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CASE SERIES

CARDIOLOGY // IMAGING

High-Risk Coronary Plaques Complicated with Acute Coronary Syndrome in Young Patients

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ABSTRACT

Coronary computed tomography angiography (CCTA) has evolved notably over the last decade, gaining an increased amount of temporo-spatial resolution in combination with decreased radiation exposure. The importance of CCTA is emerging especially in vulnerable and young patients who might not have developed a viable collateral vascular network to sustain the circulation to an infarction area during a major adverse coronary event. There are a few well-known markers by which a vulnerable plaque can be assessed and that can predict the subsequent events of sudden myocardial ischemia, such as an increased positive remodeling index (cut-off >1.4), low-attenuation plaque (cut-off <30 HU), plaque burden (cut-off >0.7), and napkin-ring sign (NRS). This manuscript presents a series of 3 clinical cases of young patients experiencing symptoms and signs of myocardial ischemia who underwent CCTA in order to assess the composition and functional characteristics of atherosclerotic plaques and their repercussion in developing an acute coronary syndrome.

Keywords: vulnerable plaque, coronary computed tomography angiography, acute coronary syndrome

INTRODUCTION

According to the World Health Organization, cardiovascular diseases (CVD) prevail over other causes of morbidity and mortality worldwide, accounting for over 17.7 million deaths in 2015 and an estimated 7.4 million deaths due to coronary heart disease. The main source of CVD is represented by the progression of the vascular atherosclerosis process towards coronary atherosclerotic plaques, which may develop into “vulnerable” or “unstable” plaques, leading eventually to an acute coronary syndrome (ACS) through their rupture.[1]

It is universally accepted that the main pathogenic model of unstable plaques is based on mechanical and/or inflammatory stress. In fact, according to related studies, in an estimated 30–40% of cases mechanical stress is responsible

for the acute event, inflammation stress being responsible in 60–70% of ACS cases. These types of vascular stress are acting progressively at the fibrous thin cap site on the plaque, leading towards an acute coronary event, the most severe consequence of atherosclerosis that characterizes the final, critical stage of "high-risk plaques" or "vulnerable plaques".[2]

Nowadays, there are many imaging diagnostic tools for coronary plaque characterization that can reveal the degree of obstruction caused by the atheroma in a variety of ranges, starting with conventional imaging such as coronary angiography. However, the actually challenging milestone is to use various biomarkers to describe the inflammatory status of the plaque and thus the risk of rupture, in order to identify the so-called "vulnerable patient".[3,4]

Concerning new cardiological approaches of atherosclerotic plaques, modern coronary imaging techniques such as coronary computed tomography angiography (CCTA), alongside optical coherence tomography (OCT), virtual histology intravascular ultrasound (VH-IVUS), near-infrared spectroscopy (NIR), and near-infrared diffuse reflectance spectroscopy (NIRS) are able to identify morphological and compositional aspects of vulnerable plaques.[5] It has been proved that there is a strong correlation between unstable plaques and CCTA-specified composition imaging biomarkers in predicting acute coronary events. The demonstrated relevance of this correlation was based on markers such as spotty calcifications, active positive vascular remodeling, low-density atheroma, and the napkin-ring sign.[6,7] Based on measuring the dimensions of low-density lipid core (LDLC) and plaque density on CCTA, Benedek *et al*. showed that lipid core proportions are in inverse correlation to CT plaque density, more precisely an unstable plaque is characterized by a greater volume of LDLC and lower plaque CT attenuation. Thus, it was showed that a coronary plaque with an estimated CT density lower than 30 Hounsfield Units (HU) is more prone to trigger an acute coronary syndrome event.[8] Therefore, CCTA can actually represent a relevant coronary imaging tool for performing morphological and compositional measurements that serve as important diagnostic tools, which can be performed timely, in such a manner to prevent the development of acute coronary syndrome events.

CASE SERIES

This manuscript presents a series of three clinical cases of young patients experiencing symptoms and signs of myocardial ischemia who underwent CCTA to investigate the composition and functional features of atherosclerotic plaques and their risk to develop acute coronary syndromes. All CCTA acquisitions describe vessel information, plaque characteristics, and degree of obstruction. Based on coronary CTA protocols, the image acquisition was done throughout an inspiratory breath-hold, 60 mL of contrast material (Iopamidol, 370 mg I/mL, Bayer Healthcare, Germany) were administered with an injection rate of 4.0 mL/second followed by 20 mL at 2.0 mL/second. All examinations were acquired by using a retrospective electrocardiography (ECG)-gated spiral mode after administering a short-acting beta-blocker to achieve the desired cardiac rate and were conducted only after achieving a stable rate below 60 beats/minute.[9]

All patients consented to publication of their data and the publication was approved by the Ethics Committee of the center where the examinations were performed. All the examinations were performed in accordance to the principles stated in the Declaration of Helsinki.

