Tissue Doppler Imaging Limitations for Evaluating the Diastolic Function in Elderly People

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Abstract

Background: **Tissue Doppler imaging is a technique that complements the analysis of left ventricular (LV) diastolic function. Some factors may influence these parameters, however the true influence of age on Tissue Doppler velocities remains unclear.**

Objective: **To compare the indices of diastolic function derived from tissue Doppler imaging in hypertensive and non-hypertensive elderly individuals.**

Methods: **Subjects aged over 60 years, divided into two groups were studied: a control group (GC) without cardiovascular comorbidities and a hypertensive group (HAS). Left ventricular systolic and diastolic function (conventional and tissue Doppler) was assessed, and measurements of left atrial volumes and LV mass were obtained.**

Results: **The group consisted of 56 subjects (70.1 ± 6.6 years), 23 (41.1%) in the GC and 33 (58.9%) in the HAS. Except for LV hypertrophy, more frequent in the HAS group compared to HG (34.4% versus 4.8% respectively; p=0.017), all structural echocardiographic findings were similar. Tissue Doppler analysis revealed no differences between the groups (septal e': 8.0 ± 1.5 vs. 7.2 ± 1.9 cm/s; p=0.083 and lateral e': 9.8 ± 2.2 versus 8.7 ± 2.0 cm/s; p=0.074, respectively, for GC and HAS). A longer E-wave deceleration time was observed for HAS group (253 ± 62 versus 208 ± 36 ms in GC; p=0.003).**

Conclusion: **In the analysis of diastolic function in elderly, tissue Doppler imaging was not able to discriminate hypertensive individuals, with the greatest potential for the occurrence of diastolic dysfunction, to the non-hypertensive individuals.The E-wave deceleration time proved to be a valuable parameter in this population. (Arq Bras Cardiol: Imagem cardiovasc. 2014;27(3):184-190)**

Keywords: **Echocardiography, Doppler; Ventricular Function, Left; Aged; Hypertension.**

Introduction

The Heart Failure (HF) is one of the many causes of death and hospital admissions in our environment, and its prevalence is higher in the elderly population[1]. Around 30% to 40% of the individuals who develop HF have preserved systolic function, given they have diastolic dysfunction as the cause for this[1, 2]. There is higher prevalence of HF as a subsidiary to diastolic dysfunction in elderly individuals, as a consequence of the cardiovascular aging changes and the high incidence of comorbidities which cause diastolic dysfunction in this age group[2-8].

The hypertension is often associated with diastolic dysfunction[8, 9], with some studies revealing prevalence higher than 50% of the changes of diastolic function in hypertensive patients[10]. The chronic increase of cardiac after-load is an important element conducive to changes, such as the myocardial reshaping and hypertrophy, in addition to the increase of interstitial collagen, resulting in higher stiffness and ventricular relaxation. In this population, heart failure with preserved ejection fraction is prevalent and stands as an important cause for morbidity[8-11].

Echocardiography stands as the main non-invasive method for diagnosing and classifying the diastolic dysfunction. Traditional methods, such as the transmitral flows and pulmonary vein flows are known to be influenced by age[4]. The tissue Doppler imaging stands as a relatively recent technique, which supplements efficiently the analysis of the diastolic function and adds to the estimate of the left ventricular filling pressures[12, 13]. Some factors may present influence on its measurements, including age[6]. However, the appropriate contribution of this variable on the parameters used by the tissue Doppler imaging is not clear.

This study is targeted at comparing the behavior of the indices of the diastolic function derived from the tissue Doppler imaging and conventional Doppler imaging in elderly hypertensive individuals and non-hypertensive elderly individuals.

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Methodology

Population

Elderly patients were studies (age higher than 60 years old), of both genders, who sought hospital assistance for cardiac evaluation and were subject to transthoracic echocardiography. Patients were divided in the control group (CG) and the hypertensive group (HAS). The CG consisted of elderly people without known heart diseases. The HAS group was formed by patients who presented this diagnosis over at least one year and were regularly using antihypertensive medication. Additional clinical data were taken into the analysis, such as the presence of Diabetes Mellitus, Coronary Artery Disease and other possible coexisting diseases, contributing to the presence of the diastolic dysfunction. Patients who presented left ventricular systolic dysfunction (FE < 55%) were discarded, in addition to collagenosis or other diseases associated with heart morpho-functional abnormalities.

