Hypertensive Effect of Bronchial Asthma
M. F. Lutfi and M. Y. Sukkar

Abstract
Background: Both bronchial asthma and hypertension are spastic disorders of smooth muscle, salt sensitive and sometimes associated with higher renin-angiotensin system activity, suggesting similarities between their aetiologies. This study was intended to assess the blood pressure status in asthmatic patients.

Patients and Methods: The study involved two groups: a control group of 56 healthy subjects matched for gender and age with the study group of 100 patients with a medical history of asthma but no other respiratory disease. Asthma history was recorded to assess asthma activity at the time of examination together with medications. The non-invasive ausculatory method was used for measuring the systolic (SBP) and diastolic (DBP) blood pressures. Mean arterial blood pressure (MABP) was determined by the formula: MABP = DBP + [(SBP – DBP)/3].

Results: DBP was significantly higher in asthmatics (mean±SD = 80±10 mmHg) compared with non-asthmatics (mean±SD = 75±10 mmHg) (P = 0.002). DBP of off-treatment asthmatics was significantly higher compared with that of non-asthmatics (P = 0.015). Diastolic blood pressure of asymptomatic patients was not significantly higher compared with that of symptomatic patients (P = 0.774). Systolic and mean arterial blood pressures were not significantly different in asthmatics and control groups (P = 0.267 and 0.116 respectively).

Conclusions: In contrast to systolic and mean arterial blood pressures, diastolic blood pressure was significantly elevated in asthmatics (even in off-treatment patients) compared with non-asthmatics indicating mechanisms that predominantly increases peripheral vascular resistance.

Keywords: osmolarity, renin-angiotensin, catecholamines, endocrinometabolic.
Lutfi M F and Sukkar M Y. Hypertensive Effect of Bronchial Asthma

age with the study group of 100 patients with a medical history of asthma (at least for two years) but no other respiratory or heart diseases. The control groups were recruited mainly from among university students and employees.

Following verbal consent, asthma history and drug therapy were recorded to assess asthma activity at the time of examination. The non-invasive auscultatory method was used for measuring the blood pressure (Mercury in glass Sphygmomanometer – GOH Industries Limited - Japan). The systolic blood pressure (SBP) was determined by appearance of heart sounds (Korotkoff sound I) while diastolic blood pressure (DBP) was determined by disappearance of the sounds (Korotkoff sound V). Mean arterial blood pressure (MABP) was determined by the formula: MABP = DBP + [(SBP – DBP)/3]. Patients were grouped according to the presence of symptoms and according to anti-asthma medication taken during the time of examination. Screening studied variables for significant differences in the means between the groups was performed using analysis of variance. When significant differences were identified, individual groups were compared using the Student two-tailed, unpaired T-test. In all of these statistical tests, only P < 0.05 was considered significant.

Results

Diastolic blood pressure was significantly higher in asthmatics (mean±SD = 80±10 mmHg) compared with non-asthmatics (mean±SD = 75±10 mmHg) (P = 0.002). This was true for both symptomatic (P = 0.014) and symptoms-free asthmatics (P = 0.006) (table 1).

Table-1: (A) means (M) and standard deviations (SD) of blood pressures for non-asthmatics, asthmatics with and without symptoms (B) the significance of mean difference.

<table>
<thead>
<tr>
<th></th>
<th>Non Asthmatics (N = 56)</th>
<th>Asthmatics (N = 100)</th>
<th>Asthmatics without Symptoms (N = 53)</th>
<th>Asthmatics with Symptoms (N = 47)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>SBP</td>
<td>118.32</td>
<td>13.69</td>
<td>115.80</td>
<td>13.25</td>
</tr>
<tr>
<td>DBP</td>
<td>75.04</td>
<td>9.98</td>
<td>80.20</td>
<td>10.02</td>
</tr>
<tr>
<td>MABP</td>
<td>89.46</td>
<td>9.61</td>
<td>92.07</td>
<td>10.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Non Asthmatics Vs Asthmatics</th>
<th>Non Asthmatics Vs Asthmatics without Symptoms</th>
<th>Non Asthmatics Vs Asthmatics with Symptoms</th>
<th>Asthmatics without Symptoms Vs Asthmatics with Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td>0.267</td>
<td>0.537</td>
<td>0.180</td>
<td>0.473</td>
</tr>
<tr>
<td>DBP</td>
<td>0.002*</td>
<td>0.006*</td>
<td>0.014*</td>
<td>0.774</td>
</tr>
<tr>
<td>MABP</td>
<td>0.116</td>
<td>0.110</td>
<td>0.284</td>
<td>0.611</td>
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</tbody>
</table>

* Significant mean difference

Diastolic blood pressures of asymptomatic patients were not significantly different compared with that of symptomatic patients (P = 0.774).