The first case is represented by a 49-year-old male with positive personal history of CVD, experiencing sudden onset of chest pain associated with arterial hypertension stage 3 and vertigo. Upon admission, the ECG showed only negative T waves in DI, aVL, V5, and V6 leads. No enzymatic reaction was found. The laboratory displayed increased values of blood cholesterol of 280 mg/dL. Clinical and laboratory assessment indicated a diagnosis of unstable angina. CCTA imaging revealed that there was a culprit lesion located on the proximal segment of the anterior descending coronary artery. Moreover, the lesion length was estimated at 19.5 mm and was associated with a 579.04 mm^3 plaque volume, as seen in Figure 1 and Figure 2. Furthermore, by aid of post-processing software, plaque burden was calculated (81.99%), of which 56% was the necrotic core volume, 18% fibrous fatty volume and under 1% dense calcium volume (Figure 3). In addition, the plaque thickness was measured at 5.19 mm, plaque attenuation at 50.8 HU, transluminal attenuation gradient at 1.6 HU/mm, and the degree of obstruction, resulting in a stenosis area of 85.8%, combined with an eccentricity index of 0.91 and a remodeling index of 0.84.

The following case concerns a 48-year-old male with positive personal history of arterial hypertension stage 2 and chronic ischemic disease, complaining of typical angina pectoris associated with exertion dyspnea. The laboratory investigation showed no enzymatic reaction present at the moment of admission, although a mixed dyslipidemia was found with increased blood cholesterol (312 mg/dL) and triglycerides (196 mg/dL). However, 12-lead ECG showed negative T waves in anterior limbs leads. During hospitalization, he underwent a CCTA assessment of

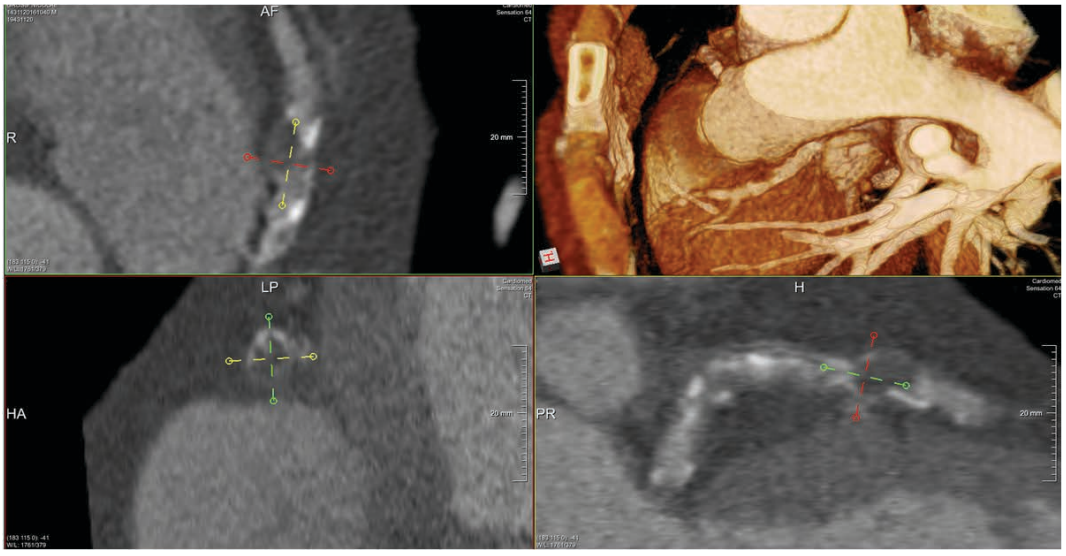

FIGURE 1. Coronary CT angiography — analysis of vessel and degree of stenosis

the components and functional aspects of atherosclerotic plaques, which revealed a coronary stenosis in the middle segment of the left anterior descending artery (Figure 4). Post-processing the CCTA images, the software estimated that the length of the lesion was 4.50 mm, associated with a 121.19 mm^3 plaque volume. Moreover, the following lesion values were measured: plaque burden 79.84%, of which 52% was the necrotic core volume, 14% fibrous fatty volume, and 1% dense calcium volume; in addition, plaque thickness was measured at 3.33 mm, plaque density at 88.5 HU, transluminal attenuation gradient at 21 HU/mm, and the obstruction degree, resulting in a stenosis area of 46.8%, combined with an eccentricity index of 0.88 and a remodeling index of 0.97.

