THE USE OF VELOCITY VECTOR IMAGING PROGRAM TO ESTIMATE LEFT VENTRICULAR SYSTOLIC FUNCTION IN HEALTHY VOLUNTEERS AND PATIENTS WITH DILATED CARDIOMYOPATHY

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The aim of the investigation is to estimate the feasibility of Velocity Vector Imaging (VVI) program in studying left ventricular systolic function in patients with dilated cardiomyopathy and healthy volunteers.

Materials and methods. The study included 3 patients with dilated cardiomyopathy and 4 patients without cardiovascular pathology. Left ventricle was analyzed using VVI program, from apical four-chamber position and from parasternal position along short axis at the level of papillary muscles. There were analyzed the indices of myocardial motion speed, strain, left ventricular ejection fraction and volume.

Results. The indices of left ventricular systolic function in standard echocardiography (using Simpson method) and using VVI program were equal in both groups. Axial and radial velocity of left ventricular endocardium were higher in healthy volunteers ($p<0.05$). The group of volunteers had the tendency for speed reduction from left ventricular base to apex, while in the group of patients with dilated cardiomyopathy the tendency was less expressed. In patients with dilated cardiomyopathy there was relatively uniform decrease of axial and radial velocities in the studied segments. Compared to healthy volunteers, the patients with dilated cardiomyopathy had lower indices of axial strain ($p<0.05$).

Conclusion. VVI program in estimating left ventricular systolic function enables to assess accurately and objectively the degree of contractility defect.

Key words: left ventricular systolic function, strain, Velocity Vector Imaging program.

The study of myocardial contractive function using echocardiography (echoCG) is traditionally based on visual assessment of cardiac wall motion. Systolic function of the left ventricle (LV), as a rule, is estimated by ejection fraction calculated by volume indices of left ventricular cavity in systole and diastole using modified Simpson method or other mathematical approximations. The estimation of segment contractility presents greater problems. The thickening of walls and their motion can be visually assessed by two-dimensional echocardiography. Though this approach has a number of limitations related to the researcher's experience, and, in some cases, the quality of ultrasonic equipment. Moreover, visual estimation does not allow revealing insignificant myocardial malfunctions [1]. The use of tissue Doppler-echoCG contributes to early diagnosis of minimal functional changes [1, 2], though their possibilities are limited by the dependence of measurements on scanning angle. The source of errors is also complex parallel and rotational motion that the heart has in thorax all through the cardiocycle.

The technology of myocardial Velocity Vector Imaging (VVI) enables to obtain information of the direction and size of velocity vector of myocardial motion within the whole cardiac cycle. The modality enables to estimate the deformation, deformation velocity, systolic and diastolic ventricular functions along the long and the short axes without regard to angular limitations, as well as analyze myocardial dissynchronies. The analysis is also possible in technically difficult cases [1]. The only requirement is the whole ventricle or the area of interest to be within eyeshot throughout the cardiac cycle. VVI program enables to receive velocity-time diagram with the information of the

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velocity with regard to the point chosen by a researcher. Along the endocardium there are calculated the values of deformation — strain — and the rate of deformation, and the values are also shown on corresponding diagrams. Using VVI program the analysis of ventricular functions along the long and short axes can be made.

The aim of the investigation is to estimate the feasibility of Velocity Vector Imaging program in studying left ventricular systolic function in patients with dilated cardiomyopathy and healthy volunteers.

Materials and Methods. Using traditional echocardiography (Simpson method) and VVI program, LV systolic function was studied in 3 patients with dilated cardiomyopathy (DCMP) and in 4 patients without cardiovascular pathology (control group).

The mean age of the control patients was 21-–5 yrs, and that of the patients with DCMP ranged within 51–69 yrs.

All the patients studied underwent EcoCG study using ultrasound diagnostic system Siemens Acuson X300 (Germany), with sector sensor with the frequency of 1–5 MHz, in B-, M-, and D-modes and colour Doppler mapping. When analyzing echoCG at rest, there were estimated end-diastolic volume (EDV) of the left ventricle, end-systolic volume (ESV), and ejection fraction (EF). The volumes of LV cavity were calculated using the formula “area-length” in Simpson modification (1989).

Table 1

The comparison of indices of systolic function of the left ventricle using Simpson method and VVI

Indices	Healthy volunteers		Patients with DCMP	
	Simpson method	VVI	Simpson method	VVI
EDV, ml	74.5±36.7	71.3±41.1	251.1±26.0	238.7±25.4
ESV, ml	27.5±12.6	29.6±17.6	194.3±20.5	195.3±27.06
EF, %	62.5±3.5	58.5±2.08	22.3±7.5	18.3±8.5

Left ventricle was analyzed using VVI program, from apical four-chamber position and from parasternal position along the short axis at the level of papillary muscles [3]. There were analyzed the indices of myocardial motion velocity, deformation (strain), left ventricular ejection fraction and volume.

Results and Discussion. The comparison of the findings of LV systolic function using standard echoCG study and VVI revealed their close indices both in healthy volunteers and in patients with DCMP (Table 1). LV volumes in the group of patients with DCMP are significantly higher than those in healthy volunteers, and EF indices — significantly lower ($p<0.05$).

