

Evaluation of cardiac mechanical dyssynchrony with longitudinal strain analysis in 4-chamber cine magnetic resonance imaging

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Introduction: Cardiac resynchronization therapy (CRT) is an effective treatment for heart failure patients with mechanical dyssynchrony¹. In order to predict response to CRT, a longitudinal strain analysis with tissue Doppler echocardiography is used in the evaluation of mechanical dyssynchrony². Although analysis with echocardiography is restricted due to the narrow field of view (FOV), four-chamber (4CH) cine magnetic resonance imaging (MRI) has no restrictions due to the FOV and thus should allow a more precise evaluation of cardiac dyssynchrony. The longitudinal strain analysis using MRI has not been fully investigated in terms of cardiac dyssynchrony³. The purpose of this study was to propose a method for evaluating mechanical dyssynchrony by using longitudinal strain analysis in 4CH cine MRI.

Methods: In 73 patients with chronic heart failure (CHF) [New York Heart Association functional class II, III, IV, 41 males and 32 females, 57 ± 15 years-old (mean \pm SD)], cardiac MRI (Achieva 3.0T TX, PHILIPS, 32-channel phased array coil) incorporating cine and late gadolinium enhancement (LGE) was performed. On 4CH view cine imaging, the longitudinal length of biventricular free-walls and ventricular septum were measured at 20 time points through the entire cardiac cycle (Fig.1A). The timing of end-systole was defined as time reaching a minimum value of longitudinal length for biventricular free-walls and ventricular septum. Left ventricular dyssynchrony (LVD) index (ms) was defined as a difference between end-systolic time for left ventricular free-wall and ventricular septum. Inter-ventricular dyssynchrony (IVD) index was defined as a difference between end-systolic time for biventricular free-walls (Fig.1B). LVD and IVD indices between the patients with indication for CRT (QRS \geq 120ms, left ventricular ejection fraction \leq 35%) ($n = 16$) and without ($n = 57$), and between the patients with LGE ($n = 40$) and without ($n = 27$) were compared by Wilcoxon rank-sum test.

Results: LVD index was significantly longer for the patients with indication for CRT than those without (93.2 ± 62.3 ms vs. 30.4 ± 41.6 ms, $P < 0.00001$) (Table 1). There was no difference in IVD between the two groups. LVD and IVD indices were significantly longer for the patients with LGE than those without (LVD: 51.9 ± 59.0 ms vs. 24.2 ± 30.7 ms, $P < 0.05$ and IVD: 45.8 ± 39.7 ms vs. 29.5 ± 38.1 ms, $P < 0.05$) (Table 2).

Table 1. Comparison of ventricular dyssynchrony indices between the patients with and without indication for CRT

Dyssynchrony indices	Indication for CRT ($n = 16$)	Non-indication for CRT ($n = 57$)	P
LVD (ms)	93.2 ± 62.3	30.4 ± 41.6	<0.00001
IVD (ms)	54.9 ± 59.8	27.3 ± 36.0	NS

LVD: left ventricular dyssynchrony
IVD: inter-ventricular dyssynchrony

Table 2. Comparison of ventricular dyssynchrony indices between the patients with and without LGE

Dyssynchrony indices	with LGE ($n = 40$)	without LGE ($n = 27$)	P
LVD (ms)	51.9 ± 59.0	24.2 ± 30.7	<0.05
IVD (ms)	45.8 ± 39.7	29.5 ± 38.1	<0.05

LVD: left ventricular dyssynchrony
IVD: inter-ventricular dyssynchrony

Conclusions: We propose a new analytic technique using a longitudinal strain curve in 4CH cine MRI, for evaluating cardiac mechanical dyssynchrony. Our results suggest that the LVD index is a candidate index to select CHF patients with indication for CRT, and that cardiac dyssynchrony is more advanced in CHF patients with myocardial scar.

Reference: 1) Abraham WT, et al., N Engl J Med 2002; 346: 1845-53. 2) Jeroen J. Bax, et al., J. Am. Coll. Cardiol. 2004; 44: 1-9. 3) Albert C. Lardo, et al., J. Am. Coll. Cardiol. 2005; 46: 2223-8.