The last clinical case we present regards a 51-year-old male with chronic heart failure and arterial hypertension stage 2, experiencing constrictive chest pain with recent onset, associated with mild rest dyspnea and facial flush. The laboratory results were in normal ranges, except for blood cholesterol, which was above the normal range at 221 mg/dL. Twelve-lead ECG was performed, and it showed biphasic T waves in V1–V3 and negative T waves in DI, V5–V6. CCTA displayed a 50% stenosis at the origin of the left anterior descending coronary. The estimated lesion length was 19.5 mm at a 579.04 mm^3 plaque volume. Furthermore, we calculated the plaque burden, which was 71.84%, out of which 31% was the necrotic core volume, 14% fibrous fatty volume and under

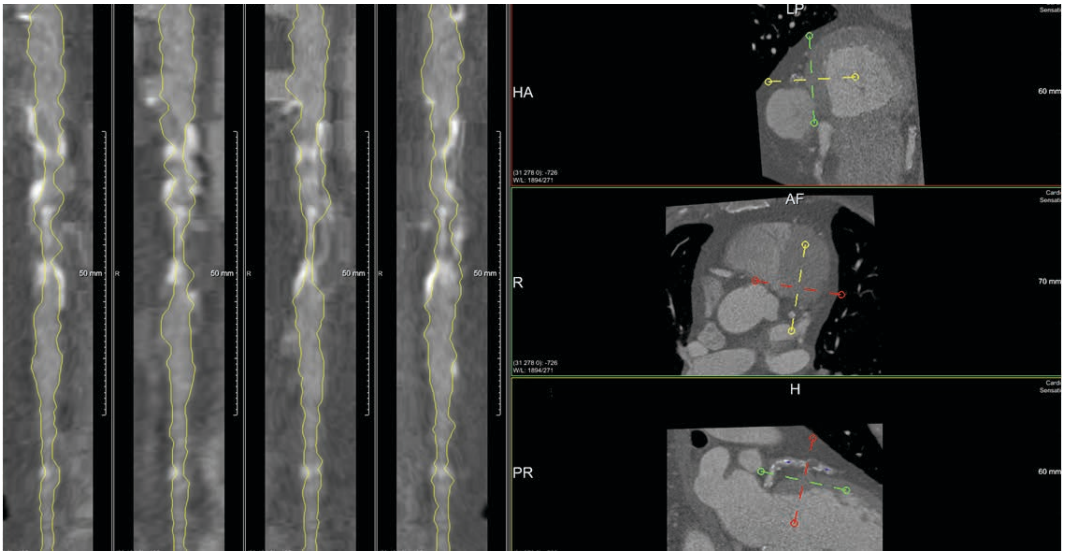

FIGURE 2. Post-processing CCTA — analysis of coronary degree of stenosis

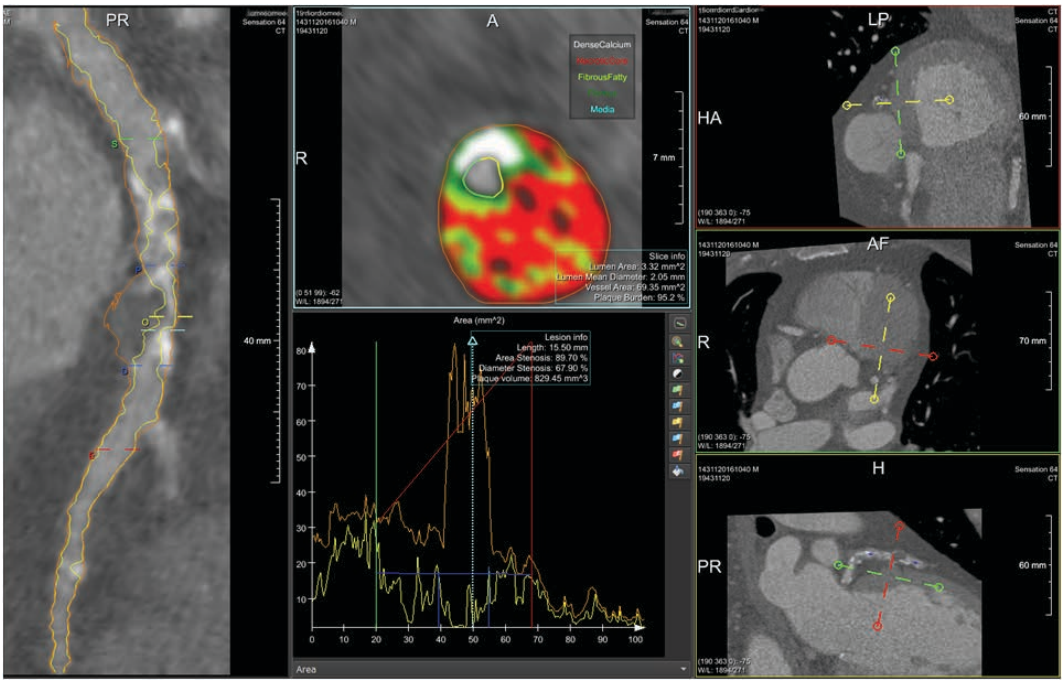

FIGURE 3. Post-processing with QAgioCT software — analysis of lesion composition (fibrous fatty tissue, necrotic core, dense calcified masses)

21% dense calcium volume. Additionally, measurements of plaque thickness (2.94 mm) combined with an eccentricity index of 0.85 and a remodeling index of 0.85 was calculated.

