Mechanical asynchrony or myocardial shortening as MRI predictors of response to biventricular pacing. Which is best?

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Background: Regional mechanical function has better predictive value than global function and electrical asynchrony, regarding the prediction of response to cardiac resynchronization therapy (CRT).

Purpose: To investigate whether this regional function should be characterized by asynchrony measures (e.g. regional differences in onset time of shortening), or by instantaneous measures (differences in strain at a particular time, e.g. regional differences in end-systolic (ES) shortening).

Methods: Baseline mechanical function was studied with MRI tagging in 12 patients with chronic heart failure. Six patients had ischaemic myocardial disease, and six non-ischaemic disease. Myocardial CSPAMM tagging was performed with a Steady State Free Precession sequence, on a Siemens 1.5T 'Sonata' whole body system. Using high temporal resolution (tr=14 ms) tagging (figs 1 and 2), two mechanical asynchrony measures were defined: the standard deviation (SD) in onset time of circumferential shortening (T_{onset}), and the SD in time to first peak of shortening ($T_{peak,first}$). Further, three instantaneous measures were defined: the coefficient of variation (CV) in ES strain, the peak shortening reserve (i.e. potential increase in shortening if all regional peaks would occur simultaneously), and the septal strain at ES. Finally, global function was determined from standard cines. Temporary biventricular stimulation was applied, and the relative increase in left ventricular dP/dt_{max} was used to measure the response.

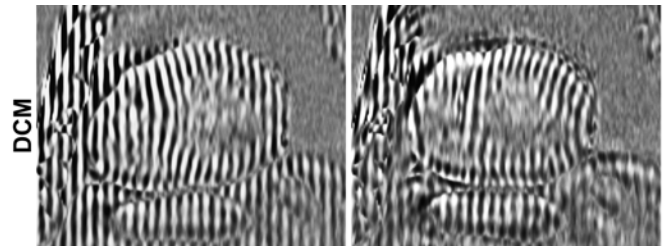

Fig 1. Short-axis tagging images for a patient with non-ischemic cardiomyopathy. Early shortening occurs in the septum (left image), while this shortening is not preserved at end-systole (right image). Instead, the septum shows stretching at end-systole.

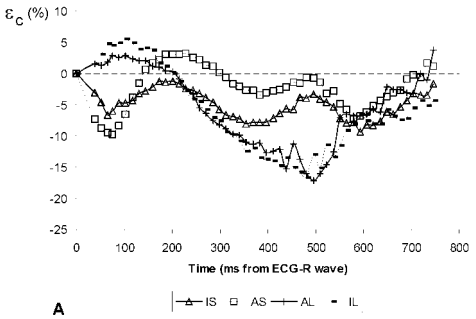

Fig 2. Strain curves for a patient with dilated cardiomyopathy. Circumferential strain is plotted over time, for 4 segments of a mid ventricular slice. The anterior and inferior segments are left out for clarity. Note the early shortening in the septal regions (IS=InferoSeptal, AS=AnteroSeptal) with concomitant prestretch in the lateral regions (AL= AnteroLateral, IL=InferoLateral).

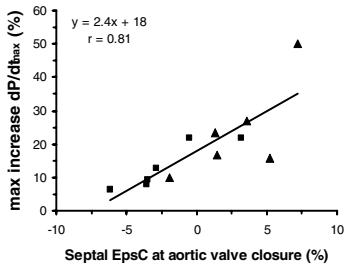

Fig 3. The response to biventricular pacing versus septal circumferential strain (EpsC) at the moment of aortic valve closure (end-systole). Triangles: 6 non-ischemic patients, squares: 6 ischemic patients. Positive circumferential strain means stretching, instead of shortening. The more stretching of the septum at end-systole, the more increase of dP/dt_{max} in response to pacing.

Results: Of the asynchrony measures, only the electrical asynchrony (QRS width) correlated significantly with the acute response: $r = 0.65$, $P < 0.05$, but mechanical asynchrony did not: $r = 0.22$, $P = 0.50$ for SD(T_{onset}) and $r = 0.46$, $P = 0.16$ for SD($T_{peak,first}$). In contrast, all instantaneous measures performed well: $r = 0.78$, $P < 0.01$ for CV, $r = 0.72$, $P < 0.01$ for peak shortening reserve, and $r = 0.81$, $P = 0.001$ for ES septal strain (fig 3). Global function measures correlated poorly ($r < 0.17$) except for the duration of isovolumic contraction: $r = 0.81$, $P = 0.001$.

Discussion: It appears that different hearts have different sensitivity to asynchronous activation. Thus not only the asynchrony, but also the regional systolic strain in reaction to asynchronous activation determines the pacing respons.

Conclusion: Instantaneous measures reflecting the regional non-uniformity in myocardial shortening perform much better in the prediction of response to CRT, than measures based on pure mechanical asynchrony.

References: Nelson GS, Curry CW, Wyman BT et al. Circulation 101: 2703-2709, 2000.
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