More objective quantitative estimation of LV myocardial

Table 2

Axial and radial velocities of the left ventricular segments of healthy volunteers and patients with DCMP, cm/s

Segments	Axial velocities		Radial velocities	
	Healthy volunteers	Patients with DCMP	Healthy volunteers	Patients with DCMP
Basal anterior lateral	3.406±1.001	1.744±0.788	3.180±0.819	2.019±0.733
Middle anterior lateral	2.523±0.631	1.249±0.922	2.117±0.526	1.335±0.241
Apical anterior lateral	1.854±0.662	1.626±1.347	1.325±0.327	0.254±0.145
Basal posterior septum	4.558±1.756	2.819±0.360	3.943±0.652	1.369±0.703
Middle posterior septum	2.316±0.602	1.709±0.568	2.269±0.813	0.857±0.694
Apical posterior septum	1.788±0.172	0.898±0.479	1.068±0.221	0.480±0.240
Average velocity	2.556±0.241	1.713±0.537	2.109±0.48	1.142±0.294

Table 3

Longitudinal and circular strains of the left ventricle of healthy volunteers and patients with DCMP, %

Segments	Longitudinal strain		Circular strain	
	Healthy volunteers	Patients with DCMP	Healthy volunteers	Patients with DCMP
Basal anterior lateral	–21.0±1.9	–11.0±1.6	–24.0±5.1	–5.0±1.5
Middle anterior lateral	–21.0±3.8	–6.0±1.2	–22.0±5.1	–5.0±2.2
Apical anterior lateral	–21.0±2.0	–1.3±0.6	–15.0±2.0	–5.0±3.3
Basal posterior septum	–21.0±1.1	–9.0±7.0	–17.0±3.1	–6.0±3.0
Middle posterior septum	–24.0±4.2	–5.0±5.3	–20.0±4.2	–7.0±5.3
Apical posterior septum	–22.0±3.6	–4.0±1.4	–24.0±5.0	–3.0±2.3
Average value	–22.30±2.16	–6.05±3.4	–20.3±3.7	–5.2±2.5

contractive function was made by means of the assessment of myocardial motion velocity and its deformation. Myocardial motion velocities when studied in apical section in norm decrease from the base to the apex [1, 4, 5]. VVI program enables to estimate axial and radial velocities from apical four-chamber position. Velocity indices of healthy people were compared with those of patients with DCMP (Table 2).

The analysis of axial and radial velocities of LV endocardial motion in two groups showed all the indices to be higher in healthy volunteers ($p<0.05$). This group has the tendency for velocities decrement from LV base to apex, while in the group of patients with DCMP the tendency is less expressed. The patients with DCMP had relatively regular decrease of axial and radial velocities in the studied segments.

Modern complex echoCG study using new technologies includes not only the estimation of motion velocities of LV walls but also the deformation assessment. Its values in standard segments suggest that they can be reduced and quantitatively estimate the degree of damage [4–6]. In norm systolic strain of myocardial fiber is on the average -20%. In the segments, akinetic according to echoCG findings, strain value (S) is reliably less in module than in hypokinetic ones. Criterion S<–13%, according to Russian and foreign literature, has high sensitivity (86%) and specificity (85%) in terms of revealing the areas of contractility defects in myocardial ischemia and acute myocardial infarction [1, 6, 7].

The assessment of longitudinal strain in the group of healthy volunteers showed the indices to be within the normal range (average — 22.30±2.16%) (Table 3). Compared to healthy volunteers, the patients with DCMP had significantly lower average values of longitudinal strain ($p<0.05$). The highest strain index in the group of patients with DCMP was in LV basal anterior lateral segment (–11.0±1.6%), the lowest — in apical anterior lateral segment (–1.3±0.6%).

Average indices of circular strain in healthy volunteers in apical anterior lateral and basal posterior septum LV segments were slightly lower than common normal values See Table 3). However, according to literature [6, 8, 9], the values of normal indices of strain on lateral and posterior wall on the average–-15±5% can be conceded. The values of circular strain in patients with DCMP compared to healthy volunteers dipped down, but in contrast to the values of longitudinal strain, they were found to be relatively regularly decreasing.

Thus, the VVI findings objectively give evidence of LV systolic dysfunction in patients with DCMP.

Conclusion. Velocity Vector Imaging program enables to estimate the left ventricle volumes in systole and diastole, and global ejection fraction. The findings are close to those of standard echocardiographic study (Simpson method) both in the group of healthy volunteers and in the patients with dilated cardiomyopathy.

Using VVI one can assess axial and radial velocities of endocardial motion from apical position. The endocardial motion velocities in the group of healthy volunteers were higher than in the group of patients with cardiomyopathy. The technique enables to carry out an objective quantitative assessment of segmental contractility of the left ventricle using deformation (strain) index. The indices of longitudinal and circular strains in the group of healthy volunteers corresponded to normal values, while in patients with cardiomyopathy the indices were sharply decreased. The obtained data prove that practical significance of VVI program in the estimation of left ventricular systolic function is considerably high, and enables to receive more accurate and objective indices.

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