Doppler Tissue Imaging to Assess Systolic Function in Chagas' Disease

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Objective - *To assess the usefulness of Doppler tissue imaging (DTI) for evaluating the systolic function of chagasic patients with and without electrocardiographic abnormalities, in comparision with echocardiographic study.*

Methods - *We studied 77 patients divided into 3 groups as follows: group 1 – control; group 2 – chagasic patients with normal electrocardiographic findings; and group 3 – chagasic patients with abnormal electrocardiographic findings. The following parameters were assessed: left ventricular dimensions and ejection fraction, left atrial dimensions and diastolic function on echocardiography. Systolic velocity and regional isovolumic contraction time (IVCTr) of the septal, anterior, lateral, posterior and inferior left ventricular walls were assessed on DTI.*

Results - *Left ventricular cavitary dimensions, ejection fraction and DTI systolic wave showed significant differences between groups 1 and 3 and between groups 2 and 3, which were not found between groups 1 and 2. IVCTr allowed a statistically significant discrimination among the 3 groups.*

Conclusion - *DTI allowed discrimination among the different groups assessed, being superior to echocardiography in identifying early abnormalities of contractility, and, therefore, potentially useful for detecting incipient myocardial alterations in chagasic patients with normal electrocardiographic findings.*

Keywords: Chagas' disease, echocardiography, Doppler tissue imaging

Chagas' disease is caused by the *Trypanosoma cruzi* protozoa and is one of the major causes of death in several countries in Latin America [1], therefore having a great socio-economic impact. The heart is the most frequently and severely impaired organ in Chagas' disease, and its impairment may result in death due to arrhythmia, heart failure, or thromboembolic phenomena [2]. Ventricular function is the major predictor of morbidity and mortality in chronic Chagas' heart disease [3,4], and the early identification of myocardial damage may be important in the individualized approach of chagasic patients. Of the investigative methods, 12-lead electrocardiography has been extensively studied in Chagas' disease. Although the presence of a normal electrocardiogram is related to an excellent prognosis [5], evidence of left ventricular contractile abnormalities [6,7], diastolic dysfunction [8], and even sudden death [9] exists in patients with Chagas' disease with no electrocardiographic abnormalities.

Doppler tissue imaging is a diagnostic modality that has recently been incorporated into echocardiography. It allows the regional and quantitative analysis of cardiac muscular contraction and expansion [10]. Several studies have been published showing the potential of this technique in identifying the incipient myocardial changes in several diseases [11-13]. The objective of this study was to determine the usefulness of Doppler tissue imaging for detecting early contractile abnormalities in Chagas' disease, comparing it with electrocardiography and conventional echo-Doppler cardiography.

Methods

We carried out a cross-sectional study with prospective data collection from January 1998 to April 1999. During this period, 77 patients were selected and divided into 3 groups: group 1) control (17 patients); group 2) chagasic patients with normal electrocardiograms (32); and group 3) hagasic patients with abnormal electrocardiograms (28). All patients were selected from the Referral Center for Training on Infectious and Parasitic Diseases of the Federal University of Minas Gerais, after receiving an individual explana-

tion about the objectives of the study and signing the formal written consent. The research protocol was assessed and approved by the committee on research ethics of the institution.

For recruitment, the patients initially underwent anamnesis, standardized physical examination, electrocardiography, chest X-ray, and laboratory tests (hemogram, creatinine, urea, fasting glycemia, potassium, sodium, TSH, and serological tests for *T. cruzi* infection). The chagasic patients were considered those who were serologically positive for *T. cruzi* according to at least 2 of the 3 following techniques: indirect immunofluorescence, indirect hemagglutination, and ELISA.

The exclusion criteria were as follows: systemic arterial hypertension, defined as blood pressure level measured during physical examination > 140/90 mmHg; history suggestive of coronary heart disease; a previous episode suggestive of rheumatic disease; diabetes mellitus or glucose intolerance, according to the definition of the National Diabetes Data Group; thyroid dysfunction, manifested as abnormal levels of thyroid-stimulating hormone (TSH) and of free thyroxin (T4); renal failure, defined as an increase in creatinine and urea levels; chronic obstructive pulmonary disease, based on suggestive clinical, radiological, and electrocardiographic data; fluid and electrolytic disorders, based on sodium and potassium measurements; significant anemia, defined as hemoglobin below 10 g/dL; alcoholism, defined as a mean weekly ethanol consumption of 420 g; pregnancy; and impossibility to undergo the tests in the protocol.