The study was approved by the Committee of Ethics in research of the institution (1713-13).

Echocardiography

For arranging data relating to the full analysis of the heart's anatomy, chiefly the study of the left ventricular systolic and diastolic functions, all of the patients underwent a 2D echocardiography with Doppler color imaging, spectral Doppler imaging and tissue Doppler imaging.

The measurements of diameters and diastolic thickness of the left ventricle were performed applying the 2D modality, with the resulting calculation of mass with the Devereaux's formula, subsequently indexed for the body surface area. The presence of left ventricular hypertrophy (LVH) was defined as a mass index higher than 115g/m^2 in men and higher than 95 g/m^2 in women[14]. The left ventricular ejection fraction was obtained applying the Teichholz's method. The measurement of the anteroposterior diameter of the left atrium (LA) was obtained based on the parasternal longitudinal plane, in T-wave of the electrocardiogram. The volumes of the left atrium were obtained from the apical plane four and two chambers applying the Simpson's method. Additional data about valve abnormalities, segmental contractility, great vessels and pericardium were also analyzed. The echocardiography was performed in keeping with the recommendations of the American Society of Echocardiography (ASE)[14].

Analysis of diastolic function

The mitral flow was assessed using the sample of the Doppler imaging volume of 2-3 mm positioned on the medial edge of mitral valve cuspids, in parallel and as close as possible to the center of flow, perpendicularly to the ring plane. The maximum velocities of the early (E) and the after (A) diastolic waves and the E-wave deceleration time (TD) were measured. The Isovolumic Relaxation Time (IVRT) was obtained from the apical plane five chambers, with the sample of the Doppler pulsed wave medial and anterior to the mitral valve, next to the left ventricular outflow tract, so as to simultaneously registering the transmitral flows, and the left ventricular outflow tract being afterwards measured based on the time interval between the closing of the aortic valve and the beginning of the mitral valve flow.

The pulmonary venous flow was assessed using the right inferior pulmonary vein from an apical four-chamber window. Then, the sample of volume of the Doppler pulsed wave was positioned 1 to 2 cm inside the outflow of the pulmonary vein, with a sampling volume of 3-5 mm for obtaining the systolic (S) and diastolic (D) waves and the left atrial reversed flow (Ar). In the presence of two systolic waves, only one wave was considered with the highest velocity peak.

The analysis was based on the scans of the tissue Doppler imaging obtained from the apical four chamber view with the sampling volume of the Doppler imaging of 3-5 mm positioned in the regions of the medial mitral ring (baseline of the ventricular septum), lateral mitral ring and lateral tricuspid ring, and the negative peaks of the diastolic velocities have been measured, corresponding to the peak of early diastolic velocity (e') late diastolic velocity (a'), in addition to the positive peak (s'), which represents the systolic movement. The ratio E/e' was calculated considering the average between the septal e' and lateral e' velocities.

All the echocardiographic finds were synchronized with the electrocardiographic scan. The Doppler imaging measurements are represented by the average of three beats.

The identification and classification of the diastolic function were performed based on the criteria of the American Society of Echocardiography[15]. A mild diastolic dysfunction was considered (ventricle relaxation abnormality), the presence of the septal e' < 8 cm/s, lateral e' < 10 cm/s, ratio E/A < 0.8 and ratio E/e' ≤ 8, usually associated with other parameters which confirm this classification, such as IVRT > 100 ms, TD > 200 ms, ration S/D > 1, velocity of reversed A wave (Ar) < 35 cm/s and difference between the time of waves Ar - A < 0 ms. The moderate diastolic function (pseudonormal standard) was characterized by the septal e' < 8 cm/s, lateral e' < 10 cm/s, ration E/A between 0.8 and 1.5, which diminished in 50% or more after the Valsalva maneuver, ration E/e' between 9 and 12, TD between 160 and 200 ms, ratio S/D < 1, reversed A-wave velocity (Ar) > 35 cm/s, difference between the times of waves Ar - A ≥ 30 ms and left atrial volume ≥ 34 ml/m^2. The significant diastolic function (restrictive) was characterized by septal e' < 8 cm/s, lateral e' < 10 cm/s, ratio E/A ≥ 2, ration E/e' ≥ 13, TD < 160 ms, ratio S/D < 1, reversed A-wave velocity (Ar) > 35 cm/s, difference between the times of waves Ar - A ≥ 30 ms and left atrial volume ≥ 34 ml/m^2.

