A preliminary assessment of diastolic dysfunction with normal ejection fraction with cine MRI of the atrioventricular junction motion

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Introduction: While systolic cardiac function is commonly assessed with the simple global measure of ejection fraction (EF), many patients with clinical symptoms of heart failure have normal or close-to-normal EF, indicating that they are primarily suffering from diastolic dysfunction [1]. Diastolic dysfunction is primarily associated with abnormalities of active relaxation, which primarily affects early diastole, and passive stiffness of the left ventricle (LV), which is commonly related to tissue fibrosis [2] and which affects all of diastole. In this study, the motion of the atrioventricular junction (AVJ) was measured by using the conventional cardiac cine MRI to assess abnormalities in motion of the LV during different phases of diastole. We performed a retrospective study of 11 patients and compared them with two control groups; 13 healthy young subjects and 5 healthy older subjects.

Methods: From routine clinical CMR studies (including long axis (LA) cine images) previously performed at NYU Langone Medical Center (1.5T Avanto, Siemens), we found 11 patients (71 ± 16 years old) with clinical symptoms of HF, EF > 50%, and a LV end diastolic volume index < 97 mL/m^2 [3]. For comparison, 13 healthy young subjects (28 ± 4 years old) and 5 healthy older subjects (53 ± 8 years old) were scanned at 3T (Tim Trio, Siemens) to obtain cardiac cine MR images, including 2- and 3-chamber (CH) LA views. Conventional cardiac cine imaging was performed with electrocardiogram (ECG) gating and with the following parameters: TR = 2.4 ms, TE = 1.4 ms, flip angle = 51°, slice thickness = 6 mm, spatial resolution = 1.6 x 1.6 mm^2, and temporal resolution ~ 45 ms. For image analysis, the AVJ position was manually tracked in all images and projected onto a reference line drawn from the apex to the middle of the base (Fig. 1a). The displacement
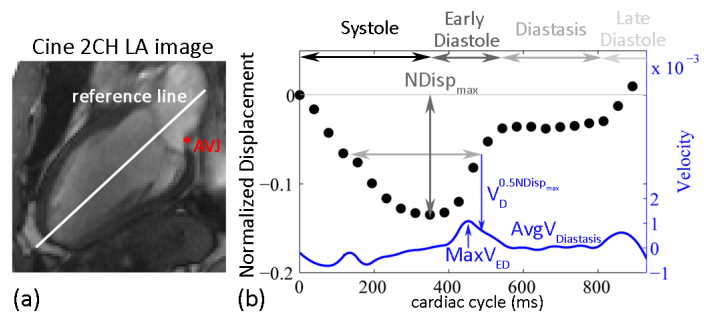

Fig. 1 (a) Cine 2CH LA image with a reference line and a AVJ point (b) Normalized displacement and corresponding velocity curves indicating five measured values.

relative to a reference point taken at end-diastole was calculated during the cardiac cycle. Four parameters were selected for the analysis (Fig. 1b): (a) maximum displacement normalized by the LV length ($\mathrm{NDisp_{max}}$), (b) velocity at half-maximal normalized displacement during diastole ($V_D^{0.5\mathrm{NDisp_{max}}}$), (c) difference between maximum velocity during early diastole and average velocity in diastasis ($\mathrm{MaxV_{ED}} - \mathrm{AvgV_{Diastasis}}$), and (d) $\mathrm{AvgV_{Diastasis}}/\mathrm{MaxV_{ED}}$.

