Echocardiographic evaluation of ventricular function in young adults with bronchial asthma

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Abstract Background: Bronchial asthma (BA) is a common chronic inflammatory condition affecting the airways. Bronchial asthma not only affects the lung but also affects other organs including the heart. Right ventricular (RV) hypertrophy and dilation and left ventricular (LV) diastolic dysfunction were observed in severe BA. However, evaluation of ventricular function in this disease by the use of recently proposed Doppler echocardiographic methods has not been extensively studied before.

Purpose: The aim of this study was to evaluate ventricular function in young adult patients with BA.

Patients and methods: Fifty patients with bronchial asthma and 30 control subjects (mean ages 28.3 ± 7.0 and 26.8 ± 6.2 years, respectively) participated in this study. Systolic function was assessed by subjective evaluation of wall motion for both ventricles and by fractional shortening for the left ventricle (LV). LV diastolic function was evaluated by standard pulsed-wave Doppler echocardiography, myocardial performance index (MPI) and transmitral flow propagation velocity (TFPV). RV function was evaluated by MPI. No subject had signs or symptoms of clinically overt heart failure.

Results: Our results revealed that there were statistically significant differences in the peak E velocity, peak E velocity/peak A velocity ratio and isovolumetric relaxation time between the two groups (p < 0.05). Mean LV MPI in the bronchial asthma group (0.40 ± 0.13) was also significantly higher than that of the controls (0.36 ± 0.11, p < 0.05). On the other hand, there were no significant differ-
Introduction

Asthma is a chronic inflammatory disorder of the airways characterized by an obstruction of airflow, which may be completely or partially reversed with or without specific therapy [1]. Dramatic worldwide variations in asthma prevalence have been found with the highest rates in the United Kingdom, Australia, and New Zealand, and the lowest prevalence in Eastern Europe, China, and India [2–4]. Bronchial asthma not only affects the lung but also affects other organs including the heart. Echocardiography detected RV systolic and diastolic dysfunctions in a considerable percent of asthmatic children even with mild cases. Left ventricular dysfunction is usually detected in severe asthmatic cases. However, these cardiac dysfunctions may be reversible especially in acute cases [5,6].

In bronchial asthma recurrent exposure to hypoxemia is one of the mechanisms besides others leading to sustained pulmonary vasoconstriction and narrowing of the pulmonary vasculature. Consequently, pulmonary hypertension develops leading to right heart enlargement with ventricular hypertrophy, and impaired cardiac function, known as cor pulmonale [7]. The occurrence of supraventricular tachycardia in BA is related to the presence of interventricular septal hypertrophy, LV dysfunction, and increased pulmonary artery pressure (PAP) [8]. Asthmatic medications can also affect the echocardiographic findings. Chronic administration of theophylline may cause a slight increase in percent fractional shortening, outflow peak velocity and atrial contribution to ventricular filling in the asthmatic children as compared to normal though these findings were found to be insignificant [9].

Although there are many noninvasive diagnostic modalities of ventricular function, right ventricular function remains difficult and challenging to quantify. Conventional imaging techniques such as radionuclide ventriculography and standard echocardiography have limitations when applied to the right ventricle. Radionuclide ventriculography involves exposure to radiation, is relatively expensive, has restricted availability, and is not easily repeatable [10].

Recently myocardial performance index (MPI) and transmitral flow propagation velocity (TFPV) have been suggested for the evaluation of ventricular function. MPI is calculated from the pulsed Doppler recordings of ventricular inlet and outlet velocities and thus combines both systolic and diastolic ventricular performances. It reflects global ventricular function and is less affected by localized wall motion abnormalities. It has been shown to be independent of changes in preload and afterload in the assessment of RV myocardial performance [11,12]. TFPV is obtained from color Doppler M-mode echocardiography and is used to assess LV diastolic function. This technique has been shown to be relatively independent of preload in patients with hypertrophic cardiomyopathy [13], dilated cardiomyopathy [14,15] and pulmonary hypertension [16,17].

In a study done by Garcia et al., the Peak E velocity/TFPV ratio was found the best estimate of pulmonary wedge pressure [18]. In a more recent study done by Mahmoud et al., MPI and TFPV confirm the classic measurements of pulsed-wave Doppler LV inflow and suggest an early stage of LV diastolic dysfunction in the course of the disease [19].

Aim of the work

This study was undertaken to evaluate ventricular function in young adults with bronchial asthma.

