Evaluation of Systolic and Diastolic Function of Left Ventricle by Using Velocities of Mitral Annulus in Patients with First Acute Anterior MI and Their one Month Follow up

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(Received 17 Dec 2009; Accepted 26 Jan 2010)

Abstract

Background: To evaluate systolic and diastolic dysfunction of left ventricle in patients with first anterior myocardial infarction and its relation to one month mortality after myocardial infarction; in this study mitral annulus motion velocity that was recorded by Tissue Doppler Imaging (TDI).

Methods: The study included 111 consecutive individuals, 81 patients with first anterior myocardial infarction, (in which 72 patients who survived and 9 patients died one month after admission), 30 individuals which matched with the studying group selected as a control group. Longitudinal function of left ventricle was evaluated by the use of mitral annular velocities in this study.

Results: Patients with myocardial infarction showed significant reduction in peak systolic, early diastolic and late diastolic annular mitral velocities comparing with control group in all studied segments. There was a good correlation between Left Ventricle Ejection Fraction (LVEF) and all mitral valve annular velocities. Also Myocardial Performance Index (MPI) more than 0.8 and (Regional Wall Motion Scoring Index (RWMSI) more than 1.77 had high sensitivity (0.94 and 0.96 respectively) in predicting death in follow-up period.

Conclusion: Reduced peak systolic mitral annulus velocity is an expression of regionally reduced systolic function. Reduced peak early and late diastolic velocities reflect regional diastolic dysfunction. Also Regional wall motion score index and myocardial performance index can be useful in predicting death after myocardial infarction.

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Keywords: Myocardial infarction” Mitral annulus” Left ventricle
Introduction

Left ventricular wall motion assessment is one of the most important procedures in evaluating left ventricular function. Regional wall motion is closely related to the status of the cardiac muscle in these local areas. However, it is still difficult to evaluate wall motion quantitatively in real time by conventional techniques. Common techniques in use, allowing the assessment of left ventricular function, have focused on the analysis of endocardial excursion. Tissue Doppler imaging (TDI) is a sensitive, noninvasive echocardiographic method that records velocity of tissue motion within the myocardium. TDI has been evaluated in both in vitro and in vivo studies, allowing for the quantitative assessment of both global and regional function of the myocardium. Indices derived from TDI, including systolic velocity (S'), early (E') and late (A') diastolic velocities of the lateral mitral annulus, are reduced in patients with heart failure (EF < 30%) and portend a poor prognosis. Transmitral to early diastolic velocity ratio (E/E') obtained via TDI correlates strongly with LV filling pressures. An E/E' ratio > 10 identifies a pulmonary capillary wedge pressure (PCWP) > 15 mm Hg with a sensitivity of 92% and a specificity of 80%. In addition to chronic CHF, a higher E/E' also has been shown to be correlated with a worse prognosis in acute myocardial ischemia and hypertension. Here, in this study our aims were to evaluate mitral valve annular velocities in different left ventricular segments in patients with first anterior myocardial infarction by means of TDI and to compare them with matched healthy control group.

Methods

Doppler tissue imaging system

We used conventional ultrasound equipment (Vivid 7, GE, U.S.A.) with a phased array transducer 2.5 to 4 MHz and software modifications which allowed the display of regional velocities within the myocardium by M-mode colour Doppler tissue imaging. The concept and technical aspects of the imaging system used in this study have been described in detail elsewhere. To permit the acquisition of velocity information, the sensitivity of the scanner has been reduced to allow the tissue echoes to pass through the clutter filter and remove the blood signals, i.e. to accommodate high echo-amplitude and low Doppler velocity signals. The Doppler velocity range was also reduced to correspond to the known velocities of the ventricular wall. Doppler gain and filters were adjusted to obtain the best spectral recordings and the transmitral peak rapid filling velocity (E), peak atrial filling velocity (A) and E-wave deceleration time. Indices derived from TDI, including systolic velocity (S'), early (E') and late (A') diastolic velocities of the lateral, septal, anterior and inferior mitral annulus.

Study group

81 consecutive patients with first acute anterior myocardial infarction having normal sinus rhythm and no bundle branch block, diabetes mellitus, hypertension, previous myocardial infarction (MI) and valvular heart disease were included to participate in the study. The diagnosis of acute myocardial infarction had been confirmed by electrocardiographic features, a rise in creatine kinase MB and Troponin-I enzymes and a marked segmental asynergy at conventional echocardiography. Echocardiographic images were recorded within the first week after the onset of myocardial infarction. All patients in the group received Streptokinase (SK). The control group comprised 30 matched healthy volunteers who had normal conventional echocardiographic findings and no history of prior cardiomyopathy, angina, arrhythmias, systemic hypertension or diabetes mellitus. The two groups were similar with respect to baseline demographics, cardiovascular risk factors, and 2D echocardiographic parameters. The basic clinical and conventional echocardiographic parameters for the patients and the healthy subjects are shown in Table 1 and 2, respectively.

