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Original Research Article

Evaluation of spirometry in asthmatic children

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ABSTRACT

Background: The use of spirometry in the assessment of children with asthma is taking on new importance with the realization that considerable airway obstruction may exist in the absence of clinically detectable abnormalities. Hence this study was planned to evaluate, forced expired volume in 1 second (FEV1), forced vital capacity (FVC), the forced expiratory flow between 25% and 75% of vital capacity (FEF25-75) and Peak Expiratory Flow rates (PEFR) in asthmatic children aged 6-12 years. The objective of the study was to determine prevalence of asthma according to clinical classification and identify common trigger factors and to determine which is more sensitive between FEV1, FVC, FEV1/FVC, FEF 25-75 and PEFR in different age groups.
Methods: The present study was conducted among 60 patients of age group 6 to 12 years with asthma. Forced vital capacity (FVC), Forced expiratory volume in 1 second (FEV1), Ratio of forced expiratory volume in 1 second and forced vital capacity (FEV1/FVC), PEFR and Forced expiratory flow between 25-75% were recorded. Data was analyzed using chi-square test, Karl Pearson's correlation coefficient. Level of significance was set at 5%. All p values less than 0.05 were treated as significant.
Results: In Age and Sex wise correlation with classification of asthma, a male preponderance was seen in all the age groups i.e. between 6-8 years, 9-10 years and 11-12 years. Mosquito coils were the most common indoor agents to trigger an asthmatic accounting for nearly 80%. Amongst the outdoor triggers, exacerbation of symptoms during the cold weather accounted for 90 % followed by variation during festivals like Diwali, dust, pollution, exercise and insects. Comparison of Pre and Post bronchodilator FEF 25-75 values have shown a high statistical significance.
Conclusions: Parents need to be educated regarding certain modifiable factors that can improve the prognosis. Pulmonary Function tests should be performed as a routine office procedure. Peak expiratory flow meter is a handy instrument. In all children above 6 years of age suspected to have asthma, this test should be performed before beginning therapy.

Keywords: Asthma, Pulmonary function test, Spirometry

INTRODUCTION

Spirometry is the preferred method of assessing lung function due to the accuracy of the test and the ability of the test to diagnose acute and chronic lung disease in children. It is indicated to evaluate signs and symptoms of respiratory obstruction verses respiratory restrictive disease, measure the severity of the disease, determine the effect of medication on the disease, assess lung function pre-operatively, monitor the disease over time, and rule out other causes of wheezing.[1]

Asthma is a heterogeneous disease, usually characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation.[2] it is thought to be caused by a combination of genetic and environmental factors. Its diagnosis is usually based on the pattern of symptoms,

response to therapy over time and spirometry. It is clinically classified according to the frequency of symptoms, forced expiratory volume in one second (FEV1) and peak expiratory flow rate. Asthma may also be classified as atopic (extrinsic) or non-atopic (intrinsic) where atopy refers to a predisposition toward developing type 1 hypersensitivity reactions.[3] Spirometry should be repeated yearly to assess the child's asthma severity and control. The goals of spirometry are to provide an objective measurement of lung function, assess the degree of obstruction, evaluate the response to therapy, and assist with the decision to step up or step down therapy.[1] The use of spirometry in the assessment of children with asthma is taking on new importance with the realization that considerable airway obstruction may exist in the absence of clinically detectable abnormalities. There has been controversy over the value and relative sensitivity of various spirometric indices. Hence this study was planned to evaluate, forced expired volume in 1 second (FEV1), and the ratio between the FEV1 and the forced vital capacity (FVC) the forced expiratory flow between 25% and 75% of vital capacity (FEF25–75) and Peak Expiratory Flow rates in asthmatic children aged 6–12 years. The objective of the study was to determine prevalence of asthma according to clinical classification and identify common trigger factors and to determine which is more sensitive between FEV1, FVC, FEV1/FVC, FEF 25-75 and PEFR in different age groups.

