Pulmonary Function in Symptom-free Asthmatic Children*

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SUMMARY **Asthmatic children may be susceptible to more severe chronic airway obstruction during symptom-free periods if pulmonary function impairment is permanent and proper management is not given. This study was undertaken to observe whether the pulmonary function of such children differs from that of normal children so that preventive measures may be takan. Using a Godart Pulmotest Spirometer, the forced vital capacity (FVC), forced expiratory volume (FEV) in the first second ($FEV_{1.0}$) and mid-maximal expiratory flow rate (MMEFR) were measured. Clinical evaluation was also performed at the same 7 ± 1-week interval for a period of one year.**

Statistical analysis revealed 1) pulmonary function abnormalities in symptom-free asthmatic children, and 2) significant improvement after the administration of bronchodilator. Early detection of these abnormalities and the provision of a bronchodilator could, perhaps, prevent the further development of more severe chronic airway obstruction.

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Airway obstruction is one of the main features of bronchial asthma. Therefore, its accurate assessment is important with regard to clinical diagnosis and management. Some asthmatic children were considered to be in remission when clinical recovery from asthma was apparent.[1] However, increased bronchial smooth muscle tone may remain present, which probably renders such children susceptible to more severe chronic airway obstruction in the fature.[2]

This study was undertaken to observe whether the pulmonary function of such children differs from that of normal children so that preventive measures may be provided.[3]

MATERIALS AND METHODS

Subjects

Pulmonary function was measured in 24 children aged 6-15 years who had been followed up continuously in a paediatric allergy clinic for over one year. They also fulfilled the following criteria: 1) history of bronchial asthma for over three years; 2) symptom-free period of more than two weeks and 3) not having received antiasthmatic treatment (i.e., bronchodilator, steroids, hyposensitisation, etc.) during the previous two weeks.

Methods

Complete histories, physical examinations and parental consent were obtained for all children. They had been trained to perform the pulmonary function test in advance. Using a Godart Pulmotest Spirometer, the following pulmonary function parameters were initially measured in all children: forced vital capacity (FVC), forced expiratory volume in the first second ($FEV_{1.0}$) and maximal mid-expiratory flow rate (MMEFR).[4] The children were classified into the following groups (Table 1):

Group I: Patients with normal pulmonary function test.

Group II: Patients with abnormal pulmonary function test, having at least one or more of the pulmonary function parameters that registered less than 70 per cent of the predicted mean value.

Group III: Patients with abnormal pulmonary function test who were

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Table 1 Age distributions among the three groups of subjects

Group	Number (n)	Age (years)		
		Range	Mean	sd
I	8	8-15	10.9	2.59
II	8	7-15	10.8	2.71
III	8	7.5-15	12.4	2.41

Table 2 Mean ($\bar{x}$) and standard deviation (sd) of pulmo-parameters of the first measurement (*time period 1*)

Group		FVC (ml)	$FEV_{1.0}$ (ml)	MMEFR (l/min)
I	Actual	1,903.02	1,752.25	144.77
		±687.99	±674.53	±44.12
	Predicted	2,121.00	1,799.82	140.24
		±707.96	±711.90	±40.08
	Actual/Predicted	0.89	0.98	1.08
		±0.04	±0.06	±0.08
II	Actual	1,620.98	1,422.55	111.48
		±531.24	±520.12	±31.50
	Predicted	2,329.21	2,050.35	153.23
		±710.88	±726.15	±42.76
	Actual/Predicted	0.69	0.69	0.72
		±0.05	±0.02	±0.02
III	Actual	1,885.12	1,697.85	114.90
		±462.16	±398.78	±26.70
	Predicted	2,601.04	2,396.44	169.08
		±636.36	±541.95	±35.12
	Actual/Predicted	0.72	0.70	0.68
		±0.02	±0.02	±0.06

administered an oral bronchodilator *on a continuous basis* (treated group).

Group I and II was given the oral bronchodilator only *on an intermittent basis* (non treated groups) and the pulmonary function tests were performed after discontinuation of the medication for at least two weeks.

The study began eight weeks after the selection and grouping of the children. The pulmonary function parameters (FVC, $FEV_{1.0}$ and MMEFR) were measured at the same time (around 9 a.m.) for all children (Table 2). All children were retested and closely followed up clinically every 7±1 weeks for a period of one year (Table 3). All values have been corrected for barometric pressure and temperature saturation (BPTS). Each series of measurements lasted about 15 minutes. The children rested for 15 minutes before each test. Measurements were taken while the patients were sitting. The most uniform reading of the three attempts was accepted for each test. For the groups undergoing treatment, the first measurement was performed on the first day of the treatment (Table 2).