Subjects and methods

Fifty young adult patients with bronchial asthma were included in this study. All asthmatic patients had paroxysmal attacks of wheezy chest, dyspnea, cough and expectoration or documented reversible airway obstruction as determined by a 20% improvement in FEV1 after bronchodilator administration or peak expiratory flow rate variability (> 20%). All patients were attendant or came for follow up in chest outpatient clinics of Al-Hayah National Hospital, Khames Mushyt, Kingdom of Saudi Arabia during the period from January to December 2011. The study protocol was approved by the local ethics committee. Informed consent was obtained from the patients.

Inclusion criteria include all patients met the criteria for bronchial asthma [20] in the age group of 18-40 years old from both genders. Exclusion criteria include patients with bronchial asthma outside the age range or with respiratory tract infections, diabetes mellitus, systemic hypertension, congenital cardiac malformation, arrhythmia, heart failure or valvular heart disease. We exclude patients above the age of 40 to avoid the effect of age on the diastolic function.

Fifty patients with bronchial asthma and 30 control subjects participated in this study. Twenty-three patients were males and 27 patients were females. The age of the patients ranged from 18 to 38 years, with a mean age ± SD of 28.3 ± 7.0 years. In all patients asthma was controlled or partially controlled on medication (inhaled corticosteroids and long acting β2 agonists) [20]. The 30 healthy volunteers included 13 males and 17 females, with an age range from 18 to 36 years with a mean age of 26.8 ± 6.2 years. All healthy subjects had no history of rhinitis, eczema, or spontaneous wheezing, and were not receiving any medications.
All patients were subjected to the following: thorough medical history and clinical examination. Chest radiological examination, Ventilatory function tests, spirometry was performed using “Spirosift spirometry 5000 FUKUDA DENSHI”, ECG, CBC, ESR, renal function and liver function were done for all patients. Conventional echocardiographic study available in our hospital was performed using a Philips HD11XE machine (Philips, Inc., USA) with 2–4 MHz phased array transducer and a color-coded Doppler screen. Real time 2D, M-mode, colored and Doppler study was done for all cases with simultaneous ECG recording. Spectral Doppler tracings were recorded. All cardiac dimensions including IVS, LVPW, LV systolic and diastolic dimensions and left atrial and aortic root dimensions were measured [21]. Pulsed Doppler recordings of ventricular inflow, by placing the sample volume at the tips of the mitral and tricuspid leaflets. MPI was measured as the sum of isovolumetric contraction and isovolumetric relaxation time divided by the LV ejection time. From pulsed Doppler spectrum of the ventricular inflow, the time interval “a” calculated from the cessation to the onset of ventricular inflow was considered as the sum of isovolumetric relaxation time. The ventricular ejection time “b” was the duration of ventricular outflow velocity profile. MPI can be calculated easily by a simple formula: (a – b)/b [22]. The isovolumetric relaxation time, isovolumetric contraction time, peak E velocity, peak A velocity and the deceleration time of the E wave were also measured. TFPV was obtained by color Doppler M-mode echocardiography from the apical four chamber view as described by Garcia et al. [18].

Statistical analyses

Statistical analysis of the present study was conducted, using SPSS V.16. To compare two independent samples we used an unpaired t-test. A p-value < 0.05 was considered significant.

Results

The demographic and clinical features of the bronchial asthma and control groups are given in Table 1. There were no statistically significant differences in age, weight, heart rate, systolic and diastolic blood pressures between bronchial asthma patients and controls.

Table 2 shows that there were no statistically significant differences in the echocardiographic indices of RV dimensions and functions between the two groups.

Table 3 shows echocardiographic parameters of LV functions. There were statistically significant differences in the peak E velocity, peak A velocity/peak A velocity ratio, isovolumetric relaxation time, myocardial performance index (MPI) and TFPV between the two groups (p < 0.05). On the other hand, there were no statistically significant differences in the mean value of peak A velocity, deceleration time, isovolumetric contraction time, ejection time and E velocity/TFPV between BA and control groups.

Discussion

Bronchial asthma (BA) is a common chronic inflammatory condition affecting the airways. Bronchial asthma not only affects the lung but also affects other organs including the heart. Even with mild cases, subclinical cardiac dysfunction can be documented and the severity of cardiac affection is parallel to the severity of the disease. LV diastolic dysfunction was observed in severe BA. The occurrence of supraventricular tachycardia in BA is related to the presence of interventricular septal hypertrophy, LV dysfunction, and increased PAP [8]. Tissue Doppler Echocardiography was found to be more sensitive in detecting cardiac dysfunction than conventional Doppler. However, these cardiac dysfunctions may be reversible especially in acute cases [5,6].

