Right ventricular function and symptomatology in patients with isolated mitral stenosis: A Doppler tissue imaging study

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Abstract Objectives: To compare RV function by DTI in symptomatic and asymptomatic patients with isolated mitral stenosis and with similar mitral valve area.

Background: Patients with MS of moderate or severe degree are not homogenous regarding symptomatology and some suffer more than others; the RV function is an important determinant of clinical symptoms. DTI is a technique that allows a quantitative assessment of myocardial function and by using this technique RV function can be assessed in MS patients of different degrees of symptomatology.

Methods: Fifty patients with isolated MS of moderate to severe degree were classified into two groups according to New York Heart Association (NYHA) class (asymptomatic group NYHA class I and symptomatic group NYHA class II–III). The RV function was evaluated by both conventional echo and Doppler tissue imaging. Pulsed wave DTI was placed at the lateral tricuspid annulus to measure the peak velocities of IVC (IVC max), S wave (S max), E', A' waves and E'/A' ratio also the duration of IVC, IVR, time to peak of IVC, S wave duration were measured then isovolumic acceleration (IVA) and Tei index were calculated.

Results: Conventional echo could not detect significant changes between the two groups, while using DTI the symptomatic group was found to show a significantly lower E' wave peak velocity (P = 0.005), E'/A' ratio (P = 0.009), S wave peak velocity (P = 0.033), IVC max (P = 0.02) and IVA (P = 0.001).

Conclusion: Patient with impaired RV function as detected by DTI are more symptomatic than other with better RV function and of similar MVA.

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1. Introduction

The importance of right ventricular function has been underestimated in the past, especially its role as a determinant of cardiac symptoms and exercise tolerance in patients with valvular disease of the left heart. Estimation of right ventricular
function is helpful to predict prognosis in various clinical situations. A qualitative assessment of the right ventricle is a routine part of echocardiography, but visual assessment of RV function is suboptimal, and the complex shape of the right ventricle greatly complicates volume quantification and quantitative assessments such as ejection fraction and other indices that are used for the left ventricle. There are few clinically applicable quantitative methods to assess RV function and most of them depend on loading conditions. Doppler myocardial imaging is a technique that offers information on myocardial

Figure 1  Recording of lateral tricuspid annular wave duration in patients with pure MS (MVA = 1.3 cm) and with NYHA II classification.

Figure 2  Recording of lateral tricuspid annular wave velocities in patients with pure MS (MVA = 1.3 cm) and with NYHA II classification.
velocities, allowing a quantitative assessment of myocardial function during the entire cardiac cycle. The technique is less dependent on chamber geometry. Furthermore, no endocardial border delineation is needed, which makes DTI usable even if the echocardiographic image quality is suboptimal.

In the presence of normal RV EF, some patients with mitral stenosis of moderate or severe degree suffer symptoms, whereas some patients with similar mitral valvular areas do not. Rowe et al. have stated 10 year survival rate of 84% in asymptomatic patients and 42% in symptomatic ones.

The aim of this study is to compare RV function by DTI in symptomatic and asymptomatic patients with isolated mitral stenosis and with similar MVA.

2. Patients and methods

2.1. Patient selection

Fifty patients with isolated rheumatic mitral stenosis (MS) of moderate to severe degree were subdivided according the New York Heart Association Functional Class (NYHA classification) into two groups (asymptomatic group NYHA class I and symptomatic group NYHA class II–III) however NYHA class IV was excluded because we could not find patient with grade IV with PASP < 50 mmHg. All participants provided informed consent and the study protocol was approved by the institutional ethics committee.

2.2. Inclusion criteria

Patients with maintained sinus rhythm and isolated rheumatic mitral stenosis (MS) of moderate to severe degree (mitral valve area < 1.5 cm²) assessed by pressure half time methods.

2.3. Exclusion criteria

Other valvular disease more than mild, significant pulmonary arterial systolic hypertension (≥ 50 mmHg), coronary artery disease, RV systolic dysfunction (RV ejection fraction < 40%), lung disease according to history, physical examination, inadequate echocardiograms, cardiomyopathies, and arrhythmias.

3. Methods

All participants were subjected to full history taking with special concern regarding the severity of dyspnea, graded according to NYHA classification and thorough clinical examination.

Echocardiographic examination was done using commercially available (Vivid 5, General Electric Healthcare, GE Vingmed, Norway) equipped with a 1.7–4 MHz phased-array transducer, echocardiographic imaging was obtained in the para-axial long, short-axis views, apical two and four-chamber views using standard transducer positions. LV end-diastolic & systolic diameter, septum & posterior wall thickness, ejection fraction (EF%), and left atrial (LA) diameter, were measured by M mode calculation. Trans-mitral velocities and pressure gradients were recorded by the continuous-wave Doppler interrogation of the trans-mitral flow in the apical four-chamber view. The estimation of mitral stenosis severity was done by the pressure half-time method, pulmonary artery systolic pressure was measured from peak tricuspid regurgitation velocity in the apical 4 chamber view & short axis views using simplified Bernoulli equation and assuming a fixed value of 10 mmHg for the right atrial pressure.

