Diagnosis of diastolic dysfunction by shear wave amplitudes measured in cardiac MR elastography

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Target audience: Physicians interested in the diagnosis of diastolic dysfunction based on the mechanical properties of the heart.

Background: The noninvasive detection and quantification of cardiac fibrosis, especially in early stages, by the altered mechanical properties of the heart could be beneficial for the diagnosis of cardiac disease (1). Several studies have shown, that cardiac MRE is feasible (3,4,5)

Purpose: To test if myocardial relaxation abnormalities in patients with diastolic dysfunction can be diagnosed by shear wave amplitudes (SWA) measured by cardiac magnetic resonance elastography (cMRE) in the myocardium.

Methods: ECG-triggered SWA-based cMRE with 24 Hz external vibration frequency was performed in 50 subjects grouped into asymptomatic young (N = 10, 18-39 years) and asymptomatic old (N = 10, 40-68 years) subjects and patients (N = 30, 44-73 years) with echocardiographically proven mild, moderate, or severe diastolic dysfunction. SWA images were analyzed in the left ventricular (LV) region and normalized against reference SWA of the thoracic wall. Analysis of variance with Bonferroni-corrected pairwise comparison and Pearson´s correlation were used for statistical evaluation.

Results: One patient with severe diastolic dysfuntion was excluded from final analysis due to motion artifacts. Young and old controls had normalized LV-SWA of 0.67 ± 0.04 and 0.56 ± 0.04 (P=0.18, F-test), respectively. Compared to the control groups, patients with mild, moderate, and severe diastolic dysfunction displayed significantly reduced normalized LV-SWA of 0.37 ± 0.04, 0.34 ± 0.04, and 0.29 ± 0.04 (P< 0.001, F-test), respectively, which was inversely correlated to the severity of diastolic dysfunction (R = -0.61, P < 0.001). The best cutoff value to differentiate between asymptomatic volunteers and patients was 0.43, yielding an area under the receiver-operating curve of 0.92 with 90% sensitivity and 89.7% specificity.

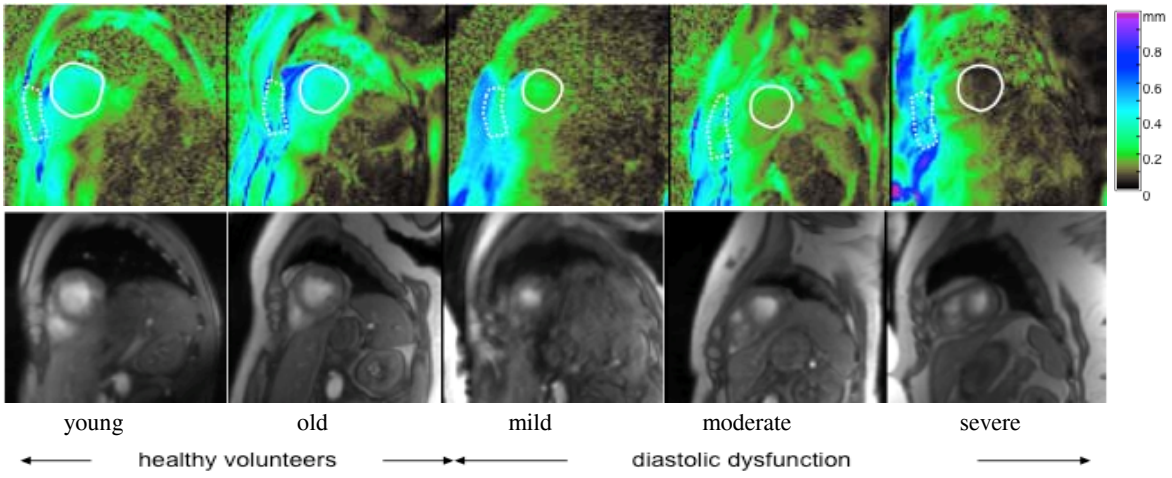

Figure 1: cMRE in five subjects. The SWA maps are displayed in the upper row showing the deflection amplitude averaged over three wave field components and 48 heart cycles (corresponding to the number of *k*-space segments). Solid white circles indicate the LV-regions of interest while dashed lines demarcate the reference regions for normalization. In the bottom row the corresponding magnitude images are displayed.

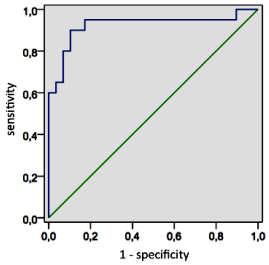

Figure 2: Receiver operating characteristics curve of normalized shear wave amplitudes for the diagnosis of diastolic dysfunction. cMRE is compared to transthoracic echocardiography.

Discussion: Transthoracic time-harmonic shear waves at low vibration frequency provide diagnostically valuable information about the ability of the myocardium to mechanically relax. Patients with diastolic dysfunction have lower shear wave amplitudes inside the left ventricle, which correlates with the severity of the disease. The decrease in shear wave amplitudes within the left ventricle can be quantified by normalization with reference amplitudes outside the heart and compared to a threshold value of 0.43, which was found to best separate patients with diastolic dysfunction from controls in our group. SWA maps can be used as a new mechanically based image contrast that directly displays myocardial relaxivity.

Conclusion: LV-SWA measured by cMRE provide image contrast sensitive to myocardial relaxation abnormalities and show significantly lower values in patients with diastolic dysfunction.

Literature:

1. van Heerebeek L et al. Circulation. 2006 Apr 25;113:1966–73.

2. Kolipaka A et al. Proceedings of the 19th Annual Meeting of the International Society of Magnetic Resonance in Medicine. Montreal; 2011. p. 274.

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