Original Article

Changes in the Parameters of Left Ventricular Diastolic Function According to Age on Tissue Doppler Imaging

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Objective
To determine the correlation between diastolic velocities on tissue Doppler imaging and age in a sample of healthy adults and to correlate age with the velocities of transmitral and pulmonary vein flows.

Methods
Echocardiographic assessment of 51 healthy individuals, whose ages ranged from 21 to 69 years. The diastolic myocardial velocities were recorded on tissue Doppler imaging. The velocities of the transmitral and pulmonary vein flows were also determined.

Results
The initial basal septal and basal lateral diastolic myocardial velocities showed an inverse correlation with age \( r = -0.40 \) \((P = 0.004)\), and \( r = -0.60 \) \((P = 0.0001)\), respectively. The atriovenous velocities of tissue Doppler imaging correlated directly with age \( r = 0.56 \) \((P = 0.0001)\) in the basal septal segment and \( r = 0.50 \) \((P = 0.0001)\) in the basal lateral segment. The velocities of transmitral and pulmonary vein flows also correlated with age.

Conclusion
Age correlates with the tissue Doppler diastolic myocardial velocities and with the velocities of transmitral and pulmonary vein flows. In healthy individuals, the parameters of left ventricular diastolic function vary with the natural evolution of age.

Key words
echocardiography, tissue Doppler imaging, left ventricular diastolic function

The understanding of left ventricular diastolic function has stimulated medical research, because congestive heart failure is a severe public health problem associated with significant morbidity and mortality. A significant proportion (50%) of patients 1 with congestive heart failure has preserved systolic function. Patients with diastolic heart failure have a mortality risk 5 to 8 times greater than that of the healthy population 2.

Of the methods for diagnosing diastolic dysfunction, Doppler echocardiography has evolved greatly in recent years. The often-used conventional echocardiographic techniques (transmitral Doppler and pulmonary vein Doppler), although very useful, have flaws and limitations. However, tissue Doppler, with its capacity for measuring myocardial velocities, and because it does not undergo significant alterations with afterload changes, has played an important role in determining diastolic dysfunction 3-9.

The distinction between normal physiology and pathological processes presupposes an appropriate knowledge of the normality pattern in the population studied. Myocardial compliance and relaxation are known to change with age, and different patterns of diastolic filling are expected for distinct age groups. However, several studies on diastolic function and diastolic heart failure have used only young individuals as the control group 10. Thus, the assessment of variations in left ventricular diastolic myocardial velocities in healthy individuals according to age by use of tissue Doppler imaging will contribute to a better understanding and evaluation of the diastolic function.

The major objective of this study was to determine the correlation between the regional myocardial diastolic velocities on tissue Doppler imaging and age in a sample of healthy individuals. The secondary objective was to demonstrate the correlation of age with the velocities of conventional Doppler (Doppler of the transmitral and pulmonary vein flows).

Methods
This study assessed 51 healthy, active volunteers (23 men and 28 women), whose ages ranged from 21 to 69 years. All participants had normal heart rate and blood pressure levels. Neither smoking, nor use of medication, nor history of diabetes mellitus or cardiovascular disease was reported. All participants had normal electrocardiograms and transthoracic echocardiograms, and none of them was an athlete.

All participants signed a written informed consent, which had been approved by the Committee on Ethics at the institution where the study was performed.
All participants underwent complete transthoracic echocardiographic study with analysis focused on the parameters of left ventricular diastolic function.

The examinations were performed in the echocardiography laboratory at our institution, with an HP Sonus 2500 echocardiographic device equipped with multifrequency transducer. A native tissue Doppler device was also available. All images were obtained by the same observer with a concomitant electrocardiographic tracing. All examinations were analyzed while being performed, recorded on a VHS tape, later being reassessed by a second observer.

The dimensions of the cardiac cavities were measured by use of M mode and recorded in all participants. The criteria adopted were those recommended by the American Society of Echocardiography11.

The myocardial diastolic velocities (fig. 1) of the mitral ring and of the left ventricular basal septal and basal lateral segments12 obtained on the apical 4-chamber view were recorded on tissue Doppler. In each segment, the initial (E’) and atriogenic (A’) diastolic velocities were determined (fig.1). Each value recorded resulted from the arithmetic mean of 8 to 10 complexes.

