into the pathogenesis of heart disease in patients treated for HIV infection. Lipodystrophy can indeed lead to ectopic spillover of triglyceride into non-adipose tissues—including the myocardium—and has previously been associated with adverse LV remodeling (2). Furthermore, that HAART exposure also predicted myocardial triglyceride content and LV dysfunction provides further insight into the pathogenesis of heart disease in HIV(+) patients. For example, HAART has been associated with lipodystrophy, hyperlipidemia, and hyperglycemia (4) and may be directly cardiotoxic (5). Thus, whereas HAART has significantly reduced HIV-related morbidity and mortality, we speculate that HAART may also contribute to the cardiovascular decline in HIV(+) patients. Future studies are warranted to further investigate these findings.

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A Comprehensive Evaluation of Left Atrial Performance Using Volumetric Analysis, Strain, and Strain Rate Imaging

We read with great interest the article by Habibi et al. (1), which demonstrates the association of left atrial (LA) function and the development of heart failure using cardiac magnetic resonance (CMR) feature-tracking. We fully agree that LA function assessment has the potential to gain an incremental role in the early diagnosis and risk stratification already at pre-clinical stages of heart failure (2).

As correctly cited by the investigators, LA echocardiographic speckle tracking studies (3) have demonstrated that a comprehensive assessment of LA deformation should include strain and strain rate parameters to describe the 3 functional components of atrial physiology: 1) reservoir function (collection of pulmonary venous return during ventricular systole—assessed with global peak longitudinal strain and global peak positive strain rate); 2) conduit function (passage of blood to the left ventricle during early ventricular diastole—assessed with global passive longitudinal strain and global peak early negative strain rate); and 3) contractile booster pump function (augmentation of ventricular filling during late ventricular diastole—assessed with global longitudinal strain during atrial contraction and global peak late negative strain rate). Furthermore, when using CMR, an atrial volumetric analysis is also well established to assess these 3 functional components (4).

Habibi et al. (1) have now applied CMR feature-tracking strain—but not strain rate—to assess LA reservoir and contractile booster pump function without studying conduit function. Conversely, they used volumetric indices to study LA reservoir and conduit function but not contractile booster pump function. It is important to note that there is evidence to suggest that impaired LA contractile booster pump function assessed with volumetric analysis has strong prognostic implications for adverse cardiac events (including development of heart failure) in asymptomatic patients at risk for left ventricular diastolic dysfunction (5).

A more comprehensive analysis including all atrial deformation parameters (strain and strain rate) and

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volumetric indices for all 3 phases of atrial physiology and the study of their prognostic implications would have been desirable to indicate which parameters are best to assess when studying atrial physiology with CMR.

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REPLY: A Comprehensive Evaluation of Left Atrial Performance Using Volumetric Analysis, Strain, and Strain Rate Imaging

We appreciate the interest shown by Drs. Kowallick and Schuster in our article (1). Both volumetric and deformational analysis methods have been used to assess phasic left atrial (LA) function. Volumetric method enables measuring passive, active, and total LA emptying fractions, which are representatives of conduit, booster pump, and global/reservoir phase functions, respectively (2). In parallel, phasic LA strain and strain rate are also representatives of phasic LA function as correctly explained by Drs. Kowallick and Schuster. Feature-tracking cardiac magnetic resonance (CMR) has the ability to assess LA function using both volumetric and deformational analysis methods. Our findings in measuring phasic LA strain rate using feature-tracking on steady state free precession cine sequences have been promising (3). However, in this study, the images were acquired using fast gradient echo protocol with a temporal resolution of ~50 ms, which is not desirable for calculating strain rate. We would also like to point out that the images were acquired between 2000 and 2002, when cine CMR sequences with higher temporal resolution were still in development.

However, as suggested by Drs. Kowallick and Schuster, we calculated LA active emptying fraction using previously described method (4). As expected, LA active emptying fraction at baseline was significantly lower in heart failure cases than in control cases (27 ± 10% vs. 32 ± 11%; $p < 0.001$). In multivariable analysis, after adjusting for traditional cardiovascular risk factors, as explained in our article (1), the magnitude of LA active emptying fraction was associated with reduced incident heart failure (odds ratio: 0.62 per SD, 95% confidence interval: 0.46 to 0.83). However, similar to LA passive emptying fraction, after additionally adjusting for left ventricular mass and N-terminal pro-B-type natriuretic peptide, the association became insignificant.

On the basis of the study population and outcome variable, the association of phasic LA function with cardiovascular events may vary. As mentioned by Drs. Kowallick and Schuster, in a study on 210 hypertensive patients among all CMR-measured volumetric LA parameters, active emptying fraction had the strongest association with major adverse cardiac events including heart failure, but also all-cause mortality, myocardial infarction, and unstable angina (4). However, about one-half of our study population did not have the diagnosis of hypertension, and we focused on incident heart failure as the only outcome.

Finally, to our knowledge, this study is the first to examine the association of LA function measured with feature-tracking CMR and incident heart failure in the general population. Future studies to compare the prognostic role of phasic LA function for different types of adverse cardiac events will be of great value.

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