The patients who did not present echocardiographic images with proper quality for assessment were not considered.

Statistic

The variables were expressed on average ± SD or ratios. The assessment between groups was performed by the unpaired Student's t-Test or Chi-square test, as the case may be. A ROC (Receiver Operating Characteristics) Curve was performed to assess which are the variables connected to the analysis of diastolic function with the best cutting point to predict the presence of the HAS group in this population sample. It was considered significant $p < 0.05$.

Results

A total of 56 individuals with more than 60 years old (average age of 70.1 ± 6.6 years old), being 33 women (58.9%) and 23 men (41.1%) had echocardiographies suitable for analysis and were included in the study. No patient presented significant valve disease or any other condition associated to the heart morpho-functional abnormalities. Only two patients (5%) were excluded due to presenting echocardiographic imaged with inappropriate quality.

The CG was formed by 23 individuals (41.1%) and HAS comprised 33 (58.9%).

In CG, three patients (15.8%) presented controlled dyslipidemia and six (21.4%) had thyroid disease. In HAS, three patients (9.1%) have Diabetes Mellitus, four (12%) had thyroid disease and six (18%) had dyslipidemia. Only one patient of HAS referred history of coronary disease associated, not clinically manifested. Among the groups, there was no significant difference connected to the main clinical characteristics (Table 1).

In HAS, 21 patients (63.6%) used regularly angiotensin-converting-enzyme inhibitors (ACE Inhibitors) or angiotensin II receptor blockers (BRA); 13 (39.3%), beta-blockers, 2 (6%), calcium channel blockers and 8 patients (24.2%) used an association of beta-blocker and ACE Inhibitors/BRA.

The left ventricular diameters were normal, without significant difference between groups. Relating to the measurements of the LA, although around one third of the patients presented increase in anteroposterior diameter, there was no significant difference among the groups, including the analysis of volume of the LA indexed to the body surface area, which presented average values within normality. The mass and the ventricular mass index were higher in the hypertensive patients' group, although with average values within the normal limits. LVH was present in 12 patients (34.4%) in HAS and in only one (4.8%) in CG (p = 0.017).

Table 2 shows the main echocardiographic data referring to the two groups.

Analysis of diastolic function

From all of the population studied, including the two groups, 29 patients (51.7%) presented ecocardiographic criteria which defined the presence of mild diastolic dysfunction, i.e., ventricle relaxation abnormality. This abnormality was present in 40.9% of the CG patients (9 individuals) and in 62.5% of the HAS patients (20 patients), with p = 0.118. There was no case of diastolic dysfunction in a higher degree than mild in the studied sample.

The study based on the Doppler pulsed wave of the transmitral flow did not reveal significant differences relating to the values of E-wave or IVRT waves between groups. However, in HAS, the velocity of A-wave was higher than that of CG (p = 0.009), resulting in a smaller ratio E/A in this group (p = 0.025). TD was more prolonged in group HAS

Table 1 – Clinical and demographic characteristics of the control and hypertensive patient groups (n = 56)

	Control Group (N = 23)	HAS (N = 33)	p
Age (years)	68.9 ± 6.8	70.9 ± 6.4	0.267
Female gender (n / %)	15 / 65.2	18 / 54.5	0.452
BMI (Kg/m^2)	26.4 ± 4.0	26.2 ± 4.1	0.797
DM (n/%)	0 / 0	3 / 9.1	0.261
DLP (n/%)	3 / 15.8	6 / 21.4	0.720

DM: Diabetes Mellitus; DLP: Dyslipidemia; BMI: Body Mass Index.