The transmitral flow velocity was measured on the apical 4-chamber view, with a sample volume positioned at the extremity of the mitral valve leaflets. The initial (E wave) and atriogenic (A wave) diastolic velocities, and the time for deceleration (TD) were recorded. The velocities of pulmonary vein flow were determined in the same echocardiographic view, with a sample volume positioned 1 cm below the orifice of the right superior pulmonary vein in the left atrium. The following velocities were recorded: systolic, diastolic, and the reverse atrial pulmonary vein flow (PVa) 13.

The continuous variables were presented as means and standard deviations.

The Pearson correlation was adopted for assessing the association between age and diastolic variables. Diagrams of dispersion were used for the graphic demonstration of these relations.

Age was categorized into 2 groups (< 40 years and > 40 years), and the diastolic measures were compared by using the Student t test for independent samples.

The 8.0 version of the statistical program SPSS was used for data analysis.

The alpha level adopted for the comparisons was 0.05.

Results

The means and respective standard deviations of the myocardial diastolic velocities obtained in the basal septal and basal lateral segments are shown in table I, as are the velocities of transmitral flow and pulmonary vein flow. Data were divided into 2 groups (above and below 40 years of age).

The myocardial diastolic velocities were observed to correlate with age (fig. 2 and 3).

The initial basal septal and basal lateral myocardial diastolic velocities were inversely correlated with age \( r = -0.40, P = 0.004 \), in the basal septal segment (fig. 2-A), and \( r = -0.60, P = 0.0001 \), in the basal lateral segment (fig. 2-B).

The atriogenic velocities were directly correlated with age \( r = 0.56, P = 0.0001 \), in the basal septal segment (fig. 3-A), and \( r = 0.50, P = 0.0001 \), in the basal lateral segment (fig. 3-B).

The velocities of transmitral flow also correlated with age (fig. 4). Figure 4-A shows an inverse correlation of age with initial diastolic velocity \( r = -0.36, P = 0.009 \), and figure 4-B shows a direct correlation of age with atriogenic velocity \( r = 0.40, P = 0.004 \).

When assessing the pulmonary venous flow, an inverse correlation with age was observed \( r = -0.40, P = 0.004 \) (fig.5-A), and a direct correlation with systolic velocity was observed \( r = 0.33, P = 0.02 \). The amplitude of the reverse pulmonary A wave also had a direct correlation with age \( r = 0.57, P = 0.0001 \) (fig.5-B).

Discussion

Tissue Doppler imaging has been extensively studied and has proved, among other applications, to be useful in the following situations: the differential diagnosis between constrictive pericarditis and restrictive cardiomyopathy, in the follow-up of heart transplantation, in assessing the segmentary ventricular function, and in the diagnostic differentiation between pathological and physiological ventricular hypertrophy13,14-16. The method has also been studied for assessing left and right ventricular systolic function17-20.

Table I - Tissue Doppler velocities: transmitral flow and pulmonary venous flow in healthy individuals

<table>
<thead>
<tr>
<th>Parameters</th>
<th>&lt; 40 years (n = 22)</th>
<th>&gt; 40 years (n = 29)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>E' (cm/s)</td>
<td>9.8 ± 1.9</td>
<td>8.1 ± 1.8</td>
<td>0.002</td>
</tr>
<tr>
<td>E (cm/s)</td>
<td>13 ± 2.8</td>
<td>9.4 ± 2.3</td>
<td>0.0001</td>
</tr>
<tr>
<td>A (cm/s)</td>
<td>5.5 ± 1.2</td>
<td>7.2 ± 1.6</td>
<td>0.001</td>
</tr>
<tr>
<td>A mitral (cm/s)</td>
<td>5.8 ± 1.6</td>
<td>7.3 ± 1.5</td>
<td>0.011</td>
</tr>
<tr>
<td>A mitral (cm/s)</td>
<td>93 ± 31</td>
<td>74 ± 23</td>
<td>0.014</td>
</tr>
<tr>
<td>E mitral (cm/s)</td>
<td>49 ± 14</td>
<td>61 ± 17</td>
<td>0.008</td>
</tr>
<tr>
<td>E/A ratio</td>
<td>1.9 ± 0.4</td>
<td>1.2 ± 0.3</td>
<td>0.0001</td>
</tr>
<tr>
<td>TD (ms)</td>
<td>142 ± 13</td>
<td>154 ± 29</td>
<td>0.06</td>
</tr>
<tr>
<td>SP (cm/s)</td>
<td>42 ± 9</td>
<td>50 ± 19</td>
<td>0.08</td>
</tr>
<tr>
<td>DP (cm/s)</td>
<td>45 ± 9</td>
<td>35 ± 9</td>
<td>0.001</td>
</tr>
<tr>
<td>S/D ratio</td>
<td>1.0 ± 0.2</td>
<td>1.4 ± 0.5</td>
<td>0.0001</td>
</tr>
<tr>
<td>PVa (cm/s)</td>
<td>23 ± 4</td>
<td>30 ± 5</td>
<td>0.0001</td>
</tr>
<tr>
<td>E/E’ ratio</td>
<td>7.5 ± 3</td>
<td>8.1 ± 2.6</td>
<td>0.412</td>
</tr>
<tr>
<td>E/E’S ratio</td>
<td>9.8 ± 3.5</td>
<td>9.3 ± 2.8</td>
<td>0.553</td>
</tr>
</tbody>
</table>

