Quantitative Assessment of Atrioventricular Plane Displacement in Normals and Diastolic Heart Failure-A Cine MRI Study.

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Introduction: Conventional assessment of global cardiac function focuses on systolic function, e.g., the ejection fraction (EF). Many patients with symptoms of heart failure have normal or near-normal EF, but they can suffer primarily from diastolic dysfunction, i.e., impaired ventricular relaxation [1]. In echocardiography, it has been studied that monitoring the diastolic motion of the left ventricle (LV) with mitral annulus longitudinal velocity can assess diastolic dysfunction [2, 3]. In this study, we used long-axis (LA) views of the conventional cine MRI to measure the left atrioventricular (AV) plane displacement as a means to assess diastolic dysfunction. This method was performed in healthy volunteers and patients with diastolic dysfunction, but with normal or near-normal ejection fraction (EF).

Methods: Conventional cine MR images were acquired from ten normal volunteers (**Nl**) at 3T MR scanner (29±4.4 years old; Trio, Siemens) and twenty-one patients with heart failure, but with EF≥45%, at 1.5T MR scanner (59±18 years old; Avanto, Siemens) in two-chamber LA view. Patients were grouped into three based on their symptoms and the wall thickness (WT) measured at end-diastole. Eight patients had a history of mild cardiomyopathy with normal wall thickness (WT≤10mm, **NT**), six patients had mild left ventricular hypertrophy (10<WT≤15mm, **MH**) and seven patients had moderate-severe hypertrophy (WT>15mm, **H**). The measurement of the displacement of the AV plane was done by the customized software written in MATLAB (Natick, MA). In the cine LA image, a reference line was drawn from the ventricular apex towards the base of the left ventricle (green line in Fig.1a). The position of the AV junction (AVJ) was manually tracked during the cardiac cycle (red dot in Fig. 1a) and was projected onto the reference line. The displacement of the AVJ along the reference line was measured relative to the position at end-diastole. Three parameters were selected for analysis: (1) Maximum displacement (mm) of the AVJ towards apex, (2) cardiac cycle time at half maximum diastolic displacement (T1/2maxd) and (3) velocity at half maximum diastolic displacement (V1/2maxd) (Fig. 1b).

Results: Figure 1c shows that the maximum displacement is decreased in patient groups as compared to the normal (mean: -17.9, -13.9, -11.2, -8.20; Nl, NT, MH, H; respectively). In particular, the patient group (H) with further increase in wall thickness shows further reduced displacement, as compared to MH and NT. Figure 1d shows that the time to reach half max diastolic displacement (T1/2maxd) is increased in patient groups as compared to the normal (mean: 417.06, 488.68, 515.19, 606.18; NI, NT, MH, H respectively) because with increasing wall thickness the LV takes more time to relax during diastole. Figure 1e shows that patients groups with reduced displacements also have decreased velocities, as compared to the normal (mean: 0.115, 0.0849, 0.04864, 0.017; NI, NT, MH, and H, respectively), as has been seen with tissue Doppler echocardiography [2, 3].

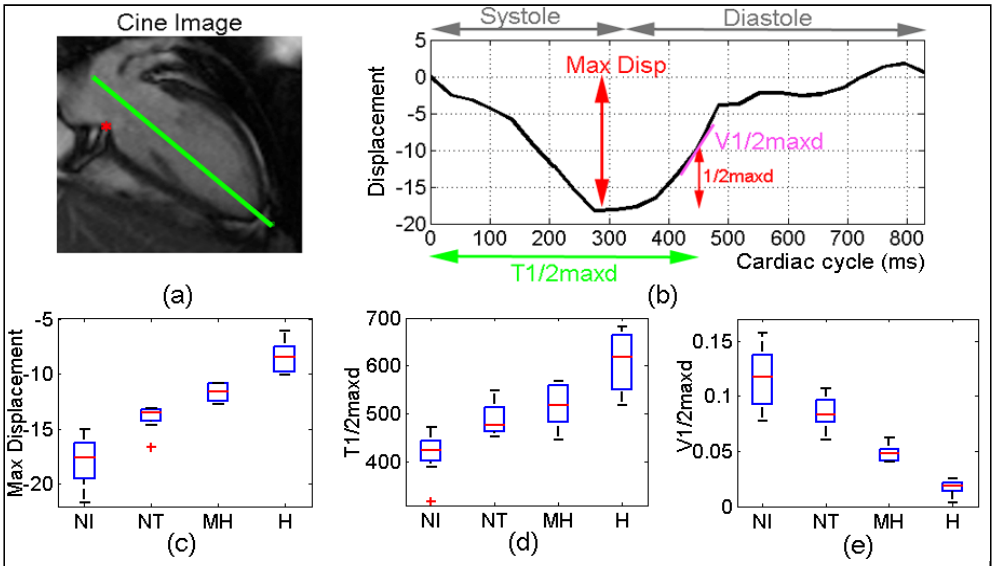

Figure 1. (a) Cine MR 2CH image, showing a reference line and an AVJ. (b) AVJ displacement in cardiac cycle, showing the three measured parameters. (c) Maximum displacement. (d) Cardiac cycle time at half maximum diastolic displacement. (e) Velocity at half maximum diastolic displacement.

Discussion: Cine MRI has emerged to be a valuable imaging modality to evaluate cardiac function, as it provides high-quality morphological images of the heart throughout the cardiac cycle, with excellent spatial, contrast and temporal resolution. This study shows a simple, novel and efficient method to assess cardiac function, especially, for diastolic dysfunction.using conventional cine MRI. We have found that the measurements of the AVJ displacement and the associated rate of LV relaxation during diastole show a strong relation with LV wall hypertrophy, which is known to be associated with the development of early stages of heart failure. Thus, it can provide a simple and potentially valuable noninvasive method to assess LV diastolic dysfunction when systolic function is not impaired (normal or near normal EF); further studies to assess the additional diagnostic and prognostic information seem warranted.

References:
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