In the present study it was found that both groups (asthma patients and controls) were properly matched together regarding age/years (28.3 ± 7.0 and 26.8 ± 6.2, respectively, p-value >0.05), height/cm (173.8 ± 19.5 and 168.5 ± 15.9, respectively, p-value >0.05) and weight/kg (68.15 ± 3.99 and 66.35 ± 3.36, respectively, p-value >0.05). Also there were no statistically significant differences in respiratory rate, heart rate, systolic and diastolic blood pressures between bronchial asthma patients and controls. This finding is corresponding to the study done by Shedeed; who found that there were no statistically significant differences between asthmatic children and controls regarding heart rate, systolic and diastolic blood pressure [23]. Also Mahmoud et al.; found the same results [19].

In this study there were no significant differences in the echocardiographic indices of RV dimensions and functions between the two groups (RV wall thickness, RV diameter, E velocity, A velocity, E/A velocity ratio, isovolumetric relaxation time, isovolumetric contraction time and ejection time). Also the mean RV MPI in the bronchial asthma group (0.29 ± 0.11) was not significantly different from that of the
control group (0.27 ± 0.08) and was comparable to the previously published normal values (0.28 ± 0.04) [24]. This was in agreement with Mahmoud et al. [19] who observed no significant difference in the echocardiographic indices of RV performance between the two groups, Elmasry et al. [25] who revealed that the right ventricular echocardiographic dimensions showed no significant differences among asthmatic patients compared to control subjects and Alpaslan et al. [26] and was in disagreement with Chicherina et al. [8] who concluded that diastolic dysfunction of the right ventricle was the earliest hemodynamic changes in bronchial asthma. Also Eniseeva et al. [27] reported that in patients with bronchial asthma, the degree of right ventricular dysfunction depends on right ventricular hypertrophy and total pulmonary resistance. This could be explained by the younger age of our study group and the well controlled asthma in our patients so that; the clinical and echocardiographic findings of chronic lung diseases are not significant.

In our study we found that there were statistically significant differences between the bronchial asthma group and the control group regarding the peak E velocity (55.74 ± 6.31 and 76.56 ± 3.94, respectively, *p*-value < 0.05), peak E velocity/peak A velocity ratio (0.9 ± 0.7 and 1.3 ± 0.5, respectively, *p*-value < 0.05), isovolumetric relaxation time (73.68 ± 5.29 and 56.50 ± 8.08, respectively, *p*-value < 0.05), myocardial performance index (MPI) (0.40 ± 0.13 and 0.36 ± 0.11, respectively, *p*-value < 0.05) and TFPV (37.10 ± 2.13 and 43.40 ± 3.11, respectively, *p*-value < 0.05). These findings are corresponding to the study done by Mahmoud et al. [19] who evaluated ventricular function by measurement of myocardial performance index (MPI) and transmitral flow propagation velocity (TFPV) in patient with bronchial asthma and found that the peak E velocity, E velocity/A velocity ratio, isovolumetric relaxation time, MPI and TFPV in the BA group were significantly different from those of the controls (*p* < 0.05). They also concluded that; LV diastolic function is impaired in patients with bronchial asthma. Also Hirono et al. [28] studied LV diastolic dysfunction in patients with bronchial asthma with long term oral β2-adrenoceptor agonists and found that the regular use of oral β2-adrenoceptor agonists induced left ventricular diastolic dysfunction. Goloskokova et al. [29] studied right and left ventricular functions in patients with asthma and found that LV alterations in patients with asthma were minimal and included LV diastolic dysfunction in patients with severe asthma. These alterations deteriorated as asthma step increased. Elmasry et al. [25] assessed the left ventricular function among asthmatic children both during and after resolution of acute severe asthma and found that during acute exacerbations of asthma, patients had significantly higher transmitral peak A velocity and lower E/A ratio (i.e. impaired LV diastolic function) during acute asthma exacerbation but disappeared after its resolution and concluded that transmitral inflow velocity patterns during acute severe asthma in children are suggestive of altered LV preload due to an acute transient elevation in pulmonary artery pressure secondary to the altered lung mechanics.

