Original Research Article

Comparative study of peak expiratory flow rate and pulmonary score index in acute exacerbation of mild and moderate asthma in age group of 6 to 12 years

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Abstract
The availability of new diagnostic methods, a better understanding of asthma's pathophysiology, and the introduction of several oral and inhaled drugs have revolutionized asthma management in children. It has also increased the pediatrician's burden to keep abreast of the advances and educate them on the subjects. Children of 6-12 years coming to the department of pediatrics, who are Known asthmatic and children presented first time with symptoms suggestive of asthma, and exacerbation severity graded as mild, moderate& severe acute asthma exacerbation according to GINA 2019 guidelines, only children with mild and moderate exacerbation were selected in this study. The mean predicted PEFR improved with treatment by 20.82% from 50.68% to 71.5% of expected ($p<0.0001$) by 15 minutes. The mean PSI decreased by 2.84 ($p<0.0001$) from 4.8 to 2.0 by 15 minutes.
Keywords: Peak expiratory flow rate, pulmonary score index, asthma

Introduction

Asthma is a chronic inflammatory disease of the airways that significantly impacts the quality of life and Is particularly important in children due to higher incidences of allergies.

The prevalence of asthma has dramatically increased during this period, with the highest increase in developed countries' urban areas. It seems developing countries may follow this trend of an increase in prevalence.

A recent report shows a wide variation (4-32%) in the prevalence of asthma in school-going children from different geographic areas in India & increasing prevalence over the last few decades [1, 2]. The prevalence of asthma among school children aged between 7-10 years of age in the Chittoor district of Andhra Pradesh is 10.82% [3]. Recognizing children's problems is essential since the spectrum of presentation is variable and multiple for proper management.

The availability of new diagnostic methods, a better understanding of asthma's pathophysiology and the introduction of several oral and inhaled drugs have revolutionized asthma management in children. It has also increased the pediatrician's burden to keep abreast of the advances and educate them on the subjects.

Most of the parents not willing to use these drugs in children because of the

- Expense.
- The widespread belief among parents that these aerosols are habit-forming in the long run.
- difficult to have good adherence to preventive aerosols even when the child is asymptomatic.

Typically wheezing attacks in young children are episodic and interval symptoms are frequently absent. Most children who wheeze before two years of age are rare to wheeze later, and only a minority have symptoms three to five years after their initial illness. Another group who wheeze in early life and continue to wheeze at the age of six has been noted to have a higher incidence of atopy and greater bronchial hyper-responsiveness (sensitivity). This group probably represents the early onset of asthma in children [4].

A child's susceptibility to developing asthma depends on the complex interplay of multiple genes, along with environmental exposures. Understanding the critical role of environmental exposures in asthma development is essential to reducing this disease's burden in children.

An essential step in initiating treatment with appropriate medication and monitoring response to subsequent therapy is the accurate measurement of the severity of an acute asthma exacerbation. Clinical evaluation, coupled with experience, does not always accurately determine the degree of airway obstruction. The most accurate method to measure asthma severity is spirometry, in which several pulmonary functions, such as forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), is measured [5].

Unfortunately, spirometry is special equipment not often available in the emergency department, as it requires trained staff to perform and interpret the results. PEFR -peak expiratory flow rate is often used to estimate the degree of airway obstruction instead of spirometry. However, spirometry and PEFR are complicated methods for younger children to perform or children of any age with severe obstruction. Even some older children have difficulty performing the expiratory maneuvers for either PEFR or spirometry.

A varied number of asthma severity scoring systems have been established based on the number of signs, such as respiratory rate and use of accessory muscle, to form a combined score that estimates the severity of an episode of acute asthma exacerbation. Even though more than 16 severity scoring systems exist, many are difficult to use. For example, some scoring systems require blood gas analyses, others require numerous objective measures, or Few scoring systems have been rigorously validated. The pulmonary score index (PSI) was developed to provide a "user-friendly "measure of the severity of exacerbation of acute asthma [6].

