Quantitative analysis of dyssynchrony using cardiovascular magnetic resonance tagging imaging in idiopathic dilated cardiomyopathy

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Introduction: Conventionally, the analysis of left ventricular (LV) function is based on tracing the contour on cine images, and this provides information such as wall motion and wall thickening. On the other hand, tagging imaging on CMR evaluates the dynamic deformation of lines or grids superimposed on the myocardium during the cardiac cycle. Radial, circumferential, and longitudinal movement of the myocardium, as well as torsion and rotation of the heart, can be evaluated qualitatively and quantitatively from tagging imaging. Strain, which is expressed as the fractional change in length from the resting state to the contractile state, can also be measured[1]. Zerhouni et al.[2] first introduced tagging imaging, and subsequent studies have reported its usefulness in myocardial diseases such as ischemic heart disease[3]. Strain is considered a sensitive indicator for the detection of a myocardial infarction and a predictor of myocardial viability.

Among this sensitivity and quantitative capability of tagging imaging for detecting the deformation of myocardium, we hypothesized that the tagging imaging can quantitatively detect the details of myocardial dysfunction as well as dyssynchrony in idiopathic dilated cardiomyopathy (DCM) patients. The purpose of this study was to evaluate the details of myocardial dysfunction in DCM patients using tagging images.

Materials and Methods: Between July 2012 and June 2013, circumferential strain (Ecc) derived from tagging images was measured in 15 normal (NML) subjects (15 males; mean age 28.5 years) and 12 DCM patients (7 males; mean age 48.9 years). We used a 1.5-T system for DCM patients and 3.0-T system for NML subjects to obtain tagging imaging, cine imaging (SSFP sequence) and T2 mapping (calculated from multi-TE FSE sequence). For tagging imaging, a total of 3 short-axis images, which are located at 25%, 50%, and 75% of the left ventricle, were obtained as well as 2- and 4-chamber long-axis images. The sequence was EPI sequence with SPAMM. The parameters were: FOV, 250mm; matrix, 176×176, TE, 4.0ms; TR, 17ms automatically determined by MR computer; FA, 13 degree; BW, 446Hz; Slice thickness, 7mm; Cardiac phase, 21 phases; Tag spacing, 6mm.

The following parameters were analyzed using the open software *inTag (www.creatis.insa-lyon.fr/inTag/)* and compared: 1) the magnitude of peak Ecc (Ecc*); 2) the coefficient of variation of the time giving Ecc* (CVtime*), which indexes dyssynchrony; and 3) descriptive findings of time-Ecc curves. We also evaluated correlations of Ecc* with ejection fraction (EF), myocardial T2 values, and late gadolinium enhancement (LGE) in DCM patients. Wilcoxon and Pearson tests were performed. Differences were considered significant at $P<0.05$.

Results: Mean Ecc*s in DCM patients and NML subjects were -12.7% and -23.5%, respectively ($P<0.0001$). Mean CVtime*s were 15.2% and 4.5%, respectively ($P=0.0002$). The findings of pre-systolic extension and systolic stretch in the septum were observed in 6 (50%) and 10 (83.3%) DCM patients, and in none of NML subjects. Ecc* correlated with EF ($R^2=0.90$, $P<0.0001$) and T2 values ($R^2=0.44$, $P=0.018$), but not with LGE.

Conclusion: Tagging images revealed the reduction of myocardial function, as well as dyssynchrony, in DCM patients. Tagging images have the potential to offer further understanding of the diseased myocardium in DCM patients.

	NML (n = 15)	DCM (n = 12)	P value
Ecc* (%)	-23.5 ± 1.0	-12.7 ± 1.2	<0.0001
CVtime* (%)	4.5 ± 1.4	15.2 ± 1.5	0.0002
Pre-systolic extension (n)	0	6 (50%)	0.0031
Systolic stretch (n)	0	10 (83.3%)	<0.0001
Mean T2 value (ms)	NA	64.5 ± 7.0	
LGE (%)	NA	9.0 ± 13.3	

Table 1. The results of cardiovascular magnetic resonance imaging .

Ecc*, peak circumferential strain; CVtime*, coefficient of variation for the time giving peak circumferential strain among the myocardial segments; LGE, late gadolinium enhancement; NA, not assessable.

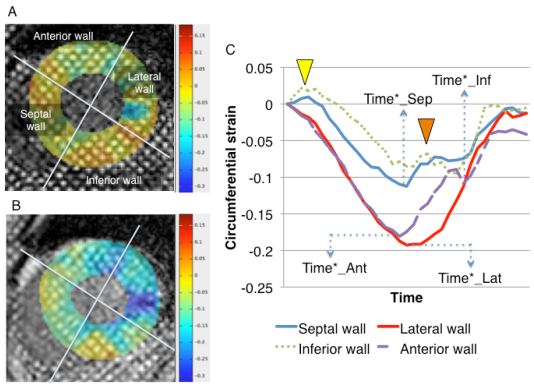

Figure 1. Circumfrectial stran maps and time-strain curves of a DCM patient.

Circumfrectial stran map of pre-systolic (Fig. 1a) and sytolic phase (Fig. 1b). From the calucrated map, each circumferential strain are plotted against time in the septal (blue line), lateral (red line), inferior (green dot line), and anterior (purple dashed line) walls (Fig. 1b). The yellow arrowhead shows pre-systolic extension and the orange arrowhead shows systolic stretching. The time point (Time*) giving Ecc* in each segment was indicated and calculated CVtime*. (CVtime* = SD of Time*s/mean of Time*s).

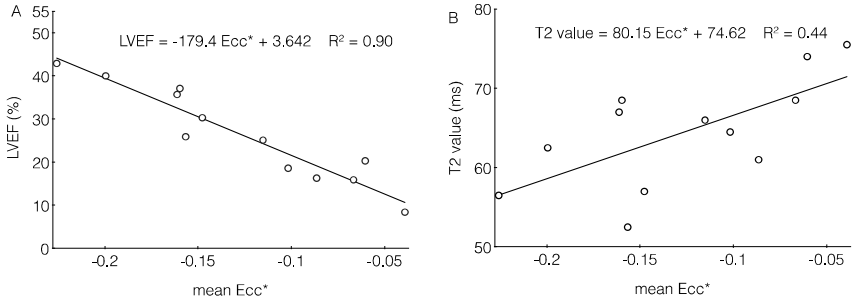

Figure 2. Scattergrams of the correlation of Ecc* with the LVEF and mean T2 value in DCM patients.

Ecc* correlated well with LVEF (Fig. 2a; $R^2=0.90$, $P<0.001$), and moderately with mean T2 value (Fig. 2b; $R^2=0.44$, $P=0.018$).

References:

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