Systolic and mean arterial blood pressures were not significantly different in asthmatics and control groups (P = 0.267 and 0.116 respectively). Diastolic blood pressure of off-treatment asthmatics was significantly higher compared with that of non-asthmatics (P = 0.015) (table 2).
Table-2: (A) means (M) and standard deviations (SD) of blood pressures for non-asthmatics, asthmatics classified according to drug taken (B) the significance of the difference between means

<table>
<thead>
<tr>
<th></th>
<th>Non Asthmatics (N = 56)</th>
<th>Asthmatics (N = 100)</th>
<th>Asthmatic Not Taking Beta Agonist or Steroid (N = 26)</th>
<th>Asthmatic Taking Beta Agonist only (N = 27)</th>
<th>Asthmatic Taking Steroid only (N = 7)</th>
<th>Asthmatic Taking both Beta Agonist and Steroid (N = 40)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M</strong></td>
<td><strong>SD</strong></td>
<td><strong>M</strong></td>
<td><strong>SD</strong></td>
<td><strong>M</strong></td>
<td><strong>M</strong></td>
<td><strong>M</strong></td>
</tr>
<tr>
<td>SBP</td>
<td>118.32</td>
<td>13.69</td>
<td>115.80</td>
<td>13.25</td>
<td>115.69</td>
<td>13.07</td>
</tr>
<tr>
<td>DBP</td>
<td>75.04</td>
<td>9.98</td>
<td>80.20</td>
<td>10.02</td>
<td>80.00</td>
<td>9.64</td>
</tr>
<tr>
<td>MABP</td>
<td>89.46</td>
<td>9.61</td>
<td>92.07</td>
<td>10.00</td>
<td>91.90</td>
<td>10.27</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Non Asthmatics Vs Asthmatics Not Taking Beta Agonists or Steroids</th>
<th>Non Asthmatics Vs Asthmatics Taking Beta Agonists Only</th>
<th>Non Asthmatics Vs Asthmatics Taking Steroids Only</th>
<th>Asthmatics Not Taking Beta Agonists or Steroids Vs Asthmatics Taking Both Beta Agonists or Steroids</th>
<th>Asthmatics Not Taking Beta Agonists or Steroids Vs Asthmatics Taking Steroids Only</th>
<th>Asthmatics Not Taking Beta Agonists or Steroids Vs Asthmatics Taking Both Beta Agonists or Steroids</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M</strong></td>
<td><strong>0.963</strong></td>
<td><strong>0.383</strong></td>
<td><strong>0.845</strong></td>
<td><strong>0.460</strong></td>
<td><strong>0.301</strong></td>
<td><strong>0.924</strong></td>
</tr>
<tr>
<td><strong>DBP</strong></td>
<td><strong>0.015</strong></td>
<td><strong>0.570</strong></td>
<td><strong>0.000</strong></td>
<td><strong>0.048</strong></td>
<td><strong>0.319</strong></td>
<td><strong>0.273</strong></td>
</tr>
<tr>
<td><strong>MABP</strong></td>
<td><strong>0.066</strong></td>
<td><strong>0.834</strong></td>
<td><strong>0.013</strong></td>
<td><strong>0.103</strong></td>
<td><strong>0.206</strong></td>
<td><strong>0.531</strong></td>
</tr>
</tbody>
</table>

* Significant mean difference

Discussion

The finding that off-treatment asthmatics have higher diastolic blood pressure compared with non-asthmatics indicates that high diastolic blood pressure in asthmatics is not attributable to hypertensive anti-asthma drug therapy. Furthermore, symptomatic patients, which were expected to be on β-2 agonist treatment (hypotensive agent), were found to have higher diastolic blood pressures compared with the control group (P = 0.014). Stress hormones like cortisol and catecholamines, which may be increased in stressful conditions like asthma, are expected to increase both systolic and diastolic blood pressures alike. Therefore, a mechanism that predominantly increases peripheral vascular resistance and consequently diastolic blood pressure may exist to explain these findings.

