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New Echocardiographic Morphofunctional Diastolic Index (MFDI) in Differentiation of Normal Left Ventricular Filling from Pseudonormal and Restrictive

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***Abstract*—**We have shown previously that reflected high intensity motion signals (RIMS) can be used for detection of left ventricular (LV) diastolic dysfunction (DD). It is also well known, that left atrial (LA) dimension can be used as a marker of DD. In this study we decided to analyze the diagnostic role of new echocardiographic morphofunctional diastolic index (MFDI) in differentiation of normal filling of LV from pseudonormal and restrictive. MFDI includes LA dimension and velocity of early diastolic component ea of RIMS (MFDI = LA/ea).

343 healthy subjects and patients with various cardiac pathology underwent dopplerechocardiographic exam. According to the criteria of "Don" classification scheme 155 subjects had signs of normal LV filling (N) and 55 - of pseudonormal and restrictive filling (PN + R). LA dimension was performed in standard manner. RIMS were registered by conventional pulsed wave Doppler from apical 4-chamber view, when the sample volume was positioned between the tips of mitral leaflets. The velocity of early diastolic component of RIMS was measured. After calculation of MFDI mean values of this index in two groups (N and PN + R) were compared. The cutoff value of MFDI for differentiation of patients with N and PN + R was determined.

Mean value of MFDI in subjects with normal filling was 1.38±0.33 and in patients with pseudonormal and restrictive filling 2.43±0.43; $p<0.0001$. The cutoff value of MFDI > 2.0 separated subjects with normal LV filling from subjects with pseudonormal and restrictive filling with sensitivity 89.1% and specificity 97.4%.

***Keywords*—**Dopplerechocardiography, diastolic dysfunction, left atrium, reflected high intensity motion signals.

I. Introduction

EARLIER we have studied Doplerrographic reflected high intensity motion signals (RIMS) in Rostov State Medical University [1]. RIMS are bright and low velocity signals which can be seen near the baseline on every conventional pulsed wave cardiac Dopplerogram obtained from intracardiac or extracardiac position of the sample volume. These signals are also known under the name of spectral Doppler artifacts. Each cardiac cycle three components of RIMS can be detected (sa – systolic, ea- early diastolic, aa – late diastolic). Analysis of RIMS has demonstrated that: a) all components of RIMS have good intra- and interobserver reproducibility [2], b) systolic component of RIMS is independent of age and diastolic components of RIMS are dependent of age [3], [4], c) velocity and time-interval characteristics of RIMS can be utilized for assessment of left and right ventricular systolic and diastolic function [5]-[8], d) the level of left ventricular diastolic pressure correlate well with value of left sided diastolic components of RIMS [9].

It is also known that left atrial (LA) dimension increases with progression of left ventricular diastolic dysfunction (LV DD) [10], [11]. In attempt to raise the level of diagnostic significance of Doppler parameters in diagnosis of LV DD we decided to combine LA dimension and velocity of early diastolic component of RIMS ea in one index and named it morphofunctional diastolic index (MFDI). MFDI = LA/ea.

The goal of this study is to determine whether MFDI is possible to differentiate effectively normal filling (N) of LV from pseudonormal and restrictive (PN + R).

II. Material and Methods

343 healthy individuals and patients with various cardiac pathology underwent dopplerechocardiographic exam. Criteria of “Don” echocardiographic classification scheme were used for initial determination of level of LV DD [12] (Table I).

TABLE I
“Don” Classification Scheme for Assessment of Left Ventricular Diastolic Dysfunction Severity

Variable	Normal filling (N)	Minimal Dysfunction (M)	Impaired relaxation (IR)	“Pseudonormal” filling (PN)	Restrictive filling (R)
			Main variable		
E/A	≥ 1	≥ 1	< 1	1-2	> 2
			Additional variables		
ea (cm/s)	> 20	≤ 20	-	≤ 20	-
aa (cm/s)	-	> 20	-	-	-
LA (mm)	-	< 38	-	≥38	≥ 38

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LA dimension was performed in a standard manner (Fig. 1).

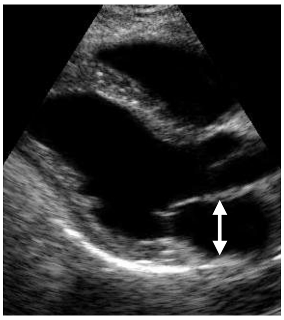

Fig. 1 Dimension of left atrium

RIMS were registered by conventional pulsed wave Doppler from apical 4-chamber view, when the sample volume was positioned between the tips of mitral leaflets. The velocity of early diastolic component of RIMS was measured (Fig. 2).

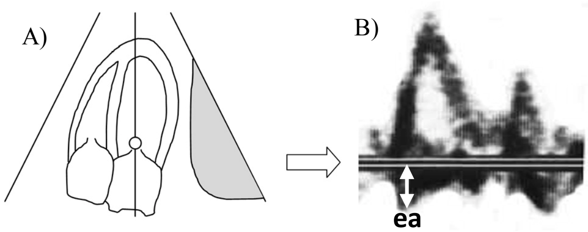

Fig. 2 (A) Position of the probe and sample volume for registration of RIMS (B) Measurement of velocity of ea component of RIMS on obtained pulsed wave spectrogram

After calculation of MFDI mean values of this index in two groups (N and PN + R) were compared. The cutoff value of MFDI for differentiation of patients with N and PN + R was determined using ROC method [13].