DISCUSSIONS

Coronary CT angiography is nowadays a reliable high-performance imaging instrument for the analysis of vulnerable atherosclerotic plaques and to identify whether there is a high risk of plaque rupture leading to imminent acute coronary syndromes, especially in vulnerable or in young patients (as in the matching three clinical cases presented in this article), whose collateral vessels are not yet viable to repair the jeopardized areas caused by coronary occlusion. Multiple randomized multicenter trials have shown the major impact of the evolving CCTA technique on detecting and rapidly and efficiently triaging patients in the emergency department suspected for ACS.[10]

In the PROSPECT (Providing Regional Observations to Study Predictors of Events in the Coronary Tree) tri-

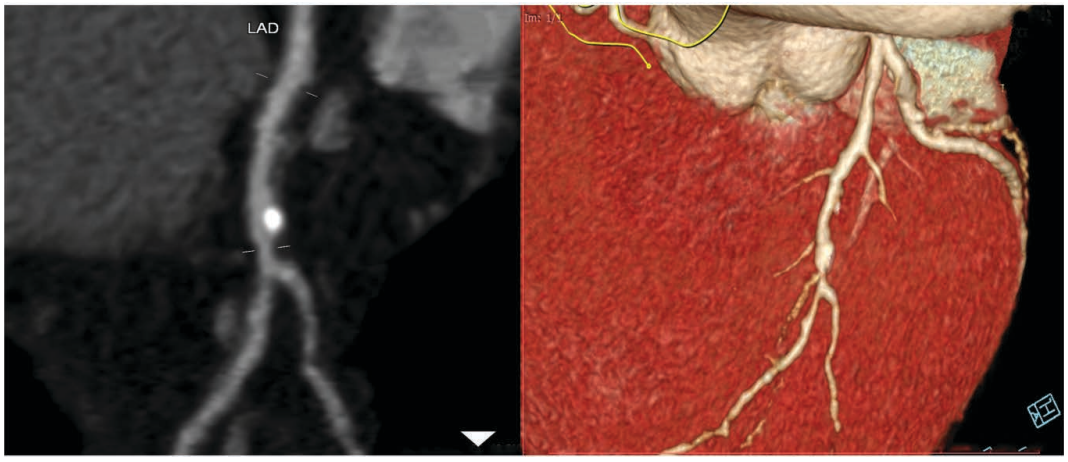

FIGURE 1. CCTA image showing a stenosis at the level of the left anterior descending artery

al, 697 patients who underwent percutaneous coronary intervention (PCI) for ACS were followed-up, and the 3-year cumulative rate for major acute coronary events was 20.4%, of which 11.6% was at a non-culprit lesion. Thus, the study concluded that the majority of mild coronary stenoses displayed by conventional coronary angiography were associated with thin-capped fibroatheromas, increased plaque burden, decreased luminal area, or a combination of these factors when assessed by non-invasive imaging tools, resulting in a higher rate of major adverse cardiovascular events.[11] A major contribution of coronary CT in the triage of patients in the emergency room was also demonstrated by Motoyama *et al*., who included 3,158 patients referred for CCTA for assessment of chest pain, in a follow-up span of 3.9 years. In patients with vulnerable plaques the event rate was 16.3%, and in patients with decreased risk plaque the event rate was 1.4%. High cardiovascular risk based on Framingham tools and its modern derivatives suggest a 10-year risk of 20% as being high. The use of CCTA can reclassify patients as having a 16% risk of ACS in 4 years.[12]

CONCLUSIONS

CCTA has evolved notably over the last decade, gaining an increased amount of temporo-spatial resolution in combination with decreased radiation exposure, thus the identification of predictive lesions of an eventual ACS could be more accurate, efficient, and rapid. There are a few well-known markers by which a vulnerable plaque can be assessed, and which can predict the subsequent events of sudden myocardial ischemia such as increased positive remodeling index, low-attenuation plaque, plaque burden, and napkin-ring sign. However, future improvements are needed, and the method should be introduced in large scale studies to have a more established decisive and rapid diagnosis capacity as therapeutic management tool.

CONFLICT OF INTEREST

Nothing to declare.

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