METHODS

The present cross-sectional study was conducted in the Department of Paediatrics, Dr. D.Y. Patil University School of Medicine Nerul, Navi Mumbai, among 60 patients of age group 6 to 12 years with asthma over duration of 1 year from March 2014 to August 2015. Children who were unable to complete the PFT were not enrolled in the present. A self-constructed semi-structured case record form was used to record the demographic details, clinical symptoms, signs and the laboratory parameters. Institutional Ethics Committee approval was taken and an informed consent was obtained from parents or guardians of all the children before enrolling patients into the study. An information sheet was given to all the participating patients. Demographic details were recorded along with the history and clinical examination in the form of a case record form. Pulmonary function tests were done using MIR Spirobank G spirometer. Forced vital capacity (FVC), Forced expiratory volume in 1 second (FEV1), Ratio of forced expiratory volume in 1 and forced vital capacity (FEV1/FVC), PEFR and Forced expiratory flow between 25-75% were recorded. Data was collected from 60 patients and statistical analysis was done using IBM SPSS software (version 22.0, USA). The data was presented using frequency, percentage, and descriptive Statistics followed by graphical presentation. Further data was analyzed using chi-square test, Karl Pearson's correlation coefficient. Level of significance was set at 5%. All p values less than 0.05 were treated as significant.

RESULTS

In this study of 60 children, 65% (39) of the subjects were males and 35% (21) were females. In this study 22 cases (36.6%) were between 6-8 years, 18 cases (30%) were between 9-10 years and 20 cases (33.3%) were between 11-12 years. In Age and Sex wise correlation with classification of asthma, a male preponderance was seen in all the age groups i.e. between 6-8 years, 9-10 years and 11-12 years.

Table 1: Age and gender wise distribution according to classification of asthma.

Age (in years)	Clinical Diagnosis								Total	
	Intermittent		Mild		Moderate		Severe			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
6-8	1	4	9	5	3	0	0	0	13	9
9-10	3	1	7	2	4	0	1	0	15	3
11-12	4	2	6	3	1	4	0	0	11	9
Total	8	7	22	10	8	4	1	0	39	21

Between 6-8 years, 9-10 years and 11-12 years majority of the males were classified as mild persistent asthmatic. Amongst the females in age group between 6-8 years and 9-10 years most of them were Mild persistent asthmatic and between 11-12 years of age most of them were classified as Moderate persistent asthma. Pre and post bronchodilator FEV1 values were significant for children between 6 years to 8 years (i.e. p value: 0.018) and for children between 9 years to 10 years (i.e. p value: 0.012) (Table 2). Pre and post bronchodilator FVC values were significant for 2 age groups between 6-8 years and between 11-12 years (Table 3). Comparison of FEV1/FVC values between different age groups was not statistically significant.

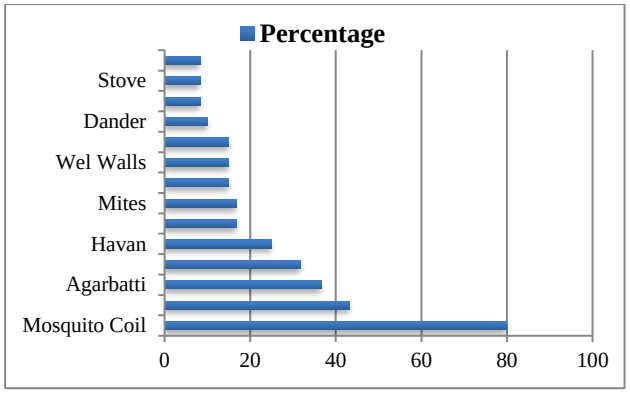

Figure 1: Indoor agents that trigger asthmatic attacks.