III. Results

155 subjects (mean age 41.5±14.9 years, male 103) had signs of normal filling (N) and 55 (mean age 56.0±9.0 years, male 34) - of pseudonormal and restrictive filling (PN + R). Mean value of MFDI in subjects with normal filling was 1.38±0.33 and in patients with pseudonormal and restrictive filling 2.43±0.43; $p<0.0001$ (Fig. 3).

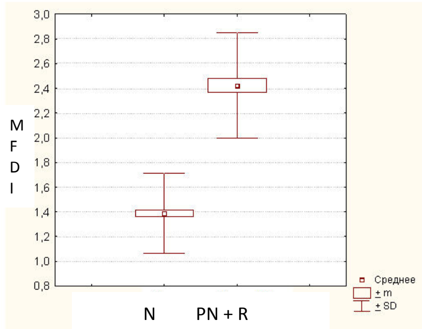

Fig. 3 Mean value of MFDI in subjects with normal (N) and pseudonormal and restrictive left ventricular filling (PN+R)

The cutoff value of MFDI for differentiation of patients with N and PN + R was determined as > 2.0 (Fig. 4).

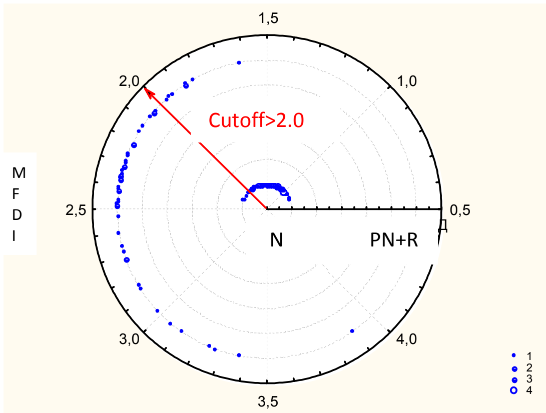

Fig. 4 Divergence of distributions of MFDI in individuals with normal LV filling (N) and pseudonormal and restrictive (PN+R)

Sensitivity and specificity of MFDI in separation of individuals with N from PN+R were 89.1% and 97.4%, respectively.

The time for measurement of LA and ea and calculation of MFDI appeared to be very shot (30.0±2.5 s).

The reproducibility of new method was evaluated by Bland-Altman analysis [14] (Figs. 5 and 6), and appeared to be high.

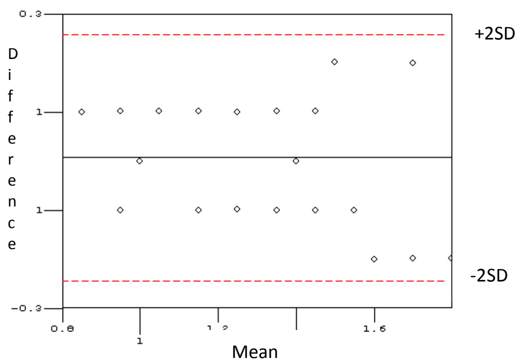

Fig. 5 Reproducibility of MFDI (one researcher)

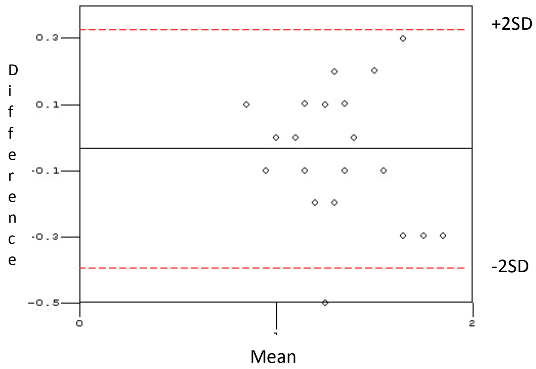

Fig. 6 Reproducibility of MFDI (two researchers)

IV. Discussion

Echocardiography plays an essential role in the evaluation of LV diastolic function in cardiac patients. The technique provides important diagnostic and prognostic information. For long period of time the main approach for assessment of LV DD was analysis of transmitral flow [15]. But recently it was found that parameters of transmitral flow can detect DD not in all cases. To improve the diagnostic value of Dopplere chocardiography in diagnosis of LV DD various classification schemes and indices were proposed [16]-[22]. Majority of them include parameters of tissue Doppler imaging. But availability of tissue Doppler imaging in developing countries is limited. That is why we decided to propose new diastolic index based on combined analysis of LA dimension and early diastolic component of RIMS registered with standard spectral Doppler.

Performed analysis showed that MFDI can effectively separate patients with normal filling from pseudonormal and restrictive. New method is simple, have good reproducibility, do not require much time for MFDI calculation. So it can be recommended for widespread use.

V. Conclusion

Calculation of MFDI is simple and effective method for differentiation of cardiac patients with normal LV filling from patients with pseudonormal and restrictive filling.

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