The present study aims to validate the pulmonary score index as a tool to measure the severity of airway obstruction in children presenting to the emergency department for the treatment of an acute asthma exacerbation.

Methodology

1. **Study design:** A prospective comparative study.
2. **Place of Study:** Department of Paediatrics.
3. **Sample size:** 200.

Inclusion criteria: Children with the age group of 6-12 years presenting to the pediatrics department with mild to moderate asthma exacerbation. Parents willing to give signed informed consent.

Exclusion criteria: Suspected or known children having immunosuppressive, cardiac, and neurological condition affecting pulmonary function and other chronic pulmonary diseases. Children who are not able to perform the peak expiratory flow rate are excluded

Selection of cases and methods

Children of 6-12 years coming to the department of pediatrics, who are Known asthmatic and children presented first time with symptoms suggestive of asthma and exacerbation severity graded as mild, moderate & severe acute asthma exacerbation according to GINA 2019 guidelines, only children with mild and moderate exacerbation were selected in this study.

Before starting treatment, they were initially assessed by measuring peak expiratory flow rate with digital peak flow meter and pulmonary score index.

Four variables-assess pulmonary score index.

Respiratory rate Wheezing
Accessory muscle use Inspiratory: expiratory ratio each variable is awarded four scores-0, 1, 2, 3, summed up to 12.
Mild exacerbation-<4/12.
Moderate exacerbation: 4-7/12.
Severe exacerbation: >7/12.

Results

Two hundred children evaluated, ranging from 6 to 12 years of age, with a mean age of 8.9. PEFR and PSI were analyzed before and after treatment at 5, 10 and 15 minutes for each child. There was a significant change in PEFR and PSI before and after treatment. As airway obstruction improved with treatment, the PSI should decrease and the PEFR should increase.

Table 1: Mean and Standard Deviation of PEFR

	Mean	Standard Deviation
Before Treatment	50.68	2.55
At 5 minutes	61.78	4.85
At 10 minutes	63.80	4.309
At 15 minutes	71.5	3.17
At discharge	81.57	6.55

Table 2: Mean and Standard Deviation of PSI

	Mean	Standard Deviation
Before Treatment	4.88	0.64
At 5 minutes	3.81	0.646
At 10 minutes	3.05	0.59
At 15 minutes	2.04	0.56
At discharge	1.33	0.6

The mean predicted PEFR improved with treatment by 20.82% from 50.68% to 71.5% of expected ($p<0.0001$) by 15 minutes. The mean PSI decreased by 2.84 ($p<0.0001$) from 4.8 to 2.0 by 15 minutes.

Table 3: Paired T Test for Construct Validity

Paired Variables	T-Value	P-Value
PEFR before treatment and PEFR at 5 minutes	-25.267	.000
PEFR before treatment and PEFR at 10 minutes	-31.731	.000
PEFR before treatment and PEFR at 15 minutes	-84.993	.000
PEFR before treatment and PEFR at discharge	-7.853	.000
PS before treatment and PS at 5 minutes	41.726	.000
PS before treatment and PS at 10 minutes	31.177	.000
PS before treatment and PS at 15 minutes	44.995	.000
PS before treatment and PS at discharge	47.421	.000

The PSI had a significant negative correlation with the PEFR; i.e., as the PEFR increased, the PSI decreased. The correlation of pre-treatment PEFR and PSI is r =-0.377 (p = 0.01) (Fig.7), that for post treatment at 5 minutes is r= -0.400 (p=0.001) at 10 minutes is r= -0.304 (p=0.002) and at 15 minutes is r = - 0.446 (p = 0.000).