Table 1 - Basic clinical parameters of the subjects

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Age</th>
<th>male</th>
<th>female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy subjects (n=30)</td>
<td>55.7±17.74</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Subjects with MI which survived one month after MI (n=72)</td>
<td>60.9±13.98</td>
<td>51</td>
<td>21</td>
</tr>
<tr>
<td>Subjects with MI which died within one month after MI (n=9)</td>
<td>64.7±10.61</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>
**Table 2 - conventional echocardiographic findings of 3 groups**

<table>
<thead>
<tr>
<th>LVEF</th>
<th>Diastolic dysfunction</th>
<th>RWMSI</th>
<th>MPI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal</td>
<td>mild</td>
<td>moderate</td>
</tr>
<tr>
<td>Healthy subjects (n=30)</td>
<td>0.46±0.03*</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Subjects with MI which survive one month after MI (n=72)</td>
<td>1.56±0.15*</td>
<td>53</td>
<td>20</td>
</tr>
<tr>
<td>Subjects with MI which dead within one month after MI (n=9)</td>
<td>1.91±0.19*</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

*Identifies significant difference between 3 groups (p<0.0005)

LVEF: Left Ventricular Ejection Fraction
RWMSI: Regional Wall Motion Scoring Index
MPI: Myocardial Performance Index

**Statistical analysis**

Statistical analysis was undertaken using an unpaired Student t test and $\chi^2$ analysis for continuous and categorical variables, respectively. Paired Student t-test to analyze data within a group and an unpaired t-test to analyze data in different were used, Stepwise linear regression method was used to identify correlations.

**Results**

The total population included 111 patients, mean age 60.7±13.4. Group I consisted of 72 patients 60.9±13.8 years old with anterior MI which were alive one month after MI. Group II consisted of subjects with MI which expired within one month after MI [8 males (64.7±10.6 years) and one 75 year-old female] and group III consisted of 30 healthy subjects, 17 males, 13 females, mean age 55.7±17.7 years. (Table 1) The three groups were similar with respect to baseline demographics, in cardiovascular risk factors, and 2D echocardiographic parameters. In subjects with MI which survived within one month after MI, 53, 20 and 8 patients had Mild, moderate, and severe diastolic dysfunction, respectively. $\chi^2$ test was impossible because of small number of subjects. Differences between TDI findings of 3 groups are given in table 3. There were significant differences between all parameters of 3 groups except septal ratio (septal E/A') and ant. Ratio (Table 3). LVEF correlated well with RWMSI, MPI, S. mean, A-mean and E’. mean ($r=-0.81$, -0.51, +0.64, +0.67, +0.59 respectively, p<0.0005). RWMSI had good correlation with S^1, mean, A^2, mean, E^3, mean and MPI ($r=-0.67$, -0.69, -0.64, +0.58 respectively, p<0.001) Also MPI correlated well with A‘, mean, E’, mean, S. mean ($r=-0.66$, $r=-0.36$, -0.28 respectively, p<0.001). MPI more than 0.8 and RWMSI more than 1.77 had high sensitivity (0.94 and 0.96 respectively) in predicting death within the follow-up period (figure1). When patients with RWMSI>1.77 and/or MPI>0.8 were compared with patients that had RWMSI<1.77 and/or MPI<0.8, these patients had higher one month mortality (figure 2). Sixty four patients (88.9%) who remained alive within one month and 1 patient (11.1%) who died in this period had MPI<0.8. However 8 patients (88.9% of subjects) that died in follow-up period had MPI>0.8 (p<0.001).

![ROC Curve](https://www.sid.ir)

**Fig 1- Predicting Death Within the Follow-up Period**

1. Peak Systolic Wave (TDI)
2. Peak Early Diastolic Wave (TDI)
3. Peak Late Diastolic Wave (TDI)
Patients with RWMSI > 1.77 and/or MPI > 0.8 compared with patients that had RWMSI < 1.77 and/or MPI < 0.8, these patients had higher one month mortality.

