaque characteristics is available in coronary CTA datasets of sufficient quality, clinical decision making utilizing the information offered by computed tomography–based plaque analysis is not widely utilized. Nonetheless, the Society of Cardiovascular Computed Tomography Guidelines for the Interpretation and Reporting of Coronary Computed Tomographic Angiography go beyond mere stenosis measurement: “If coronary disease is present, stenosis severity, plaque morphology, and extent should be described.... Plaque type should be described as calcified, predominant calcified, noncalcified, predominant noncalcified, or partially noncalcified.... Other morphologic descriptors of a stenotic lesion, such as ... apparent dissection or ulceration, and positive remodeling may also be appropriate.... Reporting of Hounsfield units in the plaque is discretional; it must be recognized that significant overlap exists between lipid and fibrous material, making interpretation of plaque HU problematic” (1).

Here, we present selected images featuring high-risk plaques in coronary CTA, with accompanying clinical scenarios that indicate potential applications not currently covered by guidelines (Figures 1 to 4). A survey querying clinical decisions based on the images was e-mailed to 2,250 Society of Cardiovascular Computed Tomography members; 10% responded, and the answers are indicated in the case descriptions. It must be emphasized that considerably more data are required before formal recommendations can be made. With further research and technical developments, computed tomography–based plaque analysis may, in the future, provide noninvasive insight into the “vulnerability” of specific lesions and may possibly contribute to the prevention of acute coronary events.
Two examples of high-risk plaques (HRPs), which typically demonstrate large plaque burden, carry large necrotic cores (NC), and are covered by intensely inflamed thin fibrous caps. In A, the lumen (L) is critically compromised, whereas modest occlusion is seen in B. These plaques usually demonstrate outward remodeling. (C and D) The necrotic cores are conveniently identified as low attenuation plaques on computed tomographic angiography (CTA); intravascular ultrasound–verified necrotic cores usually measure 30 Hounsfield units or lower. HRPs on CTA almost always demonstrate positive remodeling of 110% or more. These plaques have been referred to as 2-feature positive plaques (low attenuation plaques and positive remodeling) on CTA. Stable plaques lack these characteristics and are called 2-feature negative plaques. These figures are unrelated, and an attempt was made to match clinical and pathological data.

Figure 2: HRP Associated With ≤50% Diameter Stenosis

Clinical scenario: A 66-year-old man presented with atypical exertional chest pain; he had low-density lipoprotein of 75 mg/dl and was on statin therapy. The 2013 American College of Cardiology/American Heart Association 10-year risk estimate was 9.0%, deserving of moderate- to high-intensity statin therapy. After an equivocal nuclear stress test, he underwent CTA followed by invasive angiography because of persistent symptoms. Images: Multiplanar reconstruction of the right coronary artery (RCA) (A) reveals a 50% distal stenosis (white arrow). Cross-sectional analysis (B to D) reveals HRP features: a low attenuation lipid core adjacent to the lumen (2 to 25 Hounsfield units [HU]), spotty calcification (223 HU), and positive remodeling. Stenosis <50% was noted on invasive angiography (E, white arrow). Survey response: 89% of the respondents favored maximally intensifying medical therapy because of HRP. Comment: Several studies have demonstrated the beneficial effects of statins on CTA plaque progression. A significant reduction in low attenuation plaque on statin treatment has been reported compared with no change in patients without statin treatment in serial CTA studies, but formal studies are required before it can be concluded that these elements also predict lower future event rates. RI = remodeling index; other abbreviations as in Figure 1.
Clinical scenario: A 65-year-old man with typical angina on dual antianginal therapy underwent CTA that revealed an intermediate (50% to 70%) left anterior descending (LAD) stenosis. The plaque revealed positive remodeling (PR), low attenuation plaques (LAP), and spotty calcification. Invasive angiography confirmed an intermediate stenosis, and the fractional flow reserve (FFR) was 0.81. Images: Multiplanar reconstruction of the LAD (A) demonstrates an intermediate (50% to 70%) proximal stenosis (arrow). Cross-sectional analysis (C) and schematic (D) of the straightened vessel (B) reveals LAP adjacent to the lumen (−8 to 38 HU) and spotty calcification (745 HU); PR compared with the normal segment (RI 1.18) was also noted. Survey response: 49% of the responses favored over-riding the normal FFR and performing percutaneous coronary intervention because of the HRP. Comment: A normal FFR does not guarantee a benign outcome. In the FAME (Fractional Flow Reserve Versus Angiography for Multivessel Evaluation) study (2), 3.2% of patients who were deferred for intervention on the basis of a normal FFR had death, myocardial infarction, or revascularization within 2 years. This presents a difficult problem, and FFR may not incorporate the plaque prognostic information. A high likelihood of developing acute coronary syndrome (22% over a mean of 27 ± 10 months) in patients with CTA-verifed LAP and/or in whom PR has been reported (3). Abbreviations as in Figures 1 and 2.
**FIGURE 4  HRP Associated With Severe Stenosis Prone to Distal Embolization During PCI**

Clinical scenario: CTA in a 62-year-old woman with continued exertional angina on multiple medications revealed a critical right coronary artery (RCA) stenosis with circumferentially calcified plaque, PR, and LAP. Percutaneous coronary intervention (PCI) was planned. In this scenario, it has been presumed that a downstream “basket” may decrease the likelihood of slow flow post-PCI. Images: The curved multiplanar reconstruction (A) demonstrates a >70% mid-RCA stenosis (arrow). Cross-sectional analyses (B) at multiple levels of the straightened multiplanar reconstruction (top) revealed severe luminal reduction, LAP adjacent to the lumen (~1, 3, 12 HU), and PR (RI 1.32) compared with the normal segment. No reflow phenomenon developed in this patient during stent placement (C), and intracoronary nicorandil restored flow (D). Survey response: 79% of the responses favored urgent, rather than elective, percutaneous intervention because of the HRP, and 73% favored deployment of a downstream protection device for PCI. Comment: There are no studies specifically addressing the ideal timing of intervention following the identification of HRP in an otherwise stable clinical state. However, the wealth of data documenting the accompanying higher incidence of acute coronary syndromes, as well as the higher rupture rate associated with >75% plaque area, may support the wisdom of intervening sooner, rather than later, after discovery of a higher-likelihood culprit lesion. CTA-defined circumferential plaque calcification, defined as calcium occupying >180° of the perimeter for at least one-third of the plaque length, was associated with a high odds ratio for developing slow flow during PCI. In addition, no reflow following stenting has been identified in the setting of an extensive lipid core demonstrated by near infrared spectroscopy. The identification of these features by CTA might be a harbinger of periprocedural complications. Abbreviations as in Figures 1 to 3.