All patients underwent echo-Doppler cardiography with color-flow mapping and Doppler tissue imaging with the ATL HDI 5000 device (Bothell, Washington, USA). The following echocardiographic parameters were obtained: left ventricular final diastolic and systolic dimensions; left atrial diameter; and ejection fraction obtained according to the Simpson method with the software included in the device. Pulsed Doppler of the transmitral flow (E and A waves, E/A ratio, and deceleration time - DT) and of the left ventricular outflow tract (isovolumic relaxation time - IVRT) was used to assess diastolic function. Doppler tissue imaging was obtained with the apical window in the apical 4-chamber view, apical 2-chamber view, and long apical view to assess the septal, lateral, inferior, anterior, and posterior walls, placing the sample volume of the Doppler cursor at the level of the basal, middle, and apical portions of the referred walls to determine the velocities of contraction. Peak systolic velocity was obtained, and the time of regional isovolumetric contractility (TRIVC) was estimated measuring the

interval between the electrocardiographic Q wave and the beginning of the systolic wave.

The clinical data and those generated during the procedures were analyzed with version 6 of the Epiinfo and version 11 of the Minitab statistical packages for Windows. In all tests performed, alpha lower than 0.05 was considered an indicator of statistical significance. Whenever possible, the mathematical transformations necessary for the treatment of data with the parametric methods were performed. The means obtained were studied by using the analysis of variance (ANOVA) and the LSD Fisher test for comparing the means of the 3 groups. For nonparametric variables, the Kruskal-Wallis test was used with comparison of the medians after the Bonferroni adjustment for multiple tests. The values obtained were described as mean ± standard deviation or median and interquartile range (for nonnormally distributed variables). Because age differed in the groups, the analysis of covariance was performed to determine the significance of this variable in the parameters assessed. A p < 0.05 was considered significant.

Results

The general clinical and echocardiographic data are shown in table I, where no statistically significant difference between the control group and that of chagasic patients with normal electrocardiograms can be observed in regard to the general parameters of systolic function. Although patients in group 2 were older, the analysis of covariance did not detect a statistically significant correlation with any variable studied in this sample.

The electrocardiographic abnormalities observed in group 2 were as follows: supraventricular or ventricular, or both, extrasystoles (21.4%); complete right bundle-branch block (57.1%); incomplete right bundle-branch block (3.6%); left anterior hemiblock (57.1%); left ventricular hypertrophy (3.57%); nonspecific alterations in repolarization (14.3%); low voltage (3.6%); and electric inactivity (7.1%).

Table II shows the parameters related to diastolic function determined with conventional Doppler. A significant difference was observed in the deceleration time between the control and chagasic groups, although no difference was observed between the chagasic patients with and without electrocardiographic alterations when the test for comparing the means and that variable was used.

The assessment of TRIC with Doppler tissue imaging allowed discrimination between the 3 groups in almost all seg-

Table I – General clinical and echocardiographic data of 60 chagasic patients with and without electrocardiographic abnormalities and 17 healthy individuals							
Variable	Group 1	Group 2	Group 3	P	1x2	1x3	2x3
Age	35.8 ±10.6	40.7 ± 8.5	43.9 ± 11.1	0.03	S	S	NS
EF (%)*	65 (63.2-67.8)	62 (60-65)	57 (44.5-63)	0.0001	NS	S	S
LVDD (mm)	47.6 ± 4.4	50.1 ± 4.1	54.4 ± 6.9	0.0001	NS	S	S
LA (mm)	33.6 ± 2.6	33.7 ± 2.3	36.3 ± 4.2	0.003	NS	S	S

EF- ejection fraction; LVDD- left ventricular diastolic dimension; LA- left atrium. * data presented as median (Q1-Q3); S- significant; NS- not significant.