Table 2 – Echocardiographic characteristics of the control and hypertensive patient groups

	Control Group	HAS	p
LA (mm)	37.0 ± 5.8	38.0 ± 4.6	0.557
LVDD (mm)	44.2 ± 10.4	46.9 ± 4.3	0.189
LVSD (mm)	27.3 ± 6.7	29.8 ± 3.8	0.083
Mass (g)	144.2 ± 34.1	173.1 ± 49.4	0.048
Mass Index (g/m^2)	78.7 ± 15.7	91.3 ± 20.9	0.032
LVH (%)	4.8	34.4	0.017
LVEF	0.6 ± 0.1	0.7 ± 0.1	0.851
LA Volume (ml/m^2)	28.0 ± 6.9	27.9 ± 6.8	0.943

LA: Left Atrium; LVDD: Left Ventricular Diastolic Diameter; LVSD: Left Ventricular Systolic Diameter; LVEF: Left Ventricular Ejection Fraction; LVH: Left Ventricular Hypertrophy.

(p = 0,003), given that, in this group, there was a higher prevalence of abnormally elevated TD (69.7% *versus* 30.4% in CG; p = 0.004).

The velocities of waves S, D, ratio S/D, velocity and time of A-wave derived from the study of the pulmonary venous flow did not reveal different significant differences among groups.

The variables of the tissue Doppler imaging, represented by the velocities of septal e′, lateral e′, septal a′, lateral a′, septal s′, lateral s′ and ratio E/e′, did not present statistic differences between groups. The velocity values of the lateral e′ wave were smaller than the cutting value for the normality for the two groups. Although without statistical relevance (p = 0.074), there was a tendency to smaller velocities of the lateral e′ wave in HAS group. Similarly, for the septal e′ wave, the comparison between groups did not show significant difference (p = 0.083), however, lower average amounts than the cutting value for the normality only in HAS group.

Table 3 sums up the main findings connected to the study of the diastolic function between groups.

Table 4 shows that data obtained from a ROC curve, performed for DT variables, E wave, A wave, ratio E/A, septal e′ wave and lateral e′ wave relating to the presence of hypertension. Only the DT and the A wave (are resulting ratio E/A) presented statistical significance for the presence of hypertension. DT presented area under the ROC curve (AUC) of 0.74 with the best cutting point in this sample de 215 ms (sensibility = 73%, specificity = 61 %). Figure 1 shows the graph of the area under the curve (AUC) of parameter TD.

Discussion

Heart failure is an important cause of disability and mortality in an elderly individual, and in around 30% to 40% of the cases, the systolic function is preserved[1,3]. There is higher prevalence of systolic dysfunction in this age group as a consequence of cardiovascular abnormalities connected to aging and the higher incidence of comorbidities which cause this condition[5-8].

Table 3 – Spectral and Tissue Doppler Imaging for the control and hypertensive patient groups

	Control Group	HAS	p
E	63 ± 16	62 ± 18	0.737
A	71 ± 17	84 ± 19	0.009
E/A	0.9 ± 0.3	0.8 ± 0.2	0.025
TD	208 ± 36	253 ± 62	0.003
TA	137.3 ± 16.0	131.4 ± 30.4	0.395
IVRT	98 ± 16	99 ± 17	0.837
Pulmonary Flow S	53 ± 18.0	55 ± 10.2	0.564
Pulmonary Flow D	46 ± 14.0	40 ± 14.0	0.132
Air Velocity	31.5 ± 5.6	32.8 ± 8.1	0.533
Septal s’	7.7 ± 1.6	7.7 ± 2.1	0.943
Septal e'	8.0 ± 1.5	7.2 ± 1.8	0.083
Lateral s’	9.6 ± 2.7	8.8 ± 1.5	0.171
Lateral e'	9.8 ± 2.2	8.7 ± 2.0	0.074
E/e'	8.3 ± 2.8	8.6 ± 3.2	0.787

Ar: Atrial Reverse Wave of the Pulmonary Venous Flow; D: Diastolic Wave; HAS: Artery Hypertension Group; S: Systolic Wave; TA: A Wave Time; TD: E Wave Deceleration Time; IVRT: Isovolumic Relaxation Time.

