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USEFULNESS OF MITRAL ANNULAR SYSTOLIC VELOCITY IN THE DETECTION OF LEFT VENTRICULAR SYSTOLIC DYSFUNCTION: COMPARISON WITH THREE DIMENSIONAL ECHOCARDIOGRAPHIC DATA

YUN SEON PARK, ARDCS, JAE-HYEONG PARK, MD, PHD, KYE TAEK AHN, MD, WON IL JANG, MD, HYUNG SEO PARK, MD, JUN HYUNG KIM, MD, JAE-HWAN LEE, MD, PHD, SI WAN CHOI, MD, PHD, JIN-OK JEONG, MD, PHD AND IN-WHAN SEONG, MD, PHD

DIVISION OF CARDIOLOGY, DEPARTMENT OF INTERNAL MEDICINE, SCHOOL OF MEDICINE, CHUNGNAM NATIONAL UNIVERSITY, CHUNGNAM NATIONAL UNIVERSITY HOSPITAL, DAEJEON, KOREA

BACKGROUND: Although the modified Simpson's method is widely used for the assessment of left ventricular ejection fraction (LVEF), it has limitations including relatively high inter- and intra-observer variability and time consuming nature. We want to evaluate whether assessing mitral annular systolic velocity (S' velocity) by tissue Doppler imaging (TDI) can be used to evaluate LV systolic function with comparing LVEF by three dimensional echocardiography (3DE).

METHODS: We examined 3DE and TDI studies of patients between January and August 2008. 3DE LVEF was measured by offline commercial computer software EchoPac PC® (GE, Andover, MA, USA). S' velocity was obtained from the medial side with apical four chamber view by pulsed-wave Doppler with TDI.

RESULTS: We included 125 patients (78 males (62.4%), mean age: 57.5±13.0 years). The mean S' velocity was 7.7±1.9 cm/s and the mean LVEF was 57.2±10.4%. The S' velocity measured by TDI showed a linear correlation with LVEF measured by 3DE (r=0.688, $p<0.001$). Study patients were divided into two groups according to the presence of LV systolic dysfunction: Group I (normal LVEF), n=102 and Group II (LVEF <50%), n=23. For prediction of significant LV systolic dysfunction by the receiver operating characteristic curve according to S' velocity, the optimal cutoff value was 6.8 cm/s. At this cutoff value, the sensitivity and specificity were 94.1% and 87%, respectively.

CONCLUSION: In this study, S' velocity measured by TDI showed a significant correlation with three dimensional LVEF and can be used to detect patients with LV systolic dysfunction.

KEY WORDS: Left ventricular function · Mitral annulus systolic velocity · Tissue Doppler imaging · Three-dimensional echocardiography.

INTRODUCTION

Assessment of the left ventricular (LV) systolic function gives many important clues in the diagnosis and aids the determination of treatment option in many patients with various cardiovascular diseases. There are many parameters presenting LV systolic function including ejection fraction, fractional shortening, and myocardial performance indices.

Left ventricular ejection fraction (LVEF) is the fraction of blood pumped out of the LV with each heart beat. It can be measured by the invasive methods and noninvasive methods like gated blood fool heart scan, computerized tomography, cardiac magnetic resonance imaging (CMR) and echocar-

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• Address for Correspondence: Jae-Hyeong Park, Division of Cardiology, Department of Internal Medicine, School of Medicine, Chungnam National University, Chungnam National University Hospital, 33 Munhwa-ro, Jung-gu, Daejeon 301-721, Korea Tel: +82-42-280-7167, Fax: +82-42-280-8238, E-mail: jaehpark@cnuh.co.kr

diography.[1-3] Of them, echocardiography is the most commonly used method in the determining LVEF. We usually use modified Simpson's method in the estimation of LVEF. However, modified Simpson's method has some limitations. One of them is high inter- and intra-observer variability, and other is time consuming property. These prohibit their application in the mass screening.

In 1989, Isaaz et al.[4] introduced tissue Doppler imaging (TDI) method that can determine myocardial velocities. Mitral annular velocities can be obtained with TDI technique.[5)6)] These values can be estimated with ease and showed low inter- and intra-observer variability. Moreover, these cannot be influenced by volume status.

We sought to assess the usefulness of systolic mitral annular velocity (S' velocity) in the estimation of LV systolic function comparing with three dimensional echocardiographic (3DE) measurements.

Materials and Methods

From January to August 2008, consecutive patients with relatively good echocardiographic window were included in this study. Patients with significant valvular heart disease more than mild degree were excluded. We obtained 3DE data with using a 3V matrix array probe and stored to the digital media after routine two dimensional echocardiographic (2DE) measurements. Mitral annular velocity was estimated at the medial side of the mitral annulus with pulse wave Doppler after applying TDI. Three-dimensional LVEF was calculated with 4D LV volume measurement in an off-line commercial software EchoPac PC® (GE medical systems, Andover, MA, USA). We used Vivid 7 echocardiography machine (GE medical systems, Andover, MA, USA).