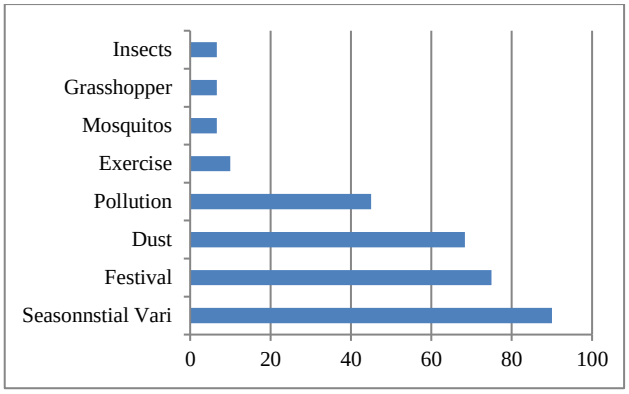

Figure 2: Outdoor agents triggering asthmatic attacks.

Table 2: Distribution of pre and post bronchodilator FEV1 with age.

Age (in years)	N	Pre		Post		t-stat	p-value
		Mean	SD	Mean	SD		
6-8	22	1.110	0.191	1.170	0.163	2.573	0.018*
9-10	18	1.483	0.250	1.551	0.291	2.794	0.012*
11-12	20	1.666	0.379	1.748	0.291	1.224	0.236

*: Significant at 5% level of significance

Table 3: Distribution of FVC values with age.

Age (in years)	N	Pre		Post		t-stat	p-value
		Mean	SD	Mean	SD		
6-8	22	1.255	0.206	1.315	0.172	2.734	0.012*
9-10	18	1.691	0.255	1.741	0.299	1.832	0.085
11-12	20	1.869	0.387	2.000	0.318	2.799	0.011*

Table 4: Distribution of FEV1/FVC values with age.

Age (in years)	N	Pre		Post		t-stat	p-value
		Mean	SD	Mean	SD		
6-8	22	88.573	7.805	89.273	6.224	0.714	0.483
9-10	18	87.594	6.524	89.161	7.532	2.076	0.053
11-12	20	85.585	6.001	87.465	5.995	1.518	0.146

Table 5: Distribution of pre and post bronchodilator PEFR values with age.

Age (in years)	N	Pre		Post		t-stat	p-value
		Mean	SD	Mean	SD		
6-8	22	145.909	25.384	165.273	25.415	4.148	0.00**
9-10	18	195.111	34.226	205.000	31.669	3.39	0.003**
11-12	20	242.000	29.665	247.000	29.218	0.942	0.358

**Significant at 1% level of significance

Table 6: Distribution of pre and post bronchodilator FEF 25-75 values with age.

Age (in years)	N	Pre		Post		t-stat	p-value
		Mean	SD	Mean	SD		
6-8	22	63.782	8.315	91.186	8.580	12.615	0.001**
9-10	18	64.733	9.796	89.356	9.191	13.906	0.001**
11-12	20	67.130	9.719	91.390	5.301	14.795	<0.001**

**: Significant at 1% level of significance

PEFR values for children between 6-8 years and 9-10 years are statistically highly significant (i.e. p value: 0.001 and p value: 0.003 respectively) (Table 5). Comparison of Pre and Post bronchodilator FEF 25-75 values amongst children between 6-8 years and 9-10 years and 11-12 years have shown a high statistical significance (i.e. p value: 0.001, 0.001, <0.001 respectively) (Table 6).

DISCUSSION

Asthma is a common chronic inflammatory disease of the airways characterized by variable and recurring symptoms, reversible obstruction and bronchospasm. Common symptoms include wheezing, coughing, chest tightness, and shortness of breath.[4] It is episodic in nature and usually reversible, either spontaneously or with treatment. However, chronic inflammation, associated with persistent symptoms, may contribute to airway remodeling that may not be completely reversible.[5]

Diagnosis of asthma is usually based on the pattern of symptoms, response to therapy over time andspirometry.[3] Spirometry is a pulmonary function test (PFT) that measures the amount (volume) or speed (flow) of air that can be inhaled and exhaled. The patients is typically asked to breathe normally and then to take the deepest possible breath and then exhale as quickly and as hard as possible.[6] It is clinically classified according to the frequency of symptoms, forced expiratory volume in one second (FEV1), and peak expiratory flow rate. Asthma may also be classified as atopic (extrinsic) or non-atopic (intrinsic) where atopy refers to a predisposition towards developing type 1 hypersensitivity reactions.[3]

