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MR cine DENSE imaging demonstrates more effective identification of dyssynchrony in heart failure with circumferential and longitudinal strain versus radial strain

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Introduction

Better imaging methods are needed to identify optimal cardiac resynchronization therapy (CRT) candidates. High-resolution magnetic resonance (MR) cine DENSE (displacement encoding with stimulated echoes) provides accurate assessment of cardiac strain, but prior experience with this technique has been based largely on circumferential and radial rather than longitudinal strain. Based on a recent multicenter echocardiography study, the role of longitudinal dyssynchrony measurements in heart failure is unclear.

Purpose

We now report our findings regarding the use of circumferential, longitudinal, and radial strain for the assessment of dyssynchrony in heart failure. Specifically, we tested the hypothesis that DENSE-based circumferential strain (E_{cc}) distinguishes pacing-induced heart failure (HF) with and without left bundle branch block (LBBB-HF, NQRS-HF) more effectively than both radial strain (E_{rr}) and longitudinal strain (E_{ll}).

Methods

Cine DENSE MR (1.5 T Siemens Avanto) was performed in n = 10 dogs: 5 LBBB-HF (with LBB ablation) and 5 NQRS-HF dogs, with HF induced by 5 weeks of rapid atrial pacing. Based on multiple DENSE short axis slices, we measured maximal timing delays to peak circumferential and radial strain, and the circumferential and radial dyssynchrony metrics CURE and RURE (measuring multislice, 24-segment myocardial stretch/contraction over the cardiac cycle; scale 0 to 1; 1 = synchrony). Based on the three long axis DENSE slices, we determined longitudinal strain in 6 basal and 6 mid segments to calculate the SD12 (standard deviation in time to peak strain in 12 segments), as used in tissue Doppler echocardiography.

Results

LBBB-HF dogs had a wider QRS (120 ms v. 60 ms; p = 0.02) but similar left ventricular ejection fraction (0.14 v. 0.20; p = 0.14) compared to NQRS-HF dogs. Both CURE (0.36 v. 0.98; p < 0.001) and regional circumferential timing delays (median 281 ms v. 105 ms; p = 0.01) effectively discriminated between LBBB-HF and NQRS-HF, while radial timing delays and E_{rr}-based RURE were only marginally different in LBBB-HF v. NQRS-HF dogs (p = NS). The SD12 (longitudinal strain) more effectively discriminated between LBBB-HF and NQRS-HF than radial strain (p < 0.01), but the interquartile range for circumferential dyssynchrony in NQRS-HF was tighter than that for longitudinal dyssynchrony. See figure 1.

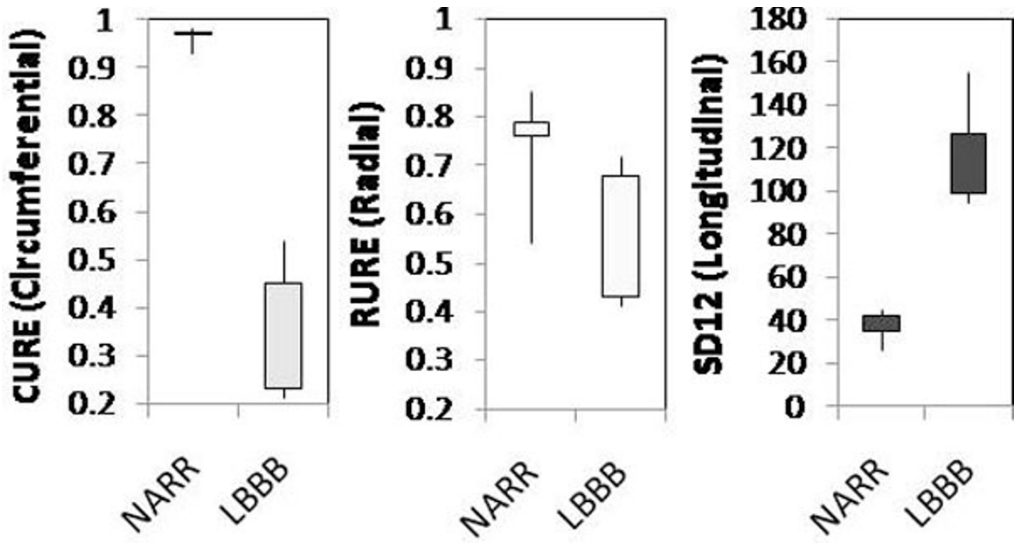

Figure 1

Conclusion

MR cine DENSE assessment of dyssynchrony using strain in any of three directions (circumferential, longitudinal, and radial) is feasible. DENSE-based measures of circumferential dyssynchrony best distinguished between HF with and without LBBB, while longitudinal dyssynchrony appeared more effective than radial dyssynchrony for this purpose. Further MR-based evaluation of circumferential, longitudinal, and radial dyssynchrony in CRT candidates is warranted.

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