Evaluation of diastolic function with flow quantification phase contrast cardiac magnetic resonance imaging

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Background: Cardiac magnetic resonance imaging (CMR) is considered the reference standard for the assessment of infiltrative heart disease. Although well established for quantifying systolic function, CMR is not currently an established modality to assess diastolic function. At our institution, patients with risk factors for infiltrative heart disease or those who present with heart failure with a preserved ejection fraction (HFpEF) are referred to CMR for evaluation with delayed-enhanced (DE) sequences. Left ventricular (LV) phase-contrast flow information combined with DE CMR may enable simultaneous assessment of diastolic function in this at-risk group, and permit assessment of treatment efficacy at follow-up.

Purpose: To evaluate the ability of mitral valve phase contrast flow sequences to diagnose diastolic dysfunction using Doppler echocardiography as the reference standard.

Materials and Methods: A retrospective analysis of 36 consecutive patients and 4 normal volunteers in whom CMR with flow quantification phase-contrast imaging of the mitral valve (MV) was performed at 1.5 T. Three patients with moderate to severe mitral regurgitation and one patient without a recent echocardiogram correlate were excluded; all other patients were included in the analysis. The patient study population consisted of 13 males (11 females) with a mean age 55.4 ± 16.6 years referred to CMR with suspected infiltrative heart disease (22 pts) or HFpEF (10 pts). All patients underwent CMR at 1.5T with through-plane phase-contrast imaging through the MV (ECG triggered, matrix 256 x 174, TR = 25 msec, TE = 3 msec, 3 averages, FA 25 degrees, slice thickness 6 mm, 20 cardiac phases, parallel factor of 2). The velocity-encoding gradient employed for phase contrast imaging averaged 110 cm/sec (range 70 to 200 cm/sec).

Results: All four volunteers and fourteen patients demonstrated normal mitral valve phase-contrast curves for peak velocity (Figure 1), average velocity, and diastolic filling. The twelve patients demonstrated normal E:a ratios at Doppler echocardiography. Five of these patients also had Doppler E/E' values of greater than 15, suggestive of grade II diastolic dysfunction (Figure 2). There was no statistically significant difference in phase-contrast peak E:A velocity ratio in patients with normal diastolic function or grade II dysfunction at echocardiography, averaging 1.64 (range 1.24 - 2.63) and 1.46 (range 1.02 - 1.97) respectively. There was a non-statistically significant trend towards shorter E wave deceleration in patients with grade II dysfunction compared to normal subjects, averaging 146 (95% conf int. 98.0 - 194.9) and 227 (95% conf int. 130.2 - 323.3) msec respectively ($p = 0.12$). CMR E-E' ratios in the subgroup with grade II dysfunction using E' values at the lateral mitral annulus averaged 6.11 (range 1.4 - 13.7), within the normal range of reported values at echocardiography**.** The remaining eleven patients demonstrated E:A reversal with an average peak E:A ratio of 0.70 (range 0.37 - 0.88), suggestive of grade I diastolic dysfunction (Figure 3); all 11 patients also had E:A reversal at echocardiography. The remaining seven patients had indeterminate findings at echocardiography; analysis at CMR suggested normal diastolic function and grade I dysfunction in one patient each, grade II dysfunction in 3 patients and grade III-IV dysfunction in 1 patient.

Conclusion: CMR with phase-contrast imaging correctly classifies patients with grade I diastolic dysfunction. E wave deceleration and E-E' ratios determined by phase-contrast CMR were unable to differentiate patients with normal diastolic function from grade II dysfunction. Higher temporal resolution phase contrast sequences are currently under investigation and may be useful in differentiation normal diastolic function from pseudonormalized E-a curves in grade II dysfunction. Assessment of grade III and IV diastolic dysfunction at phase-contrast CMR is the subject of ongoing investigation.

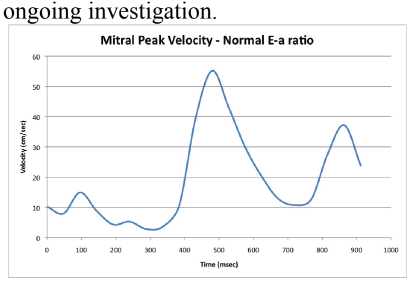

Figure 1: Normal peak velocity MV curves at CMR in a 27 year-old healthy volunteer. The peak E-A ratio is 1.42.

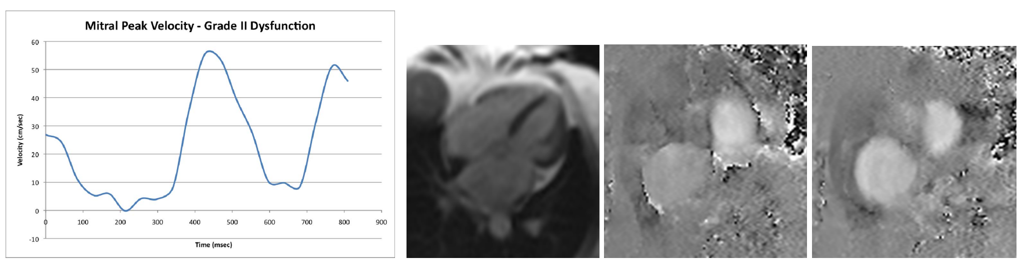

Figure 2: Pseudonormalized peak velocity MV curves and an image from a 4 chamber cine SSFP sequence in an 87 year-old female with HFpEF and Grade II diastolic Dysfunction. From left to right: Peak velocity MV curve over the cardiac cycle, 4 chamber cine SSFP, and phase-contrast imaging during the E- and A-waves. Brighter signal indicates higher through-plane velocities.

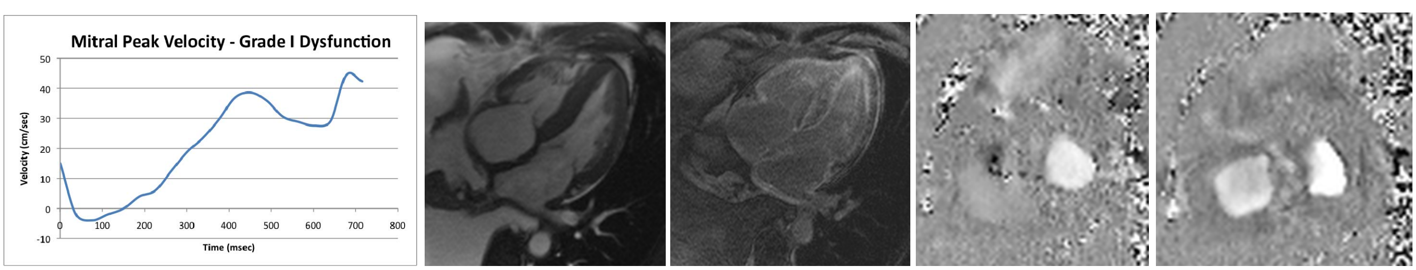

Figure 3: Peak velocity E-a reversal in a 55 year-old male with amyloidosis and grade I diastolic dysfunction at echocardiography. From left to right: Peak velocity MV curve, 4 chamber cine SSFP and delayed-enhancement imaging, and phase-contrast imaging during the E-wave and A-wave. Brighter signal corresponds to greater through-plane velocities.