

# 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 dyssynchrony<sup>1</sup>. In order to predict response to CRT, a longitudinal strain analysis with tissue Doppler echocardiography is used in the evaluation of mechanical dyssynchrony<sup>2</sup>. 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 dyssynchrony<sup>3</sup>. 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 ± 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 ≥120ms, left ventricular ejection fraction ≤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).

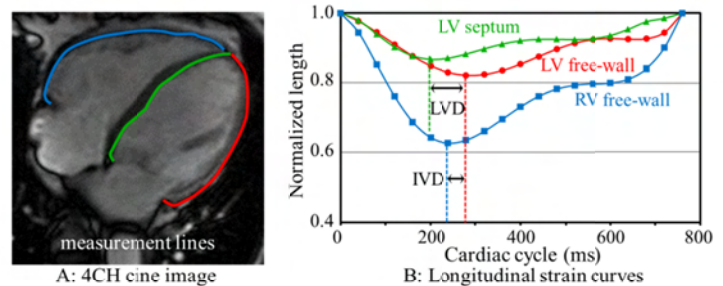


Fig. 1

A: The longitudinal lengths of the left ventricular free-wall (red), the ventricular septum (green), and the right ventricular free-wall (blue) were measured on the 4CH cine imaging system.

B: The longitudinal strain curves were obtained from the lengths at 20 images during a cardiac cycle. The time at the shortest length on the curve was defined as contractile timing for each segment. The differences in the time between the LV septum and LV free-wall and between the LV and RV free-wall were defined as dyssynchrony indices.

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.