CLINICAL STUDY

Diastolic function of the left ventricle assessed by echocardiography

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Abstract

The authors evaluated a value of diastolic indices of the left ventricle assessed by Doppler from transmitral flow in prediction of diastolic dysfunction. They were related to instantaneous pressure decline of the left ventricle, which was considered as a standard of left ventricular relaxation and was evaluated by Doppler. In a group of 38 patients the diastolic function was assessed by measuring the isovolumic relaxation time, peak velocity during the rapid filling phase of the left ventricle, its deceleration time, peak velocity during atrial contraction, its ratio and flow propagation velocity. Polynomial regression revealed significant association of the instantaneous pressure decline of the left ventricle to isovolumic relaxation time and a value of more than 100 ms identifying a high risk group of patients. There was no association to other echocardiographic indices of diastolic function. ***(Tab. 3, Fig. 2, Ref. 11.)***
Key words: diastolic function of the left ventricle, diastolic indices of the left ventricle, mitral regurgitation.

Abnormal diastolic function of the left ventricle plays an important role in the development of heart failure. It has been proved that diastolic dysfunction substantially contributes to cardiac morbidity and mortality. Currently, different therapeutic strategies which target its underlying mechanisms are under development (1, 2, 3, 4). Therefore, accurate assessment of the presence and severity of diastolic impairment is crucial. Echocardiography has become the backbone of the noninvasive evaluation of diastole (5). The aim of the study was to determine a discriminative value of echocardiographic parameters in the assessment of diastolic dysfunction. Doppler derived instantaneous pressure decline of the left ventricle (-dP/dt), considered as a standard index of left ventricular relaxation, was related to easily obtainable parameters of mitral valve inflow.

Methods

We studied a group of 38 consecutive patients, 27 men and 11 women (mean age 69.6 years, range from 24 to 86 years). Two-dimensional echocardiography was performed in every patient with moderate and severe mitral regurgitation (MR) using transthoracal 2.5 or 3.75 MHz probe (ESAOTE, S.p.A., Florence, Italy). Systolic function was assessed by calculating EF and wall motion index (WMI) of the 16-segment model of the left ventricle. Ejection fraction was assessed according to a modified biplane Simpson's method and WMI according to the guidelines recommended by the American Society of Echocardiography (6, 7). Diastolic function was assessed by Doppler from mitral inflow measuring the isovolumic relaxation time (IVRT), peak early flow velocity (E wave), its deceleration time (DT E), peak flow velocity at atrial contraction (A wave) and E/A ratio. Color M-mode echocardiography was used for the measurement of the flow propagation velocity (Vp) and E/Vp ratio as a sensitive index of left ventricular relaxation (8). Continuous wave Doppler spectra of the mitral regurgitant jet were analysed. Doppler derived -dP/dt was determined as follows: the two points on the MR spectrum corresponding to 1 m/s and 3 m/s were identified. These points corresponded to left ventricular – left atrial pressure gradients of 4 mmHg and 36 mmHg using a modified Bernoulli equation ($P=4v^2$). Doppler derived -dP/dt was defined as dP/dt=36—4/dt=32 mmHg/dt (Fig. 1). -dP/dt was determined

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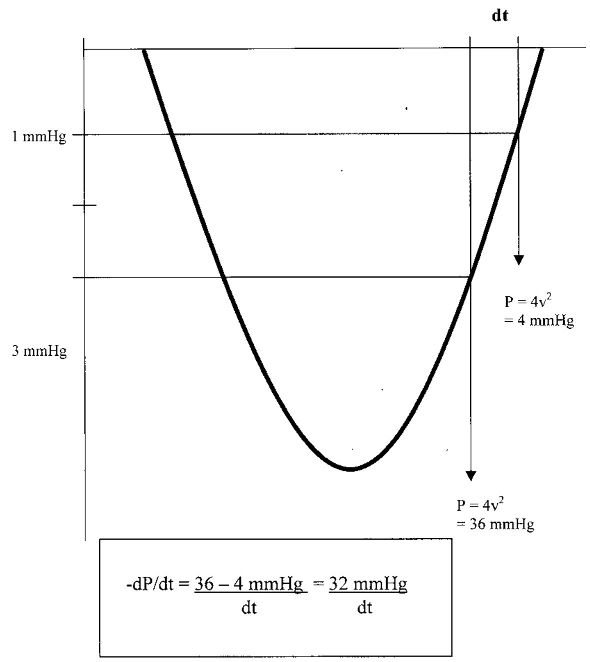