All conventional echo-Doppler parameters were performed according to the standards of the American Society of Echocardiography.
RV global systolic function was assessed according to the “ellipsoidal shell method”. Multiplication of two-thirds of RV area in apical view by the distance between RV free wall–tricuspid valve junction and outflow tract–pulmonary valve junction obtained from subcostal sagittal view was equal to RV volume according to this method. RV ejection fraction (EF) was measured by dividing the difference between end diastolic and end systolic volumes on end diastolic volume. All patients participated in our study had RV EF ≥40%.

From the apical 4 chamber view a 5-mm sample volume, placed on the lateral tricuspid annulus we assess the RV tissue Doppler indices including peak velocities of IVC (IVC max), S wave (S max), E and A’ waves and duration of IVC (IVC dur), time to peak of IVC, S wave (S dur) and IVR (Figs. 1 and 2) and from the above measurement we calculated the E’/A’ ratio, isovolumic acceleration (IVA) defined as the ratio of IVC peak velocity divided by the time to reach the peak velocity (cm/s) (Fig. 3) and Tei index calculated as the sum of isovolumic contraction time (IVCT) and isovolumic relaxation time (IVRT) divided by ejection time. Frame rate was adjusted between 120 and 180 Hz and average values of 3–5 consecutive heartbeats were recorded.

3.1. Statistical analysis

Data were analyzed statistically by using SPSS (statistical program for social science version 12) software package for Mac version and the following tests were done: description of quantitative variables as mean and standard deviation (SD), description of qualitative variables as number and percentage, chi-square test and Fisher’s exact test were used to compare qualitative variables between two or more groups. Unpaired t-test was used to compare quantitative variables in 2 independent groups in parametric data (SD < 50% of mean). Probability value (P value): P value > 0.05 is considered a non-significant value (NS), P value < 0.05 is significant value (S), P value < 0.001 is highly significant value (HS).

4. Results

Fifty patients with isolated MS of moderate to severe degrees were divided into two groups: group 1 included 25 asymptomatic patients with a female to male F/M ratio of 15/10 and group II included 25 symptomatic patients with an F/M of 16/9. There was no significant difference between both groups in terms of mean age, MVA, transmitral mean gradient, left atrial dimension, maximal systolic pulmonary artery pressure, LV dimension & EF and also RV EF (Table 1).

Tissue Doppler analysis of the RV showed a non-significantly statistical difference between the two groups regarding duration of IVC, IVR and S wave and calculated Tei index.

Peak velocities of IVC, S wave and calculated IVA reflecting RV systolic function were significantly lower in the symptomatic group, regarding diastolic parameters E’ wave peak velocity and E’/A’ ratio were highly significantly lower in the symptomatic group (Table 2).

5. Discussion

Right ventricular function in mitral stenosis, is an important determinant of clinical symptoms, exercise capacity, preoperative survival, and postoperative outcome.

TDI analysis is a technique that is not adversely influenced by preload and shows tissue contraction and relaxation rates with high resolution.

In our study RV systolic DTI parameters showed significantly lower peak velocities of IVC & S wave (P = 0.02 & 0.033, respectively) and highly significantly lower IVA (P = 0.001) in the symptomatic group.

IVA is a noninvasive measurement of RV contractile function that is unaffected by RV loading conditions over a wide range, making it eminently suitable for assessment of patients with acquired and congenital heart disease.

IVA may be used as an adjunctive, reliable, noninvasive parameter for the early detection of right ventricular systolic dysfunction in patients with MS but without signs of systemic venous congestion.

Tayyareci et al. studied RV free wall IVA in MS patients, and demonstrated that TDI-derived IVA had a good correlation with right ventricular systolic dysfunction in patients with MS. IVA was lower in severe MS group compared to mild to moderate MS group, with insignificant results of both RV IVC and S which were similar in the two groups.

Saricam et al. and Yildirim, et al. reported in 2 different studies that RV free wall IVCT and S-wave velocity were statistically not different between patients and control.