The forced expiratory volume in the first second (FEV1) of exhalation is measured and compared to the entire volume of air that can be expelled in a forced expiration (forced vital capacity [FVC]). Spirometry is indicated as part of the initial diagnostic evaluation for asthma in all patients' ≥5 years old to test for airflow obstruction, the severity, and the short-term reversibility.[6] The present study was undertaken to determine various clinical aspects of asthma prevalence and correlation of asthma in different age groups with different parameters of spirometry. Maximum number of patients were in the age group of 6-8 years i.e.22 (37%) while there were 18 (30%) patients between 9-10 years age group and 20 (33.3%) between 11-12 years of age. Overall age distribution in the study population was more or less same. There was more number of male patients compared to female patients in our study population. There were 39 (65%) male patients while there were 21 (35%) female patients. In age and gender wise correlation with classification of asthma, a male preponderance was seen in all the age groups i.e. between 6-8 years, 9-10 years and 11-12 years. Between 6-8 years, 9-10 years and 11-12 years majority of the males were classified as mild persistent asthmatic. Amongst the females in age group between 6-8 years and 9-10 years most of them were mild persistent asthmatic and between 11-12 years of age most of them were classified as moderate persistent asthma. Paramesh H7 studied prevalence of asthma in children below 18 years of age over 2 decades in the city of Bangalore and reported 64% male prevalence and 36% female prevalence. In a study carried out by Yao TC et al[8] among Taiwanese children aged 4-18 years, male-to-female prevalence ratios of current wheeze increased with age from <1 at 4-5 years, peaked at 10-11 years (2.24), then reversed to 0.57 at 16-18 years. When examined at specific time points, asthma is more common and more severe in pre- pubertal boys, with boys less than 18 years of age having a 54% higher rate of asthma than girls of the same age.[9] The prevalence of asthma and its severity increases significantly in women after puberty, with asthma becoming more common in women by age 20 in the United States.[10] The reason for the male preponderance is not exactly clear, but may be partly due to the fact that males are more adventurous and more likely to come in contact with trigger factors even though there was no association between gender and asthma control.[11,12]

There were several indoor and outdoor trigger factors found for asthma. Mosquito coil was the most common indoor trigger factor found in 40 subjects i.e. 80% of patients, paper dust in 26 children i.e. 43% of patients followed by incense sticks, pollution and pests. Chullah was found to be the least common indoor trigger factor with only 1% population. Seasonal variation was the most common outdoor trigger factor followed by festivals & dust, with percentage population of 90%, 75% & 68% respectively. Only 7% patients were found with insects as outdoor trigger factor. In a study conducted by Petronella SA et al they found that the rising prevalence of asthma worldwide seems to be correlated with modern industrialization, suggesting that changes in the ambient environment may contribute to this increase in morbidity and mortality.[13] Scientific evaluation of the links between indoor and outdoor air pollution and asthma is incomplete, however much work remains to be done in defining the environmental factors that may cause asthma and that may trigger asthma exacerbations in individuals with the disease.[13]

A case-control study among children aged 1 month to 5 years hospitalized with asthma in Kuala Lumpur by Azizi et al found that kerosene or wood stove use was not independently associated with asthma though mosquito coil smoke was independently associated.[14] Annually, 45-50 billion mosquito coils are used by, 2 billion people worldwide, particularly in rural and semirural communities of developing countries, to prevent.

Mosquito bites. Liu et al1[5] estimated that burning a mosquito coil can release a mass concentration of PM 2.5 equivalent to burning of 75-137 cigarettes. The smoke released from burning mosquito coil contains some

carcinogenic PAHs, including benzoanthracene, benzofluoranthene, benzofluoranthene, dibenzoanthracene and indenopyrene.[14]

People in developing countries tend to burn mosquito coils during the summer nights and are therefore regularly exposed to the smokes released for about 6-8 h daily. Inhalation of the smoke has been reported to cause breathing difficulties, eye irritation, bronchial irritation, itching, cough and asthma.[16-18]

Spirometry parameters like FEV1, FVC, FEV1/FVC, PEFR and FEF25-75 were analyzed for mean with standard deviation and compared for pre and post bronchodilator values.

