Clinical Impact of Left ventricular Eccentricity Index Using Cardiac Cine MRI for Assessment of Right Ventricular Hemodynamics in Adult Congenital Heart Disease

Yuzo Yamasaki[1], Michinobu Nagao[2], Masato Yonezawa[1], Satoshi Kawanami[2], Takeshi Kamitani[1], Torahiko Yamanouchi[1], Kenichiro Yamamura[3], Ichiro Sakamoto[4], Hidetake Yabuuchi[5], and Hiroshi Honda[1]

[1]Clinical Radiology, Kyushu University, Fukuoka, Fukuoka, Japan, [2]Molecular Imaging & Diagnosis, Kyushu University, Fukuoka, Fukuoka, Japan, [3]Pediatrics, Kyushu University, Fukuoka, Fukuoka, Japan, [4]Cardiovascular Medicine, Kyushu University, Fukuoka, Fukuoka, Japan, [5]Health Sciences, Kyushu University, Fukuoka, Fukuoka, Japan

Target audience: Researchers and clinicians interested in cardiac imaging, particularly with regard to congenital heart disease.

Purpose: In patients with congenital heart disease (CHD), right-sided heart failure secondary to chronic overload remains a major problem in the long-term follow-up, leading to impairment of functional status, severe arrhythmia, and premature death. The interventricular septal curvature is the hemodynamic marker of right ventricular overload. One of the simplest measures of septal curvature is the left ventricular eccentricity index (EI) that is calculated as the ratio of left ventricular diameter parallel to the septum to the diameter perpendicular to the septum [1, 2]. The relative value of EI with regards to other indices of right ventricular (RV) volume and pressure remains poorly known in CHD. RV late gadolinium enhancement (LGE), suggesting the presence of myocardial fibrosis are frequently seen in patients with CHD and RV loading conditions [3]. Therefore, the aim of this study was to clarify the relative value of EI with regards to RV volumetric indices and LGE using cardiac MRI, and pressure indices derived from right heart catheterization (RHC).

Methods: *Subjects:* Consecutive 55 patients with CHD (female, 32; mean age, 40.7 ± 20.9) (atrial septal defect, n=29; corrected Tetralogy of Fallot, n=20; partial anomalous pulmonary venous return, n=4; corrected truncus arteriosus, n=2) who had a complete cardiac MRI study and varying degrees of mean pulmonary artery pressures (PAP) (mean 21.5 ± 14.3 mmHg, range 6 to 79 mmHg) confirmed by RHC were enrolled.

MRI: All patients underwent 3 Tesla MR imaging (Achieva 3.0 T Quarsar Dual; Philips Healthcare, Best, The Netherlands) equipped with dual-source parallel radiofrequency transmission, 32-element cardiac phased-array coils used for radiofrequency reception and a 4-lead vectorcardiogram used for cardiac gating. Cine-balanced turbo field-echo sequences in axial view images and short axis view images acquired in parallel to the atrioventricular groove from the base to apex were performed. LGE images were obtained with an inversion-recovery T1 turbo field-echo sequence (fast gradient-echo pulse sequence) performed 10 minutes after contrast injection and acquired in the same orientation as the short axis cine images. The inversion time was adjusted to a completely null normal myocardium.

Eccentricity index: Eccentricity index (EI) was defined as the ratio of the distance between the septal-lateral wall (D1) and the anterior-posterior wall (D2) measured in the short-axis view at the mid-ventricular level of breath-hold cine MRI at end-systolic and end-diastolic phases (Figure 1).

The relationship between the EIs and volumetric and hemodynamic parameters; RV end-diastolic volume (EDV), RV end-systolic volume (ESV), RV ejection fraction (EF), LGE, RV systolic pressure (SP), RV diastolic pressure (DP), mean PAP was investigated.

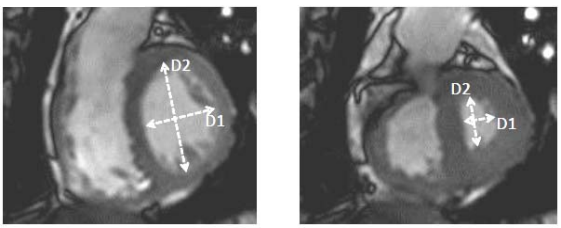
Results: The correlations between EIs and functional or hemodynamic variables are seen in Table 1, 2. A negative correlation between diastolic EI and RVEF (r=−0.62, p<0.0001), and a strong correlation between mean PAP and systolic EI (r=0.81, p<0.0001) was noted. LGE was seen at RV wall or RV insertion sites of septum in 27 patients of 41 patients. Both systolic and diastolic EIs were significantly higher in patients with LGE compared to without LGE (Figure 2).

Discussion: Nowadays, cardiac MRI become popular to evaluate right-sided heart disease, because it can measure RV volume and EF accurately and non-invasively, even in CHD patients [4, 5]. However, as compared to LV, RV volumetry is time-consuming and requires dedicated post-processing software. In addition, pressure measurement by right heart catheterization is invasive method. A reliable, non-invasive and easily measurable method of assessing the adaptive and maladaptive cardiac changes occurred in patients will be of great clinical importance in the management of CHD. Our results suggest that the EIs could substitute for RVEF and mean PAP easily and non-invasively, and predict pulmonary hypertension and RV systolic dysfunction. LV deformation expressed as a high EI is related to the presence of LGE, suggesting the progress of myocardial fibrosis in RV wall.

Conclusion: Significant correlations between EIs and right heart hemodynamic parameters were seen in patients with CHD. EI is a simple and valuable parameter to predict RV systolic function and pulmonary artery pressure in CHD. LV deformation demonstrated by high EI might be related to the presence of myocardial fibrosis in RV wall.

References: 1. Ryan T et al. JACC(1985), 2. Mendez C et al. Insights imaging(2011), 3. Lopa PH et al. Congenit Heart Dis(2006), 4. Yamasaki Y, et al. Eur Radiol(2014), 5. Mooij CF et al. JMRI(2008).

Figure 1



< Diastolic Eccentricity Index > < Systolic Eccentricity Index >

Figure 2

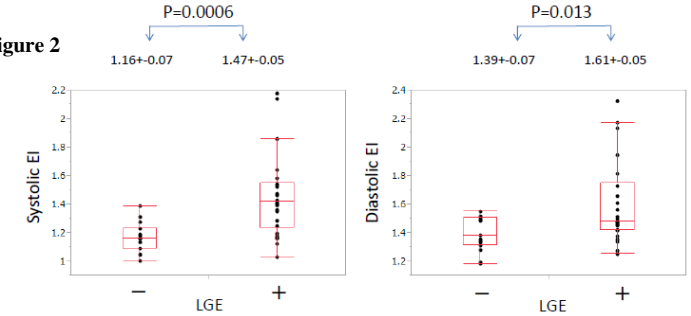


Table 1

	Systolic EI		Diastolic EI	
	r	p	r	p
RVEDV	N.S.		0.39	0.0045
RVESV	0.40	0.0029	0.58	< 0.0001
RVEF	- 0.52	< 0.0001	- 0.62	< 0.0001

Table 2

	Systolic EI		Diastolic EI	
	r	p	r	p
RVSP	0.73	< 0.0001	0.38	0.0049
RVDP	N.S.		N.S.	
Mean PAP	0.81	< 0.0001	0.51	< 0.0001