Fig. 1. Assessment of the value of -dP/dt derived from continuous-wave Doppler recording of mitral regurgitation.

from the diastolic slope of the MR spectrum (9, 10). The averages of three measurements in case of sinus rhythm and five measurements in case of atrial fibrillation were calculated for each echocardiographic variable.

All values of the measurements were expressed as mean± standard deviation (SD). Unpaired t-test was performed and correlation was analysed using linear and polynomial regression between dependent and independent variables.A $p<0.05$ was considered significant.

Results

The data expressed as mean±SD are presented in Table 1. Ten patients (26.3 %) had preserved EF>50 % and 28 patients (73.7 %) had EF<50 %. The mean±SD of two subgroups with normal and impaired EF are presented in Table 2. Patients with systolic dysfunction compared to patients with normal EF had significantly lower A velocity (0.44 cm/s vs 0.78 cm/s, $p=0.03$), shorter DT E (156.9 ms vs 263.4 ms, $p=0.002$), lower -dP/dt (591.1 vs 696.9 mmHg/s, $p=0.008$), lower Vp (40.3 vs 82.4 cm/s, $p=0.0001$) and higher E/Vp ratio (2.2 vs 1.2, $p=0.001$). High-risk group of patients (defined by -dP/dt<450 mmHg/s) compared to patients with intermediate and low-risk (-dP/dt>450 mmHg/s) had significantly prolonged IVRT (119.3 vs 70.9 ms, $p=0.0002$) and higher WMI (2.1 vs 1.7, $p=0.03$) (Tab. 3).

Polynomial regression analysis revealed significant relation of -dP/dt to IVRT ($p<0.0001$) (Fig. 2) and borderline to E/Vp ($p=0.05$). Considering that -dP/dt<450 mmHg/s presents a high-risk group of patients, interpolation yielded a value of IVRT>100 ms identifying these individuals.

Tab. 1. Basic characteristics.

	Mean±SD
Age (years)	69.60 ± 11.50
EF (%)	39.70 ± 16.50
LVMI (g/m²)	226.50 ± 81.40
WMI	1.70 ± 0.50
E (m/s)	0.79 ± 0.20
A (m/s)	0.50 ± 0.30
DT E (ms)	185.70 ± 106.50
E/A	2.30 ± 1.80
IVRT (ms)	76.60 ± 30.20
-dP/dt (mmHg/s)	618.90 ± 122.20
Vp (cm/s)	51.40 ± 33.10
E/Vp	1.90 ± 0.80

EF — ejection fraction, LVMI — left ventricular mass index, WMI — wall motion index, E — E wave velocity, A — A wave velocity, DT E — deceleration time of the E wave, IVRT — isovolumic relaxation time, -dP/dt — instantaneous pressure decline of the left ventricle, Vp — flow propagation velocity.

Tab. 2. Distribution according to systolic function.

	EF>50 %	EF<50 %	p
Age (years)	72.30± 8.80	68.60± 12.30	0.1
LVMI (g/m²)	223.10± 80.20	228.20± 84.60	0.4
WMI	1.20± 0.30	1.90± 0.40	0.0001
E (m/s)	0.86± 0.24	0.76± 0.19	0.1
A (m/s)	0.78± 0.55	0.44± 0.25	0.03
DT E (ms)	263.40±167.10	156.90± 53.40	0.002
E/A	1.30± 0.80	2.50± 1.90	0.1
IVRT (ms)	78.10± 19.30	76.10± 33.60	0.4
-dP/dt (mmHg/s)	696.90±114.00	591.10±114.30	0.008
Vp (cm/s)	82.40± 44.20	40.30± 19.20	0.0001
E/Vp	1.20± 0.50	2.20± 0.80	0.001

Tab. 3. Dividing of patients according to -dP/dt related to prognosis (high-risk group with -dP/dt<450 mmHg/s, intermediate and low-risk group -dP/dt>450 mmHg/s, respectively).