Table 4 – ROC Curve data for the echocardiographic variables relating to the presence of hypertension

Variable	Area above the ROC Curve	Standard Error	p	Cutting Point	Sensibility (%)	Specificity (%)
TD	0.735	0.067	0.003	214.5	72.7	60.9
E	0.534	0.079	0.671	63.0	60.9	60.6
A	0.717	0.072	0.006	74.5	72.7	73.9
E/A	0.665	0.077	0.037	0.79	60.9	60.6
Septal e'	0.632	0.075	0.094	7.9	60.9	57.6
Lateral e'	0.630	0.077	0.103	9.1	65.2	62.5

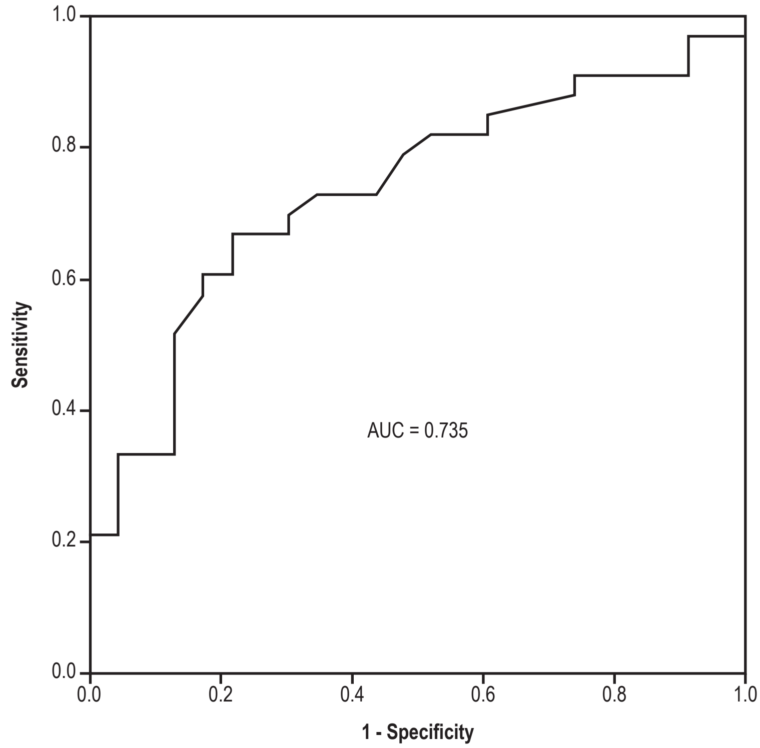

Figure 1 – *ROC (Receiver Operating Characteristics) Curve for the E deceleration time in hypertensive patients. AUC = area under the ROC curve.*

The abnormality of diastolic function is frequent in those having systemic artery hypertension. This fact is connected to the increase of interstitial collagen and myocardial hypertrophy combined with to the increase of cardiac after-load[8-10]. As the systemic artery hypertension is a condition which frequently coexists in elderly people, the accurate discrimination of the presence of mild diastolic dysfunction stands as a challenge, as most of the echocardiographic parameters have an influence on age.

Although the studies describe a prognosis better than that connected to heart failure predominantly systolic, the diastolic HF presents high mortality indices and, principally, morbidity in the long run[16-20]. Therefore, its proper diagnosis and classification are capital and the echocardiographic study plays an essential role in this context.

This study reviewed echocardiographic findings in elderly people, divided in a control group (without cardiovascular comorbidities) and a group of hypertensive individuals (and it may present other associated comorbidities, such as Diabetes Mellitus and coronary disease), with a higher potential for occurrence of diastolic dysfunction, and, thus, compared the behavior of the diastolic dysfunction indices between the groups.

Several studies reveal the efficacy of the parameters coming from the tissue Doppler imaging for assessing the diastolic function and the estimate of the left ventricular filling pressures. Differently from what happens to traditional methods, this technique is significantly connected to the invasive measures and showed a relative independence from the cardiac preload[21-23], being appropriate for the supplementing of the analysis of the diastolic function. However, despite not consistently clarified, it is known that the tissue Doppler imaging velocities may present progressive decrease after 60 years old[6].