Table II - Indices of diastolic function on conventional echo-Doppler cardiography in 60 chagasic patients with and without electrocardiographic abnormalities and 17 healthy individuals

Variable	Control	Chagasic patients		P
		Normal ECG	Abnormal ECG	
E	73.9 ± 2.8	72.3 ± 2	70.7 ± 2.2	0.68
A	52 ± 2.8	49.6 ± 1.9	50.8 ± 2.2	0.77
E/A	1.5 ± 0.1	1.6 ± 0.1	1.5 ± 0.1	0.63
IVRT	85.6 ± 1.8	90.8 ± 1.3	89.8 ± 1.5	0.07
DT	169.8 ± 5.1	181.3 ± 3.6	189.3 ± 4	0.02

ECG- electrocardiogram; E- initial filling phase; A- late filling phase; IVRT- isovolumetric relaxation time; DT- deceleration time.
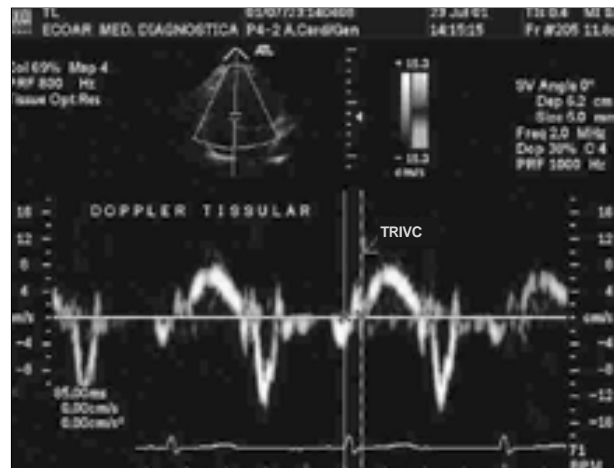

Fig. 1 - Pulsed Doppler tissue imaging of the basal segment of the ventricular septum. S- systolic wave; E- initial diastolic wave; A- late diastolic wave; TRIVC- time of regional isovolumetric contractility.

ments assessed, especially along the inferior and posterior walls. Table III shows the data obtained at the basal portion of the different walls of the left ventricular myocardium.

Although the analysis of the systolic wave on Doppler tissue imaging enabled the discrimination of patients in groups 1 and 3 and in groups 2 and 3 (chagasic patients with and without electrocardiographic abnormalities), no statistically significant difference was observed between the control group and that of the chagasic patients without electrocardiographic abnormalities (tab. IV).

Figure 1 depicts the evaluation of the basal portion of the interventricular septum on Doppler tissue imaging with the values of systolic-wave velocity and TRIC.

Discussion

The analysis of ventricular function is an essential determining factor in the therapeutical and prognostic assessment of patients with Chagas' heart disease in its different forms. Of the methods available, echocardiography provides a noninvasive and innocuous morphological and functional approach of the heart at relatively low costs. In addition, the analysis of ventricular function has a high diagnostic reliability, therefore being an important investigative tool to approach chagasic patients. The initial echocardiographic studies in Chagas' disease were performed with the M mode [14]. However, this method has several limitations for heart assessment. Because it only provides the visualization of the ventricular septal and posterior wall segments, it does not allow the analysis of the contractility of other segments, including the cardiac apex, which is a segment of essential importance in evaluating Chagas' heart disease, due to the peculiarities of the impairment of that region in Chagas' heart disease. In addition, the analysis of the right cavities, the quantitative evaluation of valvular heart diseases, the detection of intracavitary thrombi, and the determi-

Table III - Time of regional isovolumetric contractility on Doppler tissue imaging of the basal segment of several left ventricular walls in the different groups studied

	Group 1	Group 2	Group 3	P	1x2	1x3	2x3
Septum	86.3 ± 11	103.3 ± 15	108 ± 18	0.0001	S	S	NS
Lateral	85.6 ± 8.7	97.8 ± 16.1	107.5 ± 20	0.003	S	S	S
Posterior	86.4 ± 8.7	101.8 ± 17	114 ± 26	0.0001	S	S	S
Inferior	87.9 ± 8.8	103.1 ± 16	114.7 ± 26	0.0001	S	S	S
Anterior	86.3 ± 9	96 ± 17.8	108.1 ± 23	0.008	S	S	S

S- significant; NS- not significant

Table IV – Systolic wave on Doppler tissue imaging of the basal segment of several left ventricular walls in the different groups studied

	Group 1	Group 2	Group 3	P	1x2	1x3	2x3
Septum	9.29 ± 1.26	8.54 ± 1.06	7.5 ± 1.55	0.0001	NS	S	S
Lateral	10.76 ± 2.1	10.32 ± 2.5	8.35 ± 2.51	0.002	NS	S	S
Posterior	10 ± 1.96	8.83 ± 1.95	7.1 ± 2.64	0.0001	NS	S	S
Inferior	9.47 ± 1.5	8.58 ± 1.8	6.82 ± 2.37	0.0001	NS	S	S
Anterior	10.3 ± 1.49	9.51 ± 1.52	7.96 ± 2	0.001	NS	S	S

