

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 ( $27 \pm 10\%$  vs.  $32 \pm 11\%$ ;  $p < 0.001$ ). 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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