E’ - initial basal septal myocardial diastolic velocity; E - initial basal lateral myocardial diastolic velocity; A - atriogenic basal septal myocardial diastolic velocity; A'L - atriogenic basal lateral myocardial diastolic velocity; E mitral and A mitral - velocities of transmitral flow; TD - time for deceleration; SP - systolic velocity of pulmonary venous flow; DP - diastolic velocity of pulmonary venous flow; PVa - reverse atrial wave velocity of pulmonary venous flow.

Fig. 1 - Tissue Doppler imaging: myocardial diastolic velocities in the basal lateral segment.
Changes in the Parameters of Left Ventricular Diastolic Function According to Age on Tissue Doppler Imaging

As age advances, a gradual reduction in the myocardial relaxation rate occurs, as well as in the elastic shortening, which results in a delayed decline in left ventricular pressure and a delayed ventricular filling. 21-23.

Our results showed that the initial myocardial diastolic velocities are inversely correlated with age, and this effect is more evident in the basal lateral segment. Concomitantly, atriogenic myocardial velocities were observed to increase with age progression, and, therefore, a direct correlation exists between them. We believe that these manifestations may reflect a gradual decline
in the left ventricular initial diastolic filling, with a compensatory increase in the contribution of atrial systole to maintain an appropriate ventricular filling volume.

Our indices show a correlation of moderate magnitude (qualitative assessment by use of the Pearson coefficient), which is relevant in this context, because we are comparing the correlation between 2 distinct elements (age and velocities of cardiac muscle motion).

As previously reported in the literature 24-26, the Doppler velocities of the transmural flow and pulmonary venous flow in our study also correlate with age. The most evident association was expressed by the direct correlation between age and the velocity of reverse atrial pulmonary venous flow.

Dividing the participants of the study into 2 groups according to age, above and below 40 years, a significant difference in the absolute values is observed between the groups, both in regard to the myocardial velocities determined on tissue Doppler, and in regard to the velocities of transmural Doppler and the velocities of the diastolic and atrial reverse waves of pulmonary venous flow.

All these manifestations may be related to alterations in the left ventricular diastolic performance associated with the natural aging process.

The E/E’ ratio showed no difference between the groups. This may be because that ratio assesses 2 parameters that in isolation vary with age in the same direction (both decrease with age), which means that, as those velocities vary independently with age, their ratio remains constant.

According to the study by Ommen et al 27, the E/E’ ratio plays an important role in estimating the ventricular filling pressures as follows: patients with E/E’ > 15 had elevated ventricular filling pressures, and those with E/E’ < 8 had normal or low ventricular filling pressures.

Thus, this study emphasizes the usefulness of that ratio for assessing the ventricular diastolic function, because, in healthy individuals, the E/E’ ratio does not vary with age.

The results of this study could be amplified if the number of participants > 60 years was greater, stratifying the sample in narrower age groups, allowing a more detailed study of a group with more advanced age.

In conclusion, according to our data, the myocardial diastolic velocities of tissue Doppler and age correlate, which is shown by the variation in the parameters of left ventricular diastolic function with aging.

Our results serve as a reference for the analysis of the diastolic function by use of tissue Doppler and emphasizes the importance of a population-based study for a more accurate definition of the parameters of diastolic function in each age group, improving the accuracy of echocardiography in the diagnosis of ventricular diastolic dysfunction.

References