Table 4: Predicted Improvement of PEFR in Percentage in Mild Acute Asthma Exacerbation after Short Acting Beta Agonist (Saba) Nebulization's

Improvement (% of predicted (PEFR)	5 min (no of cases)	10 min (no of cases)	15 min (no of cases)
5%-10% PEFR	12(30%)	8(20%)	0
10%-15% PEFR	12(30%)	12(30%)	2(5%)
16%-20%PEFR	14(35%)	16(40%)	8(20%)
>20% PEFR	2(5%)	4(10%)	30(75%)

In our study out of 20% (n=40), mild asthma cases, for improvement of PEFR by 5-10%, around 30% children took 5 minutes, 20% by 10 minutes. For 10-15% change in PEFR, 30% children took 5 minutes, similar 30% took 10 minutes only 5% taken 15 minutes. For 16-20% change in PEFR, 35% taken 5 minutes, 40% improved by 10 minutes, 20% taken 15 minutes for more than 20% improvement in PEFR 75% children taken 15 minutes, only 5% children improved within 5 minutes, 10% took 10 minutes.

Table 5: Predicted Improvement of PEFR in Percentage in Moderate Acute Asthma Exacerbation after Saba Nebulization's

Improvement (% of predicted PEFR)	5 min (no of cases)	10 min (no of cases)	15 min (no of cases)
5%-10 % PEFR	58(36.2%)	36(22.5%)	0
10%-15% PEFR	71(44.3%)	68(42.5%)	0
16%-20% PEFR	31(19.3%)	56(35%)	48(30%)
>20% PEFR	0	0	112(70%)

In our study out of 80% (n=160), moderate asthma cases, for improvement of PEFR by 5-10%, around 36.2% children took 5 minutes, 22.5% by 10 minutes. For 10-15% change in PEFR, 44.3% children took 5 minutes, similar 42.5% taken 10 minutes, no children took 15 minutes. For 16-20% change in PEFR, 19.3% taken 5 minutes, 35% improved by 10 minutes, 30% taken 15 minutes. For more than 20% improvement in PEFR 70% children took 15 minutes.

Discussion

In the present study, out of 80% of moderate asthma exacerbations, 18% of children (n=30) used short-course oral steroids during an episode of acute exacerbation.

In the present study, children with mild asthma exacerbation, by 5 minutes of nebulization, the majority (60%) cases showed improvement in PEFR by 15% & only 40% of children had >15% PEFR change. By 10 minutes, 40% of patients showed improvement by 16-20% and by 15 minutes, 75% of cases showed improvement by more than 20%. In our study, the first treatment for all cases of mild exacerbation was only salbutamol nebulization.

In the present study, children with moderate asthma exacerbation, by 5 minutes of nebulization, the majority (44.3%) cases showed improvement in PEFR by 15% & only 19.3% of children had >15% PEFR change. By 10 minutes, 35% of patients showed improvement by 16-20% and by 15 minutes, 70% of cases showed improvement by more than 20%. In our study, the first treatment for all moderate exacerbation cases was salbutamol nebulization along with oral rescue steroids, whoever required.

Children with a mild asthma exacerbation have better & early improvement of airway obstruction.

In the present study, out of 200 children, 16 (8%) children were obese, all these had poor PEFR improvement after the first dose of nebulization, all children took more than 15 minutes for 20% change in PEFR and there is no significant change in PEFR percentage at 5 & 10 minutes of salbutamol nebulization explained in a study by McGarry *et al*. reported that obese black and Latino adolescents were 24% more likely to be bronchodilator unresponsive than their non-obese peers [7]. Moreover, among children hospitalized for asthma, obesity is associated with a longer length of stay and with a higher risk of mechanical ventilation [8].

An increase in intra-abdominal pressure on the diaphragm and fat mass on chest wall leads to mass loading of the thorax, resulting in a reduction of respiratory compliance and changes in airway resistance [9]. Further systemic and airway inflammation of obesity and asthma are interlinked by systemic spillover of “adipokines” [10]. These results are also supported by Figueroa-Muñoz, who found a clear association between obesity and asthma in 4-and 11-year-old children in the United Kingdom [11]. In India, studies done in adults have found a strong association between asthma and obesity [12].

The PSI passed two formal tests of validity. We evaluated the construct and the criterion validities of the PSI.