There was a statistical significance in pre and post bronchodilator mean values of FEV1 in age group of 6 - 8 years and 9 - 10 years (i.e. p value : 0.018 and 0.012 respectively) while there was no significant difference in the pre & post mean values 11 - 12 years age group (p value: 0.236).

There was statistical significance in the mean FVC values in pre and post findings in age group of 6 - 8 years and 11 - 12 years (i.e. p value: 0.012 and0.011 respectively). The post treatment mean values in 6 - 8 years and 11 - 12 years age group were 1.31 (±0.172) and 2 (±0.318) respectively. Hence FVC was a good indicator of obstruction in both age groups.

Pre and post nebulisation FEV1/FVC ratio was not found to be significant in all age groups.

The mean values of PEFR in pre-treatment group were 145.9 (±25.384), 195.1 (±34.22) and 242 (±29.665) in age group of 6-8 years, 9-10 years and 11-12 years respectively. The mean values of PEFR in post treatment group were 165.2 (±25.415), 205 (±31.669) and 247 (±29.218) in age group of 6-8 years, 9-10 years, 11-12 years respectively. There was highly statistically significant difference in the mean PEFR values in 6 - 8 years and 9-10 years. (i.e. p value: 0.001 and 0.003 respectively). PEFR was sensitive in diagnosing asthma in younger age groups.

With regards to FEF25-75, there was a high statistical significance in all the three age groups.

Anandi S et al assessed the clinical improvement and changes in spirometric measurements with treatment in children with newly diagnosed asthma and found that significant improvement in symptom score was evident at six weeks of therapy ($P<0.05$) while the lung function parameters FEV1 (forced expiratory volume in 1 second) and FVC (forced vital capacity) showed significant improvement at three months of therapy.[19] Another study conducted by Sopasato B et al concluded that at asthma onset, reduced baseline FEF25-75 values with normal FEV1 and FEV1/FVC may predict airway hyper-responsiveness.[20] Furthermore, a greater FEF25-75 reduction may be associated to a more severe AHR, suggesting a possible FEF25-75 role in the management of asthma when FEV1 and FEV1/FVC are normal.[20] Management of asthma depends on part on the ability of patient to monitor their condition. Self-monitoring can be performed subjectively by evaluating symptoms and objectively by performing PEFR.

As the study was conducted for a short period and is a single centric with small sample size, thus there is a need for conducting a large scale study for longer duration, with large sample size and sample taken from all socioeconomic strata which will help us to establish if PEFR helps in estimating disease severity better than other indices of spirometry and the role of FEF25 - 75 in the diagnosis and management of asthma.

Spirometry is a useful investigation for diagnosing and monitoring a number of paediatric respiratory diseases. With the availability of better equipment with incentives for children to aid spirometry performance, most children (including preschool children) can perform acceptable spirometry. Spirometry is underused in children, and there is a need to encourage its use by primary care physicians and paediatricians treating children with respiratory diseases after adequate training.[21-23]

CONCLUSION

Asthma can be successfully treated provided the patient and the relatives are well informed about the disease, its etiology, trigger factors and are also actively involved in their treatment. Parents need to be educated regarding certain modifiable factors that can improve the prognosis which would include curbing the use of mosquito coils, using filters at home and keeping the area devoid of dust, molds, pets and their dander. Appropriate care during season change and reporting to the clinic at the slightest hint of a symptom can prevent the child and parent of the entire predicament that may follow. Pulmonary Function tests should be performed as a routine office procedure. Peak expiratory flow meter is a handy instrument. In all children above 6 years of age suspected to have asthma, this test should be performed before beginning therapy. It is a good indicator to classify as well as monitor a patient on therapy.

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