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EDITORIAL COMMENT

CATCH

Technical Development and Comparison With High-Risk Plaque Features Detected by Invasive Coronary Imaging*

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Coronary plaque rupture and subsequent myocardial infarction remains a major health care problem despite advances in diagnosis, coronary angioplasty, and medical therapy. In the last decades, several noninvasive imaging techniques have been developed and clinically investigated in the quest for vulnerable plaque detection including coronary computed tomography angiography (CTA), (18)F-sodium fluoride (NaF) positron emission tomography, and T_1-weighted (T1w) cardiac magnetic resonance (CMR). CTA has been shown to be very promising for identifying high-risk plaque features such as positive remodeling and low attenuation plaques that were independent predictors of acute coronary syndrome (1). Similarly, (18)F-NaF positron emission tomography-CT successfully identified ruptured coronary plaque and was associated with high-risk plaque features including positive remodeling, spotty calcification, and necrotic core as measured by intravascular ultrasound (2). Noncontrast-enhanced carotid and coronary T1w CMR has been shown to enable direct thrombus imaging (3,4) and detection of intraplaque hemorrhage (IPH) (5,6), both features of high-risk plaque, whereas contrast-enhanced coronary T1w MR plaque imaging was associated with increased calcification (fibrosis) on CTA (7,8) and inflammation in patients with acute coronary syndrome (9), Takayasu disease (10), or systemic lupus erythematosus (11). A disadvantage of CTA and positron emission tomography compared with CMR is the exposure to ionizing radiation and the need for potentially nephrotoxic contrast agents, thus making T1w CMR a promising candidate for screening, follow-up, and guidance of therapy in patients with a high-risk of coronary artery disease. However, the long examination time, complex planning procedure, and unknown cost effectiveness remains an obstacle to widespread clinical use. The study by Xie et al. (12) in this issue of *iJACC* may be a first promising step toward addressing these technical limitations.

The first observation of MR direct thrombus imaging was made in patients with deep venous thrombosis back in late 1990s (3). The same group demonstrated that T1w CMR could be also used to identify IPH in complex carotid artery plaques (5), and the high predictive value of IPH for cerebrovascular events has been demonstrated in several follow-up studies including a recent meta-analysis (13). Later work by Noguchi et al. (14) also demonstrated an association between carotid IPH and subsequent coronary events. The first observation of high-intensity plaque (HIP) on non-contrast-enhanced coronary magnetic resonance images was reported by Maintz et al. (7) and Yeon et al. (8) in patients with stable coronary artery disease and was believed to result from the presence of fresh thrombus or intraplaque hemorrhage. In the same study, HIP after injection of an extracellular MR contrast agent was associated with increasing calcification and disease burden on CTA and x-ray angiography. In a subsequent study by Kawasaki et al. (6), hyperintense coronary artery plaque on noncontrast T1w CMR was found to be associated with positive remodeling, ultrasound attenuation, and lower Hounsfield units, all markers of unstable plaque. Jansen et al. (4) demonstrated that noncontrast T1w CMR allowed for detection of acute coronary thrombus in a small proof-of-concept single-center study. Most recent work by Noguchi et al. (15,16) in 568 patients with

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suspected or known coronary artery disease demonstrated that noncontrast HIPs were highly predictive for future coronary events (15) and that statin treatment would result in a decrease of the intensity and frequency of HIP (16). Taken together, these observations suggest that new technical developments aimed at improving T1w coronary plaque imaging may be very beneficial for better risk stratification and treatment guidance in patients that are at high risk of coronary artery disease.

TECHNICAL ASPECTS

When compared with earlier and pioneering reports on T1w characterization of coronary plaque as those alluded to herein, there are 2 main aspects that make this current study stand out from a technical perspective. First, Xie et al. (12) succeeded in breaking away from the paradigm that navigator gating is used for respiratory motion suppression, and second, they deliberately integrated a T1w scan for plaque visualization with an anatomical reference acquisition for spatial coregistration into a single scan. The former critically enables data acquisition in 10 min or less and the respiratory pattern of the patient no longer affects scanning time as was the case for conventional navigator approaches. With the technique reported by Xie et al. (12) instead, overall acquisition time is highly predictable, which tremendously improves the ease-of-use and in turn facilitates the integration of this method into a clinical CMR exam. The latter, the simultaneous acquisition of a T1w scan together with an anatomical reference image is critically important to avoid ambiguity in image interpretation and to improve specificity in the identification of enhancement localized in the coronary arteries. Whereas many of the enabling technical ingredients have been used and reported before by the same investigators and by others, it is the ingenious combination of these ingredients that distinguishes this study. First of all, and as shown in their Figure 1, retrospective affine motion correction is at the core of the algorithm. It obviates the need for navigator gating and uncertainty with regard to the overall duration of the scan is therefore entirely removed. Second, and to abbreviate the acquisition duration of 2 acquisitions with large volumetric coverage (whole heart) and a high spatial resolution (1.1 mm^3) to under 10 min, a sensitivity encoding reconstruction is exploited. Third, the technique is implemented at 3-T for improved signal-to-noise ratio. This is critically linked with the fourth ingredient, which is a robust radial gradient-echo signal readout that exploits a golden angle rotation of consecutive k-space profiles. Finally, an inversion recovery magnetization preparation scheme that alternates with consecutive heartbeats and an effective approach to fat signal suppression completes the list. It is noteworthy that a simple modification of the inversion time supports the use of this approach before and after contrast injection to provide complimentary information about plaque composition. Whereas this may sound highly technical and the combination of components rather unique, it is still worth noting that many of these do already exist to a large degree on clinical scanners. Therefore, a more widespread use of coronary atherosclerosis T_1-weighted characterization with integrated anatomical reference, or CATCH, may not be out of reach. As meticulous plan scanning, volume targeting, and navigator localization are no longer needed, the likelihood that this technique will also be successful outside of highly trained and specialized centers is undoubtedly increased.

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