Previous studies of vessels in asthmatics have focused on the pulmonary arteries and the bronchial capacitance vessels in the bronchial mucosa. There is an old report on the larger bronchial arteries and almost no studies on systemic arteries of asthmatic patients. However, recent studies on abnormalities of the bronchial arteries in asthmatics focused on systemic arteries and peripheral vascular resistance. Green et al described intimal thickening of bronchial arteries in cases of both fatal and non-fatal asthma. The lesion described was distinct from atherosclerosis and was not related to changes associated with cor pulmonale, which involves smooth muscle proliferation in both intima and media.

Although these findings could be part of remodeling of airways compartments and not
necessarily systemic process of all systemic arteries, the following suggestions deserve especial concern:
1. Long term effects:
   According to Green et al. the intimal lesions were not associated with inflammatory cells either within or adjacent to vessels showing the lesion. This finding when compared to another study, which showed that remodeling in the airway wall in patients with asthma is associated with infiltration and activation of inflammatory cells\textsuperscript{19}, it can be concluded that humeral inflammatory factor(s) cannot be ruled out as the cause of these permanent vascular lesions. This is because the intima is in closer contact with the circulating blood than the unaffected media. These findings suggest that similar intimal lesion may compromise the arterioles in systemic circulation but to a lesser extent as humeral inflammatory factors will be diluted as they reach the general circulation. This could partially explain the mild increase in diastolic blood pressure secondary to the expected mild increase in the peripheral vascular resistance of asthmatic patients.

2. Short term effects:
   Although the bronchial circulation has extensive collateral communications, it is likely that the arterial luminal narrowing observed by Green et al is physiologically significant. A major function of the airway circulation is to provide an essential route for clearance of smooth muscle bronchoconstrictor mediators. Csete et al tested the hypothesis that airway perfusion modifies the contractile response of airway smooth muscle to allergen challenge by influencing the clearance of locally released spasmogens\textsuperscript{20}. This study proved that antigen-induced airway smooth muscle contraction in vivo was due to alterations in airway blood flow rather than to alterations in airway smooth muscle responsiveness to chemical mediators. This finding can also explain why the degree of response of bronchial smooth muscles to chemical mediators (marked bronchoconstriction) is far more than vascular smooth muscles (mild diastolic hypertension) i.e. because a relatively small amount of chemical mediators (smooth muscles constrictors) will reach the general circulation.

   On the other hand, the renin-angiotensin system was found to be activated in patients with asthma during severe acute attacks\textsuperscript{7}. In addition, there is evidence of synergy in bronchoconstriction between Angiotensin II and some other bronchoconstricators like methacholine\textsuperscript{21}. The results of other studies indicate that endogenous angiotensin II promotes antigen-induced airway hyperresponsiveness and eosinophil accumulation by acting at type-1 receptors\textsuperscript{8}. Angiotensin II is a potent vasoconstrictor and can therefore explain increased diastolic blood pressure discussed above.

   The mechanism of activation of the renin-angiotensin system in asthma is uncertain. High level of angiotensin II may be a pathological phenomenon or it may represent a physiological response to asthma attack\textsuperscript{22}. According to Ramsay et al, plasma renin and angiotensin II in asthmatics were strongly correlated; implying renin-dependent angiotensin II formation. However, the above study failed to demonstrate correlation between catecholamines, endothelin-1, histamine, serum angiotensin converting enzyme activity, total immunoglobulin E (as indicators of the severity of asthmatic attack), renal function and renin or angiotensin II levels. Interestingly, Ramsay et al also did not demonstrate a relationship between blood pressure and renin or angiotensin II levels\textsuperscript{22}.

Conclusion
In contrast to systolic and mean arterial blood pressures, diastolic blood pressure was significantly elevated in asthmatics compared with non-asthmatics. Further studies are needed to identify possible causes of increased diastolic blood pressure in asthmatics. Research areas in this field include looking for evidences suggesting systemic arteries remodeling as result of chronic intimal contact with inflammatory mediators released from the lungs as well as searching for a common pathology that can explain bronchoconstriction and peripheral vasoconstriction simultaneously
Acknowledgement
We would like to acknowledge Dr. Ahmed Babikir, the dean of faculty of medicine, Al Neelain University, Dr. Amal M. Saeed, department of physiology, U of K. Thank also extend to Dr. Bassam, the head of the Department of Applied Statistics – Al Sudan University who gave us important guidance during statistical analysis.

References
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