Several mechanisms may be responsible for diastolic dysfunction in bronchial asthma. The first and most important

### Table 2 Echocardiographic parameters of RV functions.

<table>
<thead>
<tr>
<th></th>
<th>BA group (<em>n</em> = 50)</th>
<th>Control group (<em>n</em> = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV wall thickness (cm)</td>
<td>1.27 ± 0.68</td>
<td>1.04 ± 0.52</td>
</tr>
<tr>
<td>RV diameter (cm)</td>
<td>2.16 ± 0.72</td>
<td>1.96 ± 0.67</td>
</tr>
<tr>
<td>E velocity (cm/s)</td>
<td>66.28 ± 11.52</td>
<td>70.93 ± 12.45</td>
</tr>
<tr>
<td>A velocity (cm/s)</td>
<td>40.21 ± 11.74</td>
<td>37.53 ± 10.91</td>
</tr>
<tr>
<td>E/A velocity ratio</td>
<td>1.54 ± 0.11</td>
<td>1.76 ± 0.18</td>
</tr>
<tr>
<td>Isovolumetric relaxation time (ms)</td>
<td>39.54 ± 2.50</td>
<td>43.83 ± 2.69</td>
</tr>
<tr>
<td>Isovolumetric contraction time (ms)</td>
<td>37.12 ± 2.37</td>
<td>38.03 ± 2.67</td>
</tr>
<tr>
<td>Ejection time (ms)</td>
<td>285.30 ± 7.64</td>
<td>292.50 ± 6.54</td>
</tr>
<tr>
<td>Myocardial performance index (MPI)</td>
<td>0.29 ± 0.11</td>
<td>0.27 ± 0.08</td>
</tr>
</tbody>
</table>

*p* > 0.05 for all of the above variables.

### Table 3 Echocardiographic parameters of LV functions.

<table>
<thead>
<tr>
<th></th>
<th>BA group (<em>n</em> = 50)</th>
<th>Control group (<em>n</em> = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E velocity (cm/s)</td>
<td>55.74 ± 6.31</td>
<td>76.56 ± 3.94</td>
</tr>
<tr>
<td>A velocity (cm/s)</td>
<td>67.88 ± 4.43</td>
<td>65.30 ± 4.17</td>
</tr>
<tr>
<td>E/A velocity ratio</td>
<td>0.9 ± 0.7</td>
<td>1.3 ± 0.5</td>
</tr>
<tr>
<td>Isovolumetric relaxation time (ms)</td>
<td>73.68 ± 5.29</td>
<td>56.50 ± 8.08</td>
</tr>
<tr>
<td>Deceleration time (ms)</td>
<td>164.78 ± 16.88</td>
<td>144.40 ± 16.07</td>
</tr>
<tr>
<td>Isovolumetric contraction time (ms)</td>
<td>35.74 ± 4.12</td>
<td>37.93 ± 4.84</td>
</tr>
<tr>
<td>Ejection time (ms)</td>
<td>267.34 ± 16.15</td>
<td>276.83 ± 12.75</td>
</tr>
<tr>
<td>Myocardial performance index (MPI)</td>
<td>0.40 ± 0.13</td>
<td>0.36 ± 0.11</td>
</tr>
<tr>
<td>TFPV (cm/s)</td>
<td>37.10 ± 2.13</td>
<td>43.40 ± 3.11</td>
</tr>
<tr>
<td>E velocity/TFPV</td>
<td>1.9 ± 0.9</td>
<td>1.7 ± 0.8</td>
</tr>
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TFPV, transmitral flow propagation velocity.

* *p* < 0.05.
factor is the significantly increased heart rate in the bronchial asthma group. Tachycardia shortened the diastolic filling period and atrial contraction may have occurred before the early filling was completed; the myocardial performance index will be higher than it would be if the heart rate was slower. This tachycardia may be due to multiple causes including hypoxemia or medications (Mahmoud et al. [19]). Hirono et al. [28] concluded that Long-term use of oral β2 agonists impaired left ventricular diastolic function in patients with BA, and the cessation of β2 agonists reversed diastolic pump performance to the normal level.

Conclusion

From this study we concluded that LV diastolic function is impaired in patients with bronchial asthma despite no effect on RV diastolic function.

References

[23] S. Scheded, Right ventricular function in children with bronchial asthma: a tissue doppler echocardiographic study, Heart Mirror 4 (No. 4) (2010).