	-dP/dt<450mmHg/s	-dP/dt>450mmHg/s	p
Age (years)	69.60± 8.9	69.70± 11.80	0.4
EF (%)	30.60± 7.4	42.00± 17.50	0.08
WMI	2.10± 0.6	1.70± 0.50	0.03
E (m/s)	0.74± 0.3	0.79± 0.19	0.3
A (m/s)	0.45± 0.4	0.51± 0.33	0.4
DT E (ms)	207.70±84.4	187.20±112.30	0.3
E/A	2.60± 2.8	2.20± 1.70	0.4
IVRT (ms)	119.30±44.8	70.90± 21.70	0.0002
Vp (cm/s)	49.30±30.1	51.70± 33.40	0.4
E/Vp	1.80± 0.8	1.90± 0.90	0.3

Discussion

Over the past decade, echocardiography has become a well established tool for the diagnosis of left ventricular diastolic dysfunction. In most cases, careful analysis of Doppler parameters from the mitral inflow and pulmonary venous flow in combination with two-dimensiol echo and clinical data allows the correct

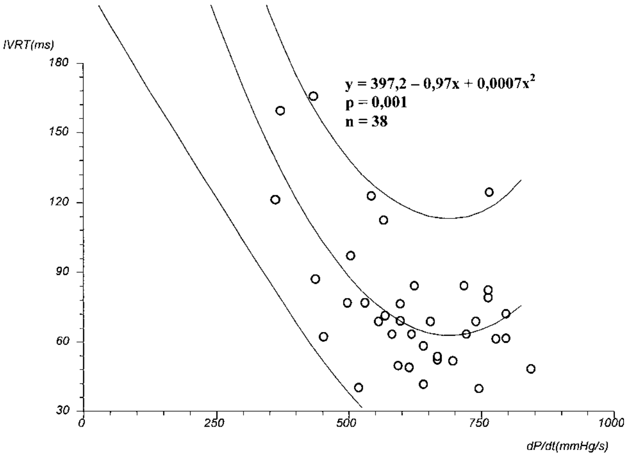

Fig. 2. Polynomial regression analysis of isovolumic relaxation time (IVRT) and instantaneous pressure gradient of the left ventricle (-dP/dt).

assessment of diastolic function. Moreover, new methodologies such as color M-mode flow propagation and tissue Doppler imaging has been introduced. These new methods are less load-dependent, however, not yet largely used in routine clinical practice.

In our study, we evaluated a value of standard diastolic indices derived from Doppler mitral inflow as well as the flow propagation velocity in prediction of diastolic dysfunction. The Doppler mitral velocity regurgitant profile was used for noninvasive calculation of the instantaneous pressure decline of the left ventricle. This was considered as a standard index of left ventricular relaxation. It has been proved that -dP/dt allows accurate and reliable assessment of the changing rate of left ventricular pressure decline. In addition, Doppler derived -dP/dt is a strong predictor of cardiovascular morbidity and mortality (11). Patients with -dP/dt<450 mmHg/s identify a high-risk group of individuals. Our study revealed significant relation of -dP/dt only to IVRT and borderline to E/Vp. Patients with severe diastolic dysfunction (-dP/dt<450 mmHg/s) had prolonged IVRT with a cut-off value >100 ms which was predictive for high-risk group. The relationship between -dP/dt and IVRT was exponential what is typical for most of the flow based parameters. There was no association of -dP/dt to other diastolic indices assessed in this study. It can be explained by the fact that while -dP/dt and IVRT present the parameters of relaxation, other indices (E and A wave velocity, DT E and Vp) are related to left ventricular filling and compliance.

A limitation of the study is that the predictive value of IVRT >100 ms identifying a high-risk group of patients was derived secondarily according to the data provided by other investigators (11). Pulmonary venous flow was not assessed because of not reliable tracing of the flow from transthoracic approach.

Isovolumic relaxation time is exponentially related to instantaneous pressure decline in the left ventricle. A value of more than 100 ms identifies patients at high risk.

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