Table 1 Demographic & conventional echo Doppler parameters of both groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Asymptomatic group (25 patients)</th>
<th>Symptomatic group (25 patients)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>37.2 ± 13.1</td>
<td>35.9 ± 8.9</td>
<td>0.78</td>
</tr>
<tr>
<td>Males (%)</td>
<td>10 (40%)</td>
<td>9 (30%)</td>
<td>0.642</td>
</tr>
<tr>
<td>Females (%)</td>
<td>15 (60%)</td>
<td>16 (70%)</td>
<td>0.78</td>
</tr>
<tr>
<td>MV mean gradient (mmHg)</td>
<td>9.8 ± 2.8</td>
<td>10.1 ± 3.3</td>
<td>0.06</td>
</tr>
<tr>
<td>MVA-PHT (cm²)</td>
<td>1.23 ± 0.1</td>
<td>1.13 ± 0.2</td>
<td>0.14</td>
</tr>
<tr>
<td>SPAP mmHg</td>
<td>39.5 ± 10</td>
<td>38 ± 11</td>
<td>0.45</td>
</tr>
<tr>
<td>Aorta (mm)</td>
<td>25.6 ± 2.9</td>
<td>27 ± 5.4</td>
<td>0.31</td>
</tr>
<tr>
<td>Left atrium (mm)</td>
<td>46.2 ± 3.8</td>
<td>47.0 ± 6.7</td>
<td>0.07</td>
</tr>
<tr>
<td>LVED(mm)</td>
<td>48.7 ± 3.8</td>
<td>46.6 ± 7.6</td>
<td>0.22</td>
</tr>
<tr>
<td>LVES(mm)</td>
<td>33.1 ± 3.5</td>
<td>30.6 ± 5.2</td>
<td>0.18</td>
</tr>
<tr>
<td>LV EF (%)</td>
<td>58 ± 2.2</td>
<td>59 ± 1.5</td>
<td>0.97</td>
</tr>
<tr>
<td>RV EF (%)</td>
<td>46 ± 2.3</td>
<td>45 ± 2.4</td>
<td>0.88</td>
</tr>
</tbody>
</table>

MVA = mitral valve area, PHT = pressure half time, mean PG = diastolic mean pressure gradient, PASP = pulmonary artery systolic pressure, LVED = left ventricular end diastole, LVES = left ventricular end systole, EF = ejection fraction, LV = left ventricle, RV = right ventricle.
The rheumatic process has also been suggested to involve RV myocardium and contribute to RV functional abnormalities.\(^{16}\) Hence our finding that symptomatic isolated MS patients had RV diastolic dysfunction in comparison to asymptomatic ones with similar MVA in the presence of normal RV systolic function may be related to the difference in the extent of rheumatic myocardial involvement.

6. Conclusion

RV function is one of the important factors in determining symptoms in patients with mitral stenosis; symptomatic patient had more impairment of RV function compared to asymptomatic or minimally symptomatic patients with similar MVA.

Funding

None.

Conflict of Interest

None declared.

References

5. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography’s Guidelines and Standards Committee and the Chamber Quantifi-

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**Table 2** Right ventricular TDI parameters of both groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Asymptomatic group</th>
<th>Symptomatic group</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVC(_{\text{max}}) (cm/s)</td>
<td>13.7 ± 2.8</td>
<td>9.8 ± 3.6</td>
<td>0.02</td>
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<tr>
<td>IVA (cm/s)</td>
<td>0.45 ± 0.1</td>
<td>0.25 ± 0.1</td>
<td>0.001</td>
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<tr>
<td>IVC(_{\text{dur}})</td>
<td>63 ± 13</td>
<td>60 ± 13.09</td>
<td>0.66</td>
</tr>
<tr>
<td>(S_{\text{max}}) (cm/s)</td>
<td>14.3 ± 2.1</td>
<td>11.2 ± 2.3</td>
<td>0.033</td>
</tr>
<tr>
<td>(S_{\text{dur}}) (ms)</td>
<td>279.7 ± 44.9</td>
<td>291.6 ± 23.5</td>
<td>0.49</td>
</tr>
<tr>
<td>IVR(_{\text{dur}}) (ms)</td>
<td>51.3 ± 66.9</td>
<td>47.4 ± 26.9</td>
<td>0.66</td>
</tr>
<tr>
<td>(E) (cm/s)</td>
<td>12.7 ± 1.6</td>
<td>9.5 ± 2.1</td>
<td>0.005</td>
</tr>
<tr>
<td>(A) (cm/s)</td>
<td>14.8 ± 4.2</td>
<td>13.4 ± 3.5</td>
<td>0.78</td>
</tr>
<tr>
<td>(E'/A')</td>
<td>0.9 ± 0.4</td>
<td>0.7 ± 0.1</td>
<td>0.009</td>
</tr>
<tr>
<td>Tei index</td>
<td>0.42 ± 0.2</td>
<td>0.37 ± 0.1</td>
<td>0.067</td>
</tr>
</tbody>
</table>

\(IVR_{\text{dur}}\) = isovolumic relaxation time duration, \(IVC_{\text{max}}\) = isovolumic contraction velocity, \(IVA\) = isovolumic contraction acceleration, \(E\) = early diastolic annular wave peak velocity, \(A\) = late diastolic annular wave peak velocity.