Statistical analysis was done using Barlett's multiple test and analysis of variance (ANOVA) using an orthogonal factorial design[5] with patient groups and the period of measurement as main variables. A rejection criterion of 0.01 was used for judging significance. The pulmo-parameters for normal Thai children using the standard spirometer (Godart Pulmotest Spirometer) had not yet been established; thus the mean values and normal ranges presented by Polgar and Promadhat[6] were used.

RESULTS

Differences in the age of the children could be expected to account for differences in height which would affect pulmonary function parameters. A base-line analysis of age among the three groups of subjects (shown in Table 1) reveals no significant differences with regard to age statistics (Barlett's multiple t-test; $p > 0.30$).

Table 3 gives the results for FVC, $FEV_{1.0}$ and MMEFR respectively for the three groups. Analysis of variance (Tables 4-7) shows significant differences among the three groups, for all pulmo- parameters ($p<0.001$), but no significant differences with regard to time periods ($p = 0.805$, 0.489 and 0.607 respectively). Although the effect of the group-time interaction is controlled, the difference in FVC, $FEV_{1.0}$ and MMEFR among groups is significant ($p<0.001$).

Tables 7 to 9 show ANOVA data for FVC, $FEV_{1.0}$ and MMEFR for the treated and non-treated abnormal groups. Only the FVC parameter shows a significant difference between the two groups ($p = 0.009$).

DISCUSSION

The importance of early diagnosis of airway obstruction in asthma is not yet clear. So far, further information is required about its natural history and whether it may be possible to use early detection and management to prevent the development of more severe chronic airway obstruction in the future. Several authors have studied with variable results[1,2] asthmatic children

Table 3 Mean ($\bar{x}$) and standard deviation (sd) of pulmo-parameter (FVC, $FEV_{1.0}$ and MMEFR) of the three groups of asthmatic children expressed as the ratio of actual value to the predicted value on the basis of height

FVC

Group		Test period* 1	2	3	4	5	6
I							
Actual/Predicted	$\bar{x}$	0.9245	0.9461	0.8720	0.9047	0.9249	0.8776
	sd	0.724	0.0857	0.0863	0.0937	0.0772	0.0824
II							
Actual/Predicted	$\bar{x}$	0.7622	0.8230	0.8034	0.8038	0.7757	0.7440
	sd	0.1178	0.1538	0.1033	0.1024	0.1408	0.1520
III							
Actual/Predicted	$\bar{x}$	0.8171	0.8430	0.8365	0.8918	0.8520	0.8908
	sd	0.1137	0.1089	0.1264	0.1120	0.1523	0.1333

$FEV_{1.0}$

Group		Test period* 1	2	3	4	5	6
I							
Actual/Predicted	$\bar{x}$	1.0375	1.0811	0.9599	0.9943	0.9868	0.8943
	sd	0.0730	0.1610	0.0628	0.1044	0.0878	0.1164
II							
Actual/Predicted	$\bar{x}$	0.8114	0.8392	0.8146	0.8029	0.7819	0.7421
	sd	0.1254	0.1143	0.0970	0.0998	0.1287	0.1436
III							
Actual/Predicted	$\bar{x}$	0.7530	0.8091	0.7908	0.8222	0.8006	0.8754
	sd	0.1436	0.1232	0.1676	0.1465	0.1944	0.1247

MMEFR

Group		Test period* 1	2	3	4	5	6
I							
Actual/Predicted	$\bar{x}$	0.9245	0.9461	0.8720	0.9047	0.9249	0.8776
	sd	0.0724	0.0857	0.0863	0.0937	0.0772	0.0824
II							
Actual/Predicted	$\bar{x}$	0.7622	0.8230	0.8034	0.8038	0.7757	0.7440
	sd	0.1178	0.1538	0.1033	0.1024	0.1408	0.1520
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*At 6-8 weeks interval. Period 1 = the day the treatment was started, eight weeks after the initial measurements.

during symptom-free periods. Most of the studies showed that the majority of asthmatic children may show some slight abnormalities, particularly in their airway resistance, thus indicating a minimal and subclinical airway obstruction. In our study, we found abnormalities of pulmonary function in 16 out of 24 symptom-free children. This finding is in accordance with that reported by McFadden *et al*[7] who carried out their investigation among American children.