Construct validity (the degree to which an instrument measures the construct or characteristic under investigation) in this study is how the PSI measures airway obstruction. To construct validity, we compared the pre-and post-treatment PSI and the pre-to post-treatment PEFRs.

The PEFRs is an established method to measure airway obstruction and improved with treatment from a mean predicted PEFR of 20.82 from 50.68% to 71.5% of predicted (p <0.0001) by 15 minutes. PEFR improves with treatment as the degree of airway obstruction decreases.

Criterion validity is the degree to which an instrument correlates with an established criterion. The PEFR was used as the known criterion and both the PEFR and the PSI at the same time. The correlation between the pre-treatment PSI and PEFR is r=-0.377. The post-treatment correlation is r=-0.446 at 15 minutes. The PEFR has been chosen as the established criterion because it is commonly used to measure asthma exacerbation.

Even though pulmonary function tests (PFTs) may provide a better tool to measure airway obstruction, PFTs require special equipment and trained staff to interpret the results. PEFRs and PFTs require special cooperation from children to get accurate severity of airway obstruction.

The PSI is a simple objective method to assess the severity of an acute asthma exacerbation in children. The score is a composite of physical findings commonly used in assessing children with asthma: respiratory rate, wheezing and accessory muscle use. These three components are easy to obtain in children and require little additional training for staff to learn.

The correlations between the PSI and PEFRs ranged from -0.304 to -0.490; these are similar to the correlations found with other clinical scoring systems, which are estimates of lung function or signs of respiratory distress.

The clinical severity score (CSS) was compared between arterial oxygen saturation and FEV1, having correlations of r = 0.49 and r = 0.52, respectively [13]. The asthma severity score (ASS) correlated between oxygen saturation (r = -0.45) and FEV1 (r = - 0.54) [14].

These correlations may have a lower than expected amount; however, all of these scoring systems contain physical signs (components) that do not measure airway obstruction. Therefore, it is not surprising to have a little correlation when compared with actual airway obstructions.

Furthermore, when an asthma child's clinical appearance improves with treatment, the underlying obstruction may take several weeks to become normal. This delayed airway obstruction relief helps explain why children in this study had PSIs suggestive of mild severity but had lower than expected PEFRs & no great difference between 15mt PSI and discharge PSI.

PEFR also a better tool to measure and grade the severity of asthma exacerbation, but some children were unaware of the device and may find it difficult to blow forcefully; this might be why low PEFR value even though the child may be relieved of airway obstruction.

Despite their flaws, objective clinical scoring systems play a somewhat important role in measuring the degree of airway obstruction for children with asthma exacerbation when true obstruction measures are not readily available.

Children with severe respiratory distress are likely to have difficulty in performing PEFRs because they cannot inhale completely before exhaling forcefully. It is the one reason that PSI correlated better with the PEFR after bronchodilator therapy because a child's ability to perform PEFR improved.

Primary goals in managing asthma are to minimize the severity and future risk of exacerbations and maintain normal lung function. Patients with previous severe exacerbation, positive asthma predictive indices and multiple allergen sensitizations require special attention. They need to be educated about these aspects of their disease so that families can be educated to detect imminent exacerbation and adhere to the asthma control plan. Referral to a pediatric allergy specialist is indicated in pediatric patients with recurrent exacerbations and persistent asthma.

Conclusion

The PSI is a convenient, simple method of assessing airway obstruction. The PSI appears to correlate better with lesser airway obstruction than greater airway obstruction; i.e., the PSI has higher post-treatment correlations, making the PSI a good tool to assess mild & moderate severity and treatment response. No scoring system is perfect, but assessing severity in children is needed when spirometry testing is not obtainable.

Diagnosis and management of bronchial asthma require assessment of pulmonary function, especially ventilatory functions.

The peak expiratory flow rate (PEFR) measurement is a very simple, reliable, reproducible ventilatory function test that can be performed by using a mini-Wright peak flow meter (a cheap, portable instrument). Assessing severity in children are required when spirometry testing is not obtainable.

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