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Quantification of myocardial stiffness in heart failure with preserved ejection fraction porcine model using magnetic resonance elastography

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Background

Heart failure with preserved ejection fraction (HF*p*EF) is associated with a complex heterogeneous pathophysiology which is poorly understood thereby preventing appropriate diagnosis and prognosis[1]. However, it is known that most of the cardiovascular and non-cardiac abnormalities that induce HF*p*EF are eventually manifested as an increase in left ventricular (LV) myocardial stiffness (MS). Therefore, we hypothesize that quantifying MS will assist in timely diagnosis of HF*p*EF and reveal pathophysiological conditions that are specific to the prognosis of HF*p*EF. Recently, with the advent of cardiac magnetic resonance elastography (cMRE) it has been feasible to estimate the shear stiffness of myocardium noninvasively[2]. In this study, we use cMRE to estimate the change in LV MS across the cardiac cycle during disease progression in HF*p*EF induced pigs.

Methods

Renal wrapping surgery was performed in 5 pigs to induce HF*p*EF[3]. cMRE was performed at baseline (Bx, prior to surgery), month 1 (M1) and month 2 (M2) on a 1.5T MRI scanner (Avanto, Siemens Healthcare, Erlangen, Germany). cMRE imaging parameters includes: TR/TE = 12.5/9.71 ms; FOV = 384 × 384 mm^2; Resolution = 3 × 3 × 8 mm^3; Flip angle = 15°; GRAPPA = 2; Mechanical frequency = 80 Hz; Encoding frequency = 160 Hz; Phase offsets = 4. Images were masked to extract the LV and estimate cMRE-derived LV MS across the cardiac cycle using 3D local frequency estimation inversion algorithm at each time point. End- systolic (ES) and diastolic (ED) MS were correlated to the corresponding ES and ED pressures obtained using LV catheterization.

Results

Fig 1 demonstrates that cMRE-derived stiffness increases with disease progression from Bx to M1 to M2 throughout the cardiac cycle indicating that HF*p*EF causes an elevation in LV MS. Furthermore, ES MS is significantly higher (p-value < 0.001) than ED MS at all-time points. Fig 2 shows moderate correlation between ES and ED MS and corresponding pressure from LV catheterization with a R^2 value of 0.4.

Conclusions

Our result demonstrates that cMRE-derived MS increases with disease progression in HF*p*EF porcine

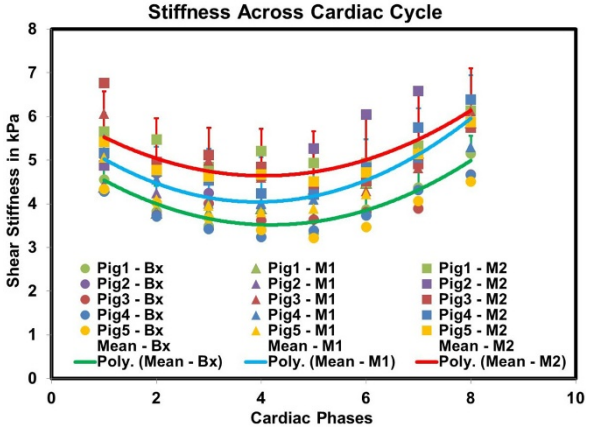

Figure 1 Plot of cMRE-derived MS across the cardiac cycle from all animals showing that mean MS at M2 (red line) increased from M1 (blue line) which increased compared to Bx (green line). ED occurred between 4 and 5 while ES occurred between 8 and 1.

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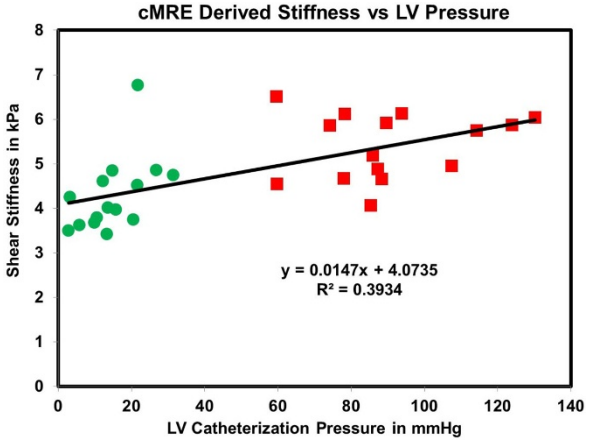

Figure 2 Graph shows correlation between cMRE-derived ES and ED MS vs catheter-based ES and ED LV pressure.

model thereby indicating the scope of using cMRE as a diagnostic tool to diagnose HF*p*EF condition.

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