Statistical analysis

We used a commercial program, SPSS version 12.0 (SPSS Inc., Chicago, Illinois, USA), for statistical analysis. All continuous variables are expressed as mean ±SD and categorical variables are expressed as number and percentage. We compared the clinical characteristics of patients according to the presence of LV systolic dysfunction. Between two groups, comparisons of continuous variables were performed using the independent sample t-test. We used receiver operating characteristic (ROC) curve analysis for the determining the cutoff values in the detection of presence of LV systolic dysfunction. Intra-observer and inter-observer variability of 3DE LVEF and S' velocity were tested in 20 patients. Intra-observer and inter-observer variability were measured by the Bland-Altman method[7] and were expressed as the ratio of the SD of the difference between the two measurements divided by the mean value (percentage). A *p*-value less than 0.05 was assessed as statistically significant.

Results

We enrolled total 125 patients during the study period. Of them, 78 (62.4%) were male and their mean age was 57.5±13.0 years. The baseline characteristics were listed in Table 1. Most patients took the echocardiographic exam before taking coronary angiography and showed normal echocardiographic results. Of them, 20 patients (16%) showed regional wall motion abnormalities: 7 patients had left anterior descending coronary arterial territory, 5 had left circumflex coronary arterial territory, 3 had right coronary arterial territory and 5 had multivessel territories.

The S' velocity showed significant correlation with 2DE LVEF (r=0.738, $p<0.001$) and 3DE LVEF (r=0.688, $p<0.001$) (Fig. 1). Intra-observer and inter-observer variability of 3DE LVEF were 5.0% and 7.1%, respectively. Intra-observer and inter-observer variability of S' velocity were 3.1% and 5.2%, respectively.

Table 1. Baseline characteristics and echocardiographic data of the study patients

	n=125
Age (years)	57.5±13.0
Female gender	47 (37.6%)
Risk factors for atherosclerosis	
Hypertension	54 (43.2%)
Diabetes	24 (19.2%)
Dyslipidemia	29 (23.2%)
Current smoking	23 (18.4%)
Reasons for taking echocardiographic examination	
Before coronary angiography	53 (42.4%)
Routine examination	37 (29.6%)
Preoperative evaluation	35 (28.0%)
Two-dimensional echocardiographic data	
LVID systole/diastole (mm)	30.1±9.1/47.2±7.6
LV end-diastolic volume (mL)	90.5±46.7
LV end-systolic volume (mL)	41.5±34.8
LV ejection fraction (%)	57.6±10.8
RWMA	20 (16%)
Conventional Doppler data	
Mitral E velocity (cm/sec)	74.8±21.6
Mitral A velocity (cm/sec)	80.0±22.0
Deceleration time (ms)	241.5±66.8
Three-dimensional echocardiographic data	
LV end-diastolic volume (mL)	104.5±60.8
LV end-systolic volume (mL)	48.2±42.7
LV ejection fraction (%)	56.8±10.4
Tissue Doppler data	
S' velocity (cm/sec)	7.7±1.9
E' velocity (cm/sec)	7.6±2.7
A' velocity (cm/sec)	9.7±2.1

LVID: left ventricular internal dimension, LV: left ventricle, RWMA: regional wall motion abnormality, S' velocity: systolic velocity, E' velocity: early diastolic velocity, A' velocity: late diastolic velocity