Our study further revealed that although asthmatic symptoms in children may disappear for a period of time, airway obstruction may remain. In the past, such airway blockage was not recognised because most tests for pulmonary functions were performed using conventional measurements such as peak flow rate and force expiratory volume in the first second. Tables 8 and 9 of our study substantiate this opinion. These tests primarily reflect changes in the large airway,[8] but they are not sensitive enough to detect abnormalities in the small airways.[8] Woolcock *et al*[9] and Heckscher *et al*[10] have shown that abnormalities of the small airways cause increased residual volume, mismatching of ventilation and perfusion, and abnormal frequency dependence of dynamic compliance. It is these silent changes in the periphery of the lung that permit abnormalities of gas exchange and lung mechanics to continue into the symptom-free period.[7,11,12] Unless sophisticated measures of the dynamics of small airways are made, the finding of $FEV_{1.0}$ or peak flow rate may encourage a false sense of security, i.e., that small as well as large airways may have returned to normal.[9,13]

The residual abnormalities may cause no symptoms at rest, but because of their persistence, they may predispose patients to future attacks.[14-16] This finding leads us to conclude that an oral bronchodilator should be given to symptom-free patients who have an abnormal

Table 4 Analysis of variance for forced vital capacity (FVC) among the three groups

Source of variation	SS	df	MS	F	p-value
Among groups	0.365	2	0.183	13.841	0.001
Among times	0.030	5	0.006	0.461	0.805
Interaction (groups vs. times)	0.076	10	0.008	0.573	0.834
Residual (error)	1.662	126	0.013	–	–
Total	2.133	143	0.015	–	–

Table 5 Analysis of variance for $FEV_{1.0}$ among the three groups

Source of variation	SS	df	MS	F	p-value
Among groups	1.142	2	0.571	30.330	0.001
Among times	0.072	5	0.014	0.891	0.489
Interaction (groups vs. times)	0.202	10	0.020	1.251	0.266
Residual (error)	2.037	126	0.016	–	–
Total	3.453	143	0.024	–	–

Table 6 Analysis of variance for MMEFR among the three groups

Source of variation	SS	df	MS	F	p-value
Among groups	3.553	2	1.776	28.524	0.001
Among times	0.225	5	0.045	0.723	0.607
Interaction (groups vs. times)	0.790	10	0.079	1.269	0.255
Residual (error)	7.847	126	0.062	–	–
Total	12.356	143	0.086	–	–

Table 7 Analysis of variance for FVC between the treated (Group III) and non-treated (Group II) abnormal groups

Source of variation	SS	df	MS	F	p-value
Between groups	0.117	1	0.117	7.169	0.009
Between times	0.031	5	0.006	0.374	0.865
Interaction (groups vs. times)	0.041	5	0.008	0.507	0.770
Residual (error)	1.371	84	0.016	–	–
Total	1.560	95	0.016	–	–

pulmonary function test. Goldstein *et al*[3] recommended the regular use of inhaled sympathomimetics and an oral theophylline preparation for those symptom-free patients whose history suggests that they are susceptible to acute exacerbation. Such patients commonly experienced an improved sense of well-being, increased exercise tolerance and a decrease in the frequency and severity of their acute episodes. Significant improvement of pulmonary function could be demonstrated in these patients after bronchodilator therapy judging by the improvement of the forced vital capacity,[17] which probably reflected the relief of peripheral airway obstruction and could be detected in the lower range of vital capacity.[18]

The pulmonary function tests which have been used in this study may not give a complete picture of lung function, but they do give a reasonable guide to the state of air movement. Most pulmonary diseases in childhood alter this aspect of respiration, so in practice these relatively simple bedside tests have been found to be valuable.[16] This is particularly true for long-term conditions such as asthma, for which they may give the only objective guide to the progress of the disease and the efficacy of treatment. These pulmonary function tests should be incorporated in the diagnosis and treatment of many types of respiratory illnesses. Asthmatic children should be checked regularly by their physicians, and they and their parents should be given guidance on the treatment of symptoms. They should be instructed in preventive measures and the promotion of health, i.e. breathing exercises, chest rehabilitation, etc. Thus, early detection of airway obstruction, although by simple but efficient pulmonary function tests, will no doubt provide advance warning which is helpful in preventing the development of more severe chronic airway obstruction in the future.

Table 8 Analysis of variance for $FEV_{1.0}$ between the treated and non-treated abnormal groups

Source of variation	SS	df	MS	F	p-value
Among groups	0.002	1	0.002	0.124	0.726
Among times	0.018	5	0.004	0.195	0.963
Interaction (groups vs. times)	0.901	5	0.018	0.977	0.437
Residual (error)	1.568	84	0.019	–	–
Total	1.680	95	0.018	–	–

Table 9 Analysis of variance for MMEFR between the treated and non-treated abnormal groups

Source of variation	SS	df	MS	F	p-value
Among groups	0.029	1	0.029	0.482	0.489
Among times	0.110	5	0.022	0.363	0.873
Interaction (groups vs. times)	0.692	5	0.138	1.219	0.054
Residual (error)	5.101	84	0.061	–	–
Total	5.915	95	0.062	–	–

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