Interestingly, in our study, the analysis of all of the parameters derived from the tissue Doppler imaging, including the septal e' and lateral e' waves and the ratio E/e' did not reveal significant statistical differences among the Control Group and the group of hypertensive patients, confirming the limitations of this technique for assessing the diastolic function in the population above 60 years old. Tighe et al.[6], in a study with 103 normal individuals, observed that the parameters derived from the Doppler tissue imaging are potentially influenced by age[6]. This segment confirms this finding, as it observed only a certain tendency to smaller velocities in the group of hypertensive patients, without statistical meaning. Both groups presented lateral e' wave velocities lower than the value defined by the literature for the presence of diastolic dysfunction. Relating to the velocities of septal velocities, although values smaller than normality have been found for hypertensive patients, the CG presented borderline values, not statistically different from HAS.

The ROC curve revealed that, in this population, relating to the literature reference values, the accuracy of septal e' lateral waves was smaller (septal e' smaller than 7.9 cm/s with sensibility of 60.9% and specificity of 57.6% and lateral e' smaller than 9.1 cm/s with sensibility of 65.2% and specificity of 62.5%) to ascertain the presence of HAS.

Relating to the transmitral flow, some parameters did not show significant differences among groups. On the other hand, we found not only a longer TD, but also a higher frequency of TD values abnormally high in HAS, pointing to the assumption that this variable may be more suitable to identify the diastolic dysfunction in the population selected (elderly people with mild diastolic dysfunction).

Additionally, TD (with cutting value of 215 ms) presented a higher sensibility to identify the presence of HAS for the population chosen.

It should be stressed that, with the development of the diastolic dysfunction, there is an increase in the LV filling pressures and, as a consequence, a decrease of TD (standard of pseudonormal and/or restrictive transmitral flow). In this situation, TD would not be an appropriate parameter and, possibly, there would be a more significant jeopardy if the velocities derived from the tissue Doppler imaging.

Still relating to the transmitral Doppler imaging, the velocity of A wave was higher in the group of hypertensive patients ($p = 0.009$), resulting in smaller absolute values of the ratio E/A. The elevation of the A-wave velocity may be connected to the increased left atrial function in given stages of systemic artery hypertension with mild diastolic dysfunction, although this abnormality is part of the natural aging process. The ROC curve revealed that the values of the A wave are higher than 74.5 cm/s which would identify HAS with a sensibility of 72.7% and specificity of 73.9%.

In addition to this, the analysis of the ROC curve also confirmed, for elderly people, the literature reference values for the ratio E/A (< 0,8), although with lower sensibility (60.9%) than DT and the A-wave, and the specificity was similar (60.6%).

The velocities derived from the study of pulmonary venous flow did not reveal significant statistical differences among groups, which may be connected to the fact that no case of diastolic dysfunction of a degree higher than mild has been reported, when these parameters are usually subject to changes[24].

The group of hypertensive patients studied included mainly elderly people using medication properly, which probably resulted in more controlled pressure levels and, as a consequence, mild degrees of diastolic dysfunction, a fact which may be evidenced by atriums with normal volumes and low prevalence of left ventricular hypertrophy. On the other hand, the sample described reflects characteristics of the population of elderly people typically found in clinical practice.

The fact that it was studied a relatively small population sample may be considered a limitations of this study. Besides this, the division of groups occurred in such a way to assume a higher potential of diastolic dysfunction in the group of hypertensive people. However, there is no certainty about the occurrence of this process, especially when there is an established treatment and proper control of pressure levels. There was a gold standard for comparison of the diastolic function in this study, although invasive measures would not be ethically justified.

Conclusion

In the analysis of the diastolic function in elderly people, the tissue Doppler imaging was not capable of accurately discriminating hypertensive individuals presenting a higher potential for occurrence of diastolic dysfunction and individuals not presenting hypertension. In this selected group, the E-wave deceleration time revealed to be a parameter to be appreciated.

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