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EDITORIAL COMMENT

Does heart rate influence CMR image quality of the coronary vessel wall?

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Cardiovascular magnetic resonance (CMR) has made tremendous advances over the past years, providing accurate evaluation of left ventricular mass, volumes and function [1–4]. CMR has shown unique abilities in characterizing myocardial tissue composition. In particular, high-resolution contrast-enhanced CMR has been used to visualize myocardial fibrosis with a high accuracy [5–7]. For instance, in patients with acute myocardial infarction, the injured myocardium shows increased CMR contrast compared to normal myocardium when imaged by delayed gadolinium enhancement. The transmural extent of delayed gadolinium enhancement predicts functional outcome after interventional procedures performed in patients with acute myocardial infarction and chronic ischemic heart disease [8–10]. Not only in the setting of an acute myocardial infarction, but also in patients with various manifestations of cardiomyopathy, evidence of delayed gadolinium enhancement may have important clinical and prognostic implications [11–13]. CMR has become the first choice imaging modality in complex congenital heart disease and imaging great vessels [14–18]. Magnetic resonance angiography (MRA) has been introduced as a method that can provide visualization of all three major coronary arteries, coronary bypasses and the aorta within a single three-dimensional acquisition [19–22]. In particular, CMR has proven to be of indispensable value in identifying aortic stiffness in Marfan patients using pulse wave velocity measurements [23, 24].

A rather new aspect of CMR is coronary vessel wall imaging. In a study by Macedo et al. [25], 88 arterial segments in 38 asymptomatic participants of the Multi-Ethnic Study of Atherosclerosis (MESA) study were evaluated using black blood CMR. CMR-assessed coronary wall thickness was compared with computed tomography calcium score, carotid intima-media thickness, and risk factors for coronary artery disease. Coronary artery wall CMR detected increased coronary wall thickness in asymptomatic individuals with subclinical markers of atherosclerotic disease and in individuals with zero calcium score. Gerretsen et al. [26] showed that both in patients with angiographically proven coronary artery disease and age-matched asymptomatic subjects, coronary vessel wall thickening was detectable with CMR coronary vessel wall imaging. Maximum and mean wall thicknesses were significantly higher in the patient population. The vast majority of asymptomatic subjects had either positive remodeling without luminal narrowing, or non-significant stenoses. Kelle et al. [27] demonstrated coronary artery vessel wall enhancement using 3.0 Tesla CMR imaging after a

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single, low-dose gadolinium contrast injection in patients with coronary artery disease, but not in healthy subjects. In the majority of the evaluated coronary segments in the patient group, late contrast enhancement of the coronary vessel wall was already detectable 30–45 min after administration of the contrast agent. Recently, Scott et al. [28] showed that high-resolution thee-dimensional spiral imaging with beat-to-beat respiratory-motion-correction allowed coronary vessel wall assessment over multiple thin contiguous slices in a clinically feasible duration. Excellent reproducibility of the technique potentially enables studies of disease progression or regression.

In the current issue of the *International Journal of Cardiovascular Imaging*, Lin et al. [29] interestingly hypothesized that black blood steady-state free precession (SSFP) would provide coronary wall images comparable to images from turbo spin-echo imaging (TSE) and would better perform than TSE under conditions of increased heart rates. The aim of the study was to prospectively evaluate a two-dimensional double inversion recovery (DIR) prepared SSFP CMR imaging sequence for black blood coronary wall imaging and to estimate its value in the detection of coronary artery disease. The authors investigated 30 healthy volunteers (19 men, 11 women, from 26 to 83 years old) using a 1.5 Tesla CMR scanner. Cross-sectional black-blood images of the proximal portions of coronary arteries were acquired with a two-dimensional, double inversion recovery prepared TSE sequence and a two-dimensional double inversion recovery SSFP sequence on the same planes. Image quality, vessel wall area and thickness, signal-to-noise ratio of the wall and contrast-to-noise ratio (wall to lumen) were compared between SSFP and TSE with SPSS software. For SSFP and TSE no differences in image quality were observed. SSFP had a higher signal-to-noise ratio and wall to lumen contrast-to-noise. Good agreements between measured wall area and thickness were found. For 10 individuals with heart rates over 80 beats per minute, the image quality of SSFP was significantly better than TSE. With its higher performance under fast heart rate conditions, SSFP allows higher thresholds for heart rate and extends therefore the clinical applicability of coronary wall MR imaging to more patient populations.

The study suffers from several limitations (also recognized by the authors). First, the thickness of the coronary wall may have been overestimated due to the limited spatial resolution of coronary wall MR imaging. In this respect, a gold standard such as IVUS should have used to verify the true thickness of the wall. Second, there were only 10 (33%) individuals with a heart rate over 80 beats per minute. Therefore, image quality rather than accuracy could be established. Third it should be realized that many physical and physiological parameters could have affected image quality in coronary wall CMR imaging. These parameters should be taken into account for upcoming studies. Fourth, only healthy volunteers were studied, precluding a valid extrapolation of the findings to patients with atherosclerotic vessel walls.

In summary, Lin et al. [29] successfully evaluated two coronary MR techniques (SSFP vs. TSE) in an asymptomatic healthy population with increased heart rates. It turned out that SSFP performed better than TSE under conditions of fast heart rate, opening avenues for studying more and different patient populations. In the near future, these important findings have to be confirmed in patients with coronary artery disease.

Conflict of interest None.

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