Compared with healthy subjects, the MI patients had a significantly reduced peak systolic velocity at all 4 sites of the mitral annulus (Table 3). Recordings of mitral annular motion and mitral annular velocities by TDI were possible in all the patients. Also we found a reduced mitral annular diastolic myocardial velocities (Table 3). In patients with anterior MI, the reduced velocity was more pronounced at the anterior wall than at other sites (Table 3).

**Table 3 - TDI findings of subjects**

<table>
<thead>
<tr>
<th>Variables</th>
<th>MI (mean ± SD)</th>
<th>Death (mean ± SD)</th>
<th>Control Group (SD ± mean)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>S- septal</td>
<td>6.16 ± 1.58</td>
<td>4.66 ± 1.11</td>
<td>13.27 ± 3.31</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S- anterior</td>
<td>8.19 ± 7.19</td>
<td>5.11 ± 1.45</td>
<td>15.72 ± 2.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S- lateral</td>
<td>7.72 ± 2.40</td>
<td>5.44 ± 1.81</td>
<td>15.9 ± 3.26</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S- inferior</td>
<td>7 ± 1.68</td>
<td>5.33 ± 1.22</td>
<td>14.36 ± 2.94</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E' septal</td>
<td>4.73 ± 1.75</td>
<td>3.77 ± 1.48/1</td>
<td>15.63 ± 6.02</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E' anterior</td>
<td>6.62 ± 2.77</td>
<td>6 ± 2.44</td>
<td>18.63 ± 6.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E' inferior</td>
<td>5.23 ± 2.16</td>
<td>3.66 ± 1.22</td>
<td>17.18 ± 7.63</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E' lateral</td>
<td>6.45 ± 2.69</td>
<td>4.33 ± 4.58</td>
<td>19.63 ± 8.24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A' anterior</td>
<td>9.55 ± 2.64</td>
<td>8.77 ± 2.43</td>
<td>22.45 ± 8.27</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A' lateral</td>
<td>10.13 ± 2.94</td>
<td>8.33 ± 2.91</td>
<td>20.45 ± 6.65</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A' inferior</td>
<td>9.88 ± 3.05</td>
<td>9.11 ± 3.48</td>
<td>18.63 ± 5.32</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A' septal</td>
<td>8.4 ± 2.38</td>
<td>7.88 ± 2.52</td>
<td>19.18 ± 7.34</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S. mean</td>
<td>7.27 ± 2.3</td>
<td>5.13 ± 1.12</td>
<td>14.18 ± 2.56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>E'. mean</td>
<td>5.76 ± 1.89</td>
<td>4.19 ± 1.35</td>
<td>17.77 ± 6.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A'. mean</td>
<td>9.49 ± 2.15</td>
<td>8.52 ± 2.52</td>
<td>20.11 ± 6.16</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Septal. Ratio</td>
<td>0.61 ± 0.37</td>
<td>0.51 ± 0.25</td>
<td>0.87 ± 0.36</td>
<td>&lt;0.54</td>
</tr>
<tr>
<td>Anterior. Ratio</td>
<td>0.79 ± 0.62</td>
<td>0.62 ± 0.35</td>
<td>1.01 ± 0.66</td>
<td>&lt;0.34</td>
</tr>
<tr>
<td>Inferior. Ratio</td>
<td>0.6 ± 0.44</td>
<td>0.49 ± 0.34</td>
<td>0.95 ± 0.34</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lateral. Ratio</td>
<td>0.71 ± 0.47</td>
<td>0.61 ± 0.39</td>
<td>1.06 ± 0.58</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

S' : Peak Systolic Wave (TDI)
E' : Peak Early Diastolic Wave (TDI)
A' : Peak Late Diastolic Wave (TDI)
Ratio: E/A

**Discussion**

Left ventricular contraction involves both a reduction of the short-axis diameter and a shortening along the longitudinal axis of the chamber. The longitudinal systolic shortening of the left ventricle is reflected by the motion of the mitral annulus toward the cardiac apex in systole, whereas its recoil away from the apex is the result of diastole. As there is no appreciable motion of the apex in relation to the imaging transducer, the magnitude of the mitral annular motion reflects the extent of myocardial shortening along its longitudinal axis. Recording the mitral annular motion has the advantage that it is devoid of trabeculae, myocardial dropout, etc, and therefore is independent of echo quality. Further analysis by quantifying the myocardial velocities by using of...
TDI opens up a new possibility of assessing LV function along the long axis. The major advantage of pulsed wave mitral annular velocity measurements is that the ultrasound beam is parallel to the LV contraction. Moreover, it probably measures the transmural myocardial velocity, not only the epicardial or endocardial velocities. Recording of LV velocity by pulsed wave TDI at different mitral annular sites is easy. We were able to record it at all the LV sites in all the patients. In addition, the method is highly reproducible with low interobserver and intraobserver variabilities.