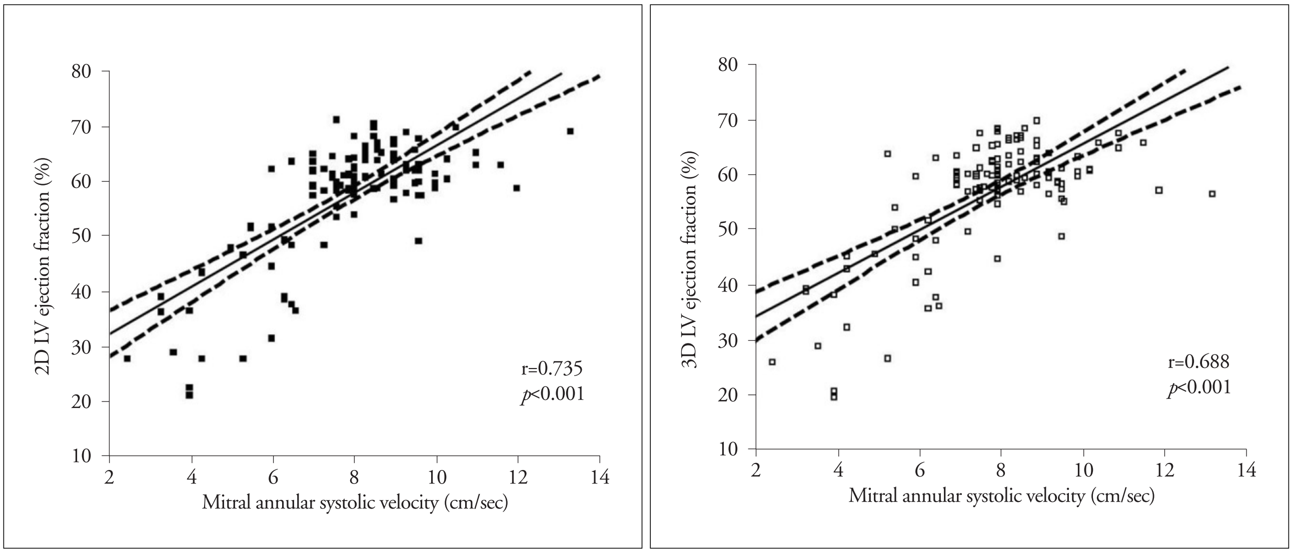

Fig. 1. Correlations between mitral systolic velocity and 2- and 3-dimensional left ventricular ejection fraction.

Table 2. Comparison of echocardiographic data according to the presence of left ventricular systolic dysfunction

	Group I (n=102)	Group II (n=23)	*p*-value
Two-dimensional echocardiographic data			
LVID-systole (mm)	27.0±4.1	44.2±11.8	<0.001
LVID-diastole (mm)	45.0±4.1	57.0±11.2	<0.001
LV end-diastolic volume (mL)	79.1±20.1	139.8±85.4	0.001
LV end-systolic volume (mL)	30.8±9.5	88.7±59.6	0.001
LV ejection fraction (%)	61.4±4.2	37.7±8.8	<0.001
Conventional Doppler data			
Mitral E velocity (cm/sec)	73.9±18.9	73.2±31.3	0.876
Mitral A velocity (cm/sec)	79.0±20.1	84.5±29.1	0.399
Deceleration time (ms)	245.0±63.6	226.1±78.8	0.221
Three-dimensional echocardiographic data			
LV end-diastolic volume (mL)	90.7±22.4	165.4±116.8	<0.001
LV end-systolic volume (mL)	35.6±9.9	103.7±76.1	0.006
LV ejection fraction (%)	60.8±4.5	39.0±10.6	<0.001
Tissue Doppler data			
S' velocity (cm/sec)	8.5±1.3	5.2±1.6	<0.001
E' velocity (cm/sec)	8.2±2.5	4.9±1.7	<0.001
A' velocity (cm/sec)	10.2±1.8	7.6±2.1	<0.001

LVID: left ventricular internal dimension, LV: left ventricle, S' velocity: systolic velocity, E' velocity: early diastolic velocity, A' velocity: late diastolic velocity

We divided the study patients into two groups according to the presence of LV systolic dysfunction (LVEF<50%). Of them, 102 showed normal LVEF (group I) and 23 showed decreased LVEF (group II). The differences between two groups were listed Table 2. In the group II, LV was more dilated, LVEF was significantly lower and their tissue Doppler velocities were lower than those in the group I.

ROC curve analysis was used to obtain the cutoff values with S' velocity in the detection of LV systolic dysfunction (Fig. 2). The S' velocity less than 6.8 cm/sec showed sensitivity, 94.1% and specificity, 87.0% in the detection of LV systolic dysfunction by 3DE. The S' velocity less than 6.8 cm/sec showed sensitivity, 95.1% and specificity, 91.3% in the detection of LV systolic dysfunction by 2DE.

Discussion

In this study, we demonstrated significant correlation with S' velocity and 3DE LVEF. In the detection of LV systolic dysfunction, S' velocity less than 6.8 cm/sec showed the best sensitivity and specificity.

The echocardiography gives many important data of structures and functions of heart noninvasively. The estimation of LV systolic function, usually with LVEF, is the most common indication of echocardiographic examination. Though there

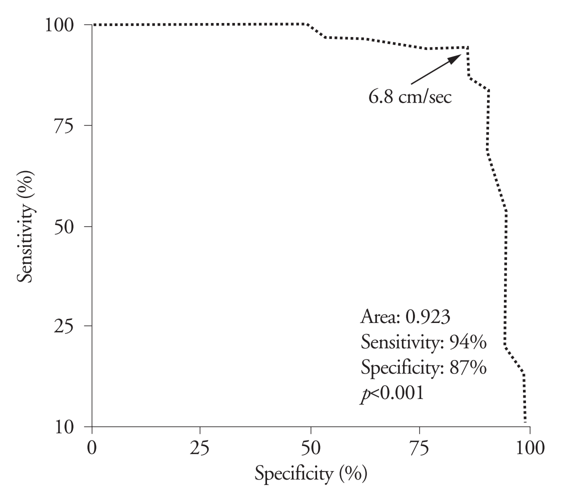

Fig. 2. Receiver operating characteristic (ROC) curve analysis in detecting left ventricular systolic dysfunction using S' velocity. S' velocity lower than 6.8 cm/sec has the best sensitivity and specificity in detection of left ventricular systolic dysfunction.