S- significant; NS- not significant

nation of the diastolic function and pulmonary arterial pressure, which are extremely important data in a general cardiac assessment, cannot be measured with this technique. The introduction of the 2-dimensional and Doppler techniques provided important additional information for the assessment of chagasic patients, allowing a more complete and noninvasive morphological and functional cardiac study [15-17]. However, the analysis of ventricular function with 2-dimensional echocardiography to evaluate wall motility or thickness, or both, and to determine the volumes and ejection fraction, which require the delineation of the muscle/cavity interface, renders the method a subjective character related to inter- and intraobserver variations, because the experience required in the subjective quantification of myocardial motility requires long-term experience with the method. The techniques allowing the quantitative analysis of myocardial contractile status have, therefore, great potential in the study of the cardiac function.

The studies of ventricular fiber architecture have revealed a complex disposition of the myocardial fibers, with the predominance of a circumferential orientation for the middle muscle layer and a longitudinal disposition of the muscle fibers at the subendocardial level [18]. The importance of the longitudinal contractility has been demonstrated in several echocardiographic studies, both for the analysis of the systolic function, and also for the assessment of ventricular relaxation [19]. Of the methods used, Doppler tissue imaging has a great potential for the study of longitudinal contractility. Unlike the study of flow dynamics at the level of the cardiac cavities, which are characterized by elevated velocities and low amplitude, Doppler tissue imaging uses a "filter" to eliminate the signal originating from the blood flow and to study the Doppler pattern at the level of the cardiac muscle, characteristically of high amplitude and low velocities. Therefore, we can analyze quantitatively the characteristics of myocardial wall motility throughout the cardiac cycle, which enables a more accurate analysis of myocardial performance. Several studies have been conducted to validate the method in several pathological cardiac conditions, including Chagas' disease [20-23].

This study showed the usefulness of Doppler tissue imaging for evidencing alterations in the contractility of the longitudinal fibers of the left ventricular myocardium in Chagas' disease. The alterations on Doppler tissue imaging were present in both groups of chagasic patients, those with and without electrocardiographic abnormalities, showing early impairment in systolic function in these patients, even in the absence of electrocardiographic and echocardiographic abnormalities.

In the group studied, the alterations on Doppler tissue imaging related more to the isovolumetric contractility phase. This phase of the cardiac cycle relates to the excitation-contraction coupling and to the capacity of the muscular mass to develop, in a fraction of a second, strength enough to overcome the pressure exerted by the arterial vascular bed. For this to happen efficiently, harmony among the several components of the heart is required, not only the myocardial fibers, but also the components of the support and fibrous skeletal system, the interstitium, the excitation-conducting system, the autonomic nervous system, and vascular integrity. Chagasic myocarditis causes disorders in all these components [24], and even in the case of focal and less intense impairment, it may cause mild alterations in ventricular function, as already shown.

The results obtained allowed determining the presence of segmentary alterations relative to ventricular longitudinal contraction, reflecting heterogeneity in the muscular shortening of the different myocardial walls in Chagas' heart disease. Of the different segments assessed, the posterior and inferior walls showed the most significant alterations in the groups studied, reflecting the segmentary characteristic of the myocardial systolic impairment in chronic Chagas' heart disease.

The limitations of the use of Doppler tissue imaging in this study related to the difficulty in analyzing the velocities at the level of the cardiac apex, which is a region of special interest in assessing cardiac impairment in chagasic patients. This region is usually stationary in regard to the motility of the cardiac muscle layers, and, therefore, the criteria of abnormality on Doppler tissue imaging have little value as compared with those of the normal pattern. In addition, studies with pulsed Doppler require obtainment of several samples along the myocardial walls, which increases the duration of the examination. The values obtained on Doppler tissue imaging also relate to cardiac translation motility; however, the data obtained did not aim at providing absolute values of velocity of myocardial contraction and expansion, but at comparatively assessing the 3 groups.

In conclusion, for studying the systolic function of Chagas' heart disease, Doppler tissue imaging proved to be superior to electrocardiography and conventional echo-Doppler cardiography in detecting incipient contractile abnormalities. This is because it shows regional alterations, allows the differentiation between normal patients and the chagasic ones with and without electrocardiographic alterations, and may be useful in the early detection of myocardial damage in those patients. Prospective studies of the longitudinal cohort type may confirm the efficacy of this method in evaluating the natural history of patients with myocardial alterations, thus far considered subclinical.

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