Yilmaz et al found that in heart failure and after myocardial infarction, (E/Ea or E/Em) ratio lower than 8 identifies patients with normal left ventricular pressures whereas E/Ea > or =15 usually associated with increased LV diastolic pressures. In the present study, after a first anterior MI, a significant regional difference was found in the peak systolic velocity at the mitral annulus related to the infarction site. These findings are similar to the findings of Alam, Palmes and Carot studies.

Anterior MI patients had lower velocities at the anterior wall and septum than other sites. The reduced velocity at the infarction site is an expression of myocardial damage after MI. In addition to the reduced systolic velocity at the infarction sites in anterior MI, the systolic velocity at the noninfarction sites was also reduced compared with that of healthy subjects. Similar finding was found in Alam study, too. Systolic velocities (S-Wave at 4 different sites) and S- mean were significantly decreased in subjects with anterior MI. Who died within one month after MI compared with subjects who survived this period. Yilmaz et al demonstrated that mitral annular velocities derived by pulsed wave Doppler tissue imaging are simple to obtain even in technically suboptimal studies, and can be used for predicting LV thrombus formation after myocardial infarction. Although the myocardial velocity and ejection fraction are two different measurements, our study demonstrates a relatively good and highly significant correlation between the mean peak systolic velocity of the mitral annulus and the LV ejection fraction. Left ventricular diastolic dysfunction may occur after MI. Other associated diseases (eg, systemic hypertension, valvular heart disease, cardiomyopathy, and diabetes mellitus) may also influence diastolic function. To assess the effects of a first MI on the myocardial diastolic velocities, we included only patients without a history of previous disease. The peak early diastolic velocity of the left ventricle along its long axis was significantly decreased in anterior MI compared with that in healthy subjects. Similar to the systolic velocity, the decrease in the early diastolic velocity was more pronounced at the infarction sites. Diastolic velocities (E´ at 4 different sites) and E- mean in the three groups were significantly decreased in subjects with anterior MI who died within one month after MI compared with subjects who survived this period. The ratio of early-to-late diastolic velocity (E/A´) was significantly lower at the inferior and lateral walls, compared with that in healthy subjects. This ratio also was significantly decreased in subjects with anterior MI who died within one month after MI compared with subjects with anterior MI who survived this period. The ratio of E/A´ in sepal and lateral sites was not significantly decreased.

Our findings do not agree with the findings of Alam et al study in this field: but, the peak early diastolic mitral annular velocity, A- mean and E- mean correlated well with the LV ejection fraction as in Alam et al study. Thus according to our study by using the mitral annular peak early diastolic velocity, it may be possible to assess the diastolic dysfunction after MI, even in the presence of pseudo normalization of the transmitral flow velocity or with an elevated LV end-diastolic pressure. In our study, there was a good correlation between LVEF and RWMSI with all mitral valve annular velocities. Similar to Alam, Bakan and Takashioki studies. MPI more than 0.8 and RWMSI more than 1.77 had higher sensitivity (0.94 and 0.96, respectively) in predicting death in follow-up period. MPI and RWMSI correlated well with all systolic and diastolic velocities, S-mean, E- mean, and A- mean. MPI and RWMSI were significantly higher in subjects with anterior MI which died within one month after MI compared with subjects with anterior MI who survived this period.
**Limitation**

Similar to other studies using TDI, this method is affected by the quality of 2D images and cardiac translation, rotation, or both. Septal annular velocities may be subjected to be influenced by the right ventricle and lateral velocities may be affected by both translational effects and beam angle. At last, this study is limited by the relatively small sample size. A larger, prospective study is needed in order to make more substantive conclusions regarding the clinical utility of tissue Doppler indices.

**Conclusion**

Mitral annular velocities can be recorded by pulse wave TDI after MI. The reduced peak systolic velocity seems to be an expression of regionally reduced systolic function. The mean peak systolic velocity from 4 mitral annulut sites correlated well with the LV ejection fraction. The peak early and late diastolic velocity is also reduced, especially at the infarction sites that reflects regional diastolic dysfunction. Thus, quantification of the myocardial velocity by TDI opens up a new possibility of assessing LV function in patients with MI.

**References**


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