are many methods in the estimation of LVEF, modified Simpson's method is the most commonly used method to calculate LVEF.[8)9)] LV volumes using this method of discs makes significantly less geometric assumptions, especially when used in a biplane method. However, there is still the assumption that the ventricle can be represented by a series of stacked discs with varying diameters. In patients with regional wall motion abnormalities or LV aneurysms, this assumption may fail. Moreover, modified Simpson's method has relatively high intra- and inter-observer variability and time consuming procedure. Moreover, it cannot give reliable data in patients without good echocardiographic window.[10)]

The mitral annulus velocities can be calculated with pulsed wave Doppler in TDI.[4)] The movement of mitral annulus produces three distinct waves: systolic velocity (S' velocity) during systole and early diastolic velocity (E' velocity) and late diastolic velocity (A' velocity) during diastole. These velocities are measured with ease, less influenced by the loading condition of the LV and have low inter- and intra-observer variability. These have been used to assess diastolic function[5)11)] and systolic function.[12)] During the ventricular ejection period, longitudinal shortening of the LV can affect the movement of mitral annulus and produce S' velocity.

Significant correlations between mitral annular systolic velocity and LVEF (r=0.54-0.86) have been reported and the correlation in this study seemed similar to the result of previous studies.[12-16)] In the assessment of LV systolic function, Gulati et al.[12)] assessed LV systolic function with mitral annular descent velocity compared with radionuclide test in 55 patients. The 6-site average peak mitral annular descent velocity was correlated well with LVEF by radionuclide method (r=0.86, SEE=1.02 cm/sec). Simonson et al.[13)] reported that mitral annular apical systolic excursion can be used to assess LV systolic function. Moreover, mitral annulus velocity was lower in patients with diastolic dysfunction with preserved LV systolic function and can be used to detect these patients more sensitively.[14)] In this study, we showed S' velocity was significantly correlated with 3DE LVEF (r=0.68, $p<0.001$).

With ROC curve analysis, mitral annular systolic velocity less than 6.8 cm/sec can be used to detect LV systolic dysfunction (LVEF<50%) with sensitivity 94.1% and specificity 87% in our study. The optimal cutoff values for identifying LV systolic dysfunction (LVEF<50%) have been reported to range from 6.9 cm/s to 8.0 cm/s for mean mitral annular systolic velocity and our result is similar to the results of the previous studies.[14)15)17)18)] Vinereanu et al.[14)] showed that 90% of the patients with systolic heart failure (LVEF<50%) had impaired mitral annular systolic velocity less than 7.05 cm/sec. Yuda et al.[18)] published their data of mitral annular systolic velocity less than 6.9 cm/sec showed best sensitivity, specificity and accuracy, 77%, 82%, and 80%, respectively, in the detection of LV systolic dysfunction (LVEF<50%). Moreover, they included patients with poor echocardiographic window.[18)] The difference in the optimal cutoff value to detect LV systolic dysfunction can be resulted from the method to calculate the S' velocity. Despite other studies used mean mitral annular systolic velocities, we used only medial site of S' velocity in this present study. However, the result of our study is similar those of the previous studies. It can be used to detect patients with LV systolic dysfunction in the mass screening.

This study may have also some limitations. First, the size of sample is relatively small. Moreover we included patients with relatively good echocardiographic window. Though there are statistically significant differences in this study, we believe further studies in a larger population are necessary to confirm these data. Second, mitral annular velocities have some limitations in the assessment of global LV systolic function because mitral annular velocities represent regional movement and these velocities are low in the patients with regional wall motion abnormalities.[15)19)20)] However, the S' velocity also showed significant correlation with 2DE LVEF (r=0.628, $p<0.001$) and 3DE LVEF (r=0.559, $p<0.001$) in the selected patients without regional wall motion abnormalities (n=105). Third, 3DE might not be the optimal technique for quantification of LVEF. However, 3DE examination is relatively accurate and reliable method. Three-dimensional echocardiographic techniques have been shown to have high accuracy and reproducibility (compared to CMR) it is likely that this method will be the technique of choice in the future for these types of studies.[21)] Moreover, it is more accessible than the CMR or computerized tomographic scanning, and can be performed without giving any hazards including radiation exposure or toxicity of radiocontrast agents.

In conclusion, S' velocity measured by TDI showed a significant correlation with 3DE LVEF and it can be used to detect patients with the LV systolic dysfunction, objectively.

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