Results: As shown in Fig. 1b, in healthy subjects, relatively high $\mathrm{MaxV_{ED}}$ is observed, but this is appreciably less in the patients, reflecting a prolonged relaxation. In addition, $\mathrm{AvgV_{diastasis}}$ is higher in patients compared to the healthy subjects, so that $\mathrm{MaxV_{ED}} - \mathrm{AvgV_{Diastasis}}$ is decreased in patients. Fig. 2 shows the boxplots of four parameters and the corresponding means ± standard deviation for young healthy, older healthy, and patient subjects are (a) -0.17±0.02, -0.15±0.01, -0.1±0.04, (b) 1.3E-3±0.4E-3, 0.9E-3±0.3E-3, 0.5E-3±0.4E-3, (c) 13.4E-4±4.5E-4, 9.2E-4±1.1E-4, 3.8E-4±3.7E-4, (d) 3.3E-2±4.1E-2, 3.0E-2±2.1E-2, 34.6E-2±25.0E-2, (e) -0.17±0.02, -0.15±0.03, -0.10±0.05, (f) 1.4E-3±0.5E-3, 1.1E-3±0.3E-3, 0.4E-3±0.3E-3, (g) 13.7E-4±3.7E-4, 9.7E-4±3.3E-4, 2.5E-4±1.6E-4, and (h) 1.6E-2±2.7E-2, 2.9E-2±4.2E-2, 42.2E-2±22.4E-2, respectively. Significant differences were found in these four parameters between young/older healthy subjects and patient subjects (p < 0.05).

Discussion: This study describes a simple and potentially valuable noninvasive approach for assessing LV diastolic dysfunction with normal EF, using cardiac cine MRI to measure the motion of the AVJ location during the cardiac cycle. Since this method can be implemented on any conventional MRI system, using routinely acquired images, it has the potential to improve our understanding of diastolic dysfunction and to assist in patient care.
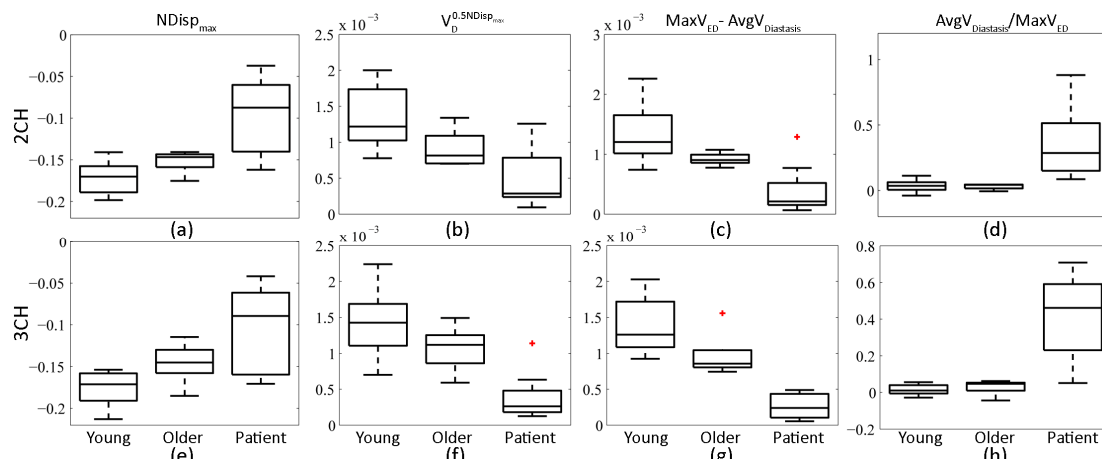
Reference:
[1] Aurigemma GP and Gaasch WH. N Engl J Med 2004, 351:1097-1105.
[2] Zile MR, et al. N Engl J Med 2004, 350:1953-1959.
[3] Paulus WJ, et al. Eur Heart J 2007, 28:2539-2550.

Fig. 2 Boxplots of: (a, e) $\mathrm{NDisp_{max}}$, (b, f) $V_D^{0.5\mathrm{NDisp_{max}}}$, (c, g) $\mathrm{MaxV_{ED}} - \mathrm{AvgV_{Diastasis}}$ and (d, h) $\mathrm{AvgV_{Diastasis}}/\mathrm{MaxV_{ED}}$; (a-d) 2CH and (e-h) 3CH; from left to right, young healthy, older healthy and patient subjects; p < 0.05.