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Original Research Article

Study on to assess pulmonary function test changes in asthmatic child using spirometry and its diagnostic and prognostic value

Pratibha M. Patil*, Manisha Chavan

Department of Paediatrics, Ashwini Rural Medical College, Hospital and Research Centre, Kumbhari, Solapur, Maharashtra, India

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***Correspondence:**
Dr. Pratibha M Patil,
E-mail: drpatilpratibha@gmail.com

ABSTRACT

Background: Asthma is a disease that has become increasingly common over the last century making it now one of the commonest chronic disorders in the world. Spirometric lung function tests are playing a key role in the diagnosis and management of asthma in children. Considering the usefulness of spirometer in the diagnosis of asthma and scarcity of the literature regarding the role of spirometer in the diagnosis of Asthma especially in Indian context, the present study was undertaken to assess pulmonary function test changes in asthmatic child using spirometry and its diagnostic and prognostic value.
Methods: The present study was conducted at Department of Paediatrics, Ashwini Rural Medical College, Hospital and Research Centre, Kumbhari during the study period of 2015 to 2016. Children presenting symptoms suggestive of asthma were included in the study.
Results: In the present study, the commonest presentations included cough, breathing difficulty and recurrent wheeze in all the children (100%) followed by chest tightness (23%) and fever (11%). In the present study, the clinical and spirometry diagnosis of moderate asthma showed total positive correlation (100%). The positive correlation of mild persistent and intermittent asthma was limited to 97.30% and 91.18%. Severe persistent asthma positively correlated in 76.77%.
Conclusions: It may be concluded that, the spirometry is not only helps to diagnose the asthma accurately, but also helps in assessing the severity which has the key role in the successful management.

Keywords: Asthma, Children, Pulmonary function test, Spirometry

INTRODUCTION

Asthma is a disease that has become increasingly common over the last century making it now one of the commonest chronic disorders in the world which has affected estimated 300 million individuals worldwide, with an expected increase to 400 million worldwide by 2025. Annually, the World Health Organization (WHO) has estimated that 15 million disability-adjusted life-years are lost and 250,000 asthma deaths are reported worldwide.[1-3] The magnitude of the impacts of asthma in children is illustrated by the fact that asthma accounts for more hospitalizations in children than any other chronic illness.[4] The magnitude of the impacts of asthma in children is illustrated by the fact that asthma accounts for more hospitalizations in children than any other chronic illness.[4] Main features of Asthma are diffuse obstruction at terminal bronchioles as a result of hyper reactivity or bronchial hyper responsiveness (BHR) of airways to a variety of stimuli and high degree of reversibility either spontaneous or as a result of treatment.[5,6] Common risk factors for asthma symptoms includes exposure to allergens occupational irritants, tobacco smoke, respiratory infections, exercise, strong emotional

expressions, sudden weather change, chemical irritants and drugs.[3]

Clinical manifestations of asthma are intermittent, dry coughing, expiratory wheezing, chest tightness, and dyspnea are commonly provoked by physical exertion and airway irritants (e.g. cold and dry air, environmental and tobacco smoke).[5]

Asthma exacerbations for prolonged periods (i.e. from days to weeks) are induced by common respiratory viral infections and by inhalant allergen exposure in sensitized asthmatics, characteristically worse at night and can progress to severe airflow obstruction, shortness of breath, and respiratory distress and insufficiency. Rarely, severe squeal such as hypoxic seizures, respiratory failure, and death can occur.[7,8]

Historically, the clinical diagnosis of asthma in adults has been based on a history of wheezing, cough and breathlessness and supported by the presence of variable airflow obstruction[9]. Peak flow variability and bronchial hyper responsiveness (BHR) measurements are widely accepted as markers for asthma, but their contribution to the diagnosis controversial [10] and diagnostic profiles of BHR are extremely variable.[11]

Childhood wheezing illness commonly present as phenotypes with similar symptoms (wheeze, cough, difficulty in breathing) but with different underlying causes, prognosis and response to therapy.[12]

Less than half of young children who wheeze go on to develop classical atopic asthma and in the under 2-year-olds it is difficult to diagnose asthma with certainly. In preschool children, the diagnosis is often made on reported symptoms only, without any objective testing. The meaning of terms such as wheeze is not well understood by many parents. The reported presence of 'wheeze', however, is used by doctors and in questionnaires to diagnose and estimate the prevalence of asthma in the community which leads to both over-diagnosis and under-diagnosis of asthma. One of the most common challenges bin diagnosing asthma is to distinguish it from isolated cough.[13,14] Simple and objective tests that could help inform the diagnosis of asthma, especially by the nonspecialist are needed.

Measurements of lung function provides an assessment of the severity, reversibility and variability of airflow limitation and help confirm the diagnosis of asthma.[15] Pulmonary function testing includes spirometry, peak expiratory flow monitoring exercise induced bronchospam and measurement of ENO (Exhaled No-FEno).

Though spirometry does not measure the individual lung volumes, it measures the forced vital capacity (FVC), which is a combination of tidal volume (TV) expiratory reserve volume (ERV) and inspiratory reserve volume (IRV). The other indices like forced expiratory volume in one second (FEV1), the ratio of FEV1 with FVC (FEV1/FVC), forced expiratory flow 25% to 75% of forced vital capacity (FEF 25%-75%) are measured from FVC. The spirometer cannot measure functional residual capacity (FRC) or total lung capacity (TLC) but these parameters are not important in routine assessment of common lung problems. Baseline spirometric values depend on various factors like race, sex, age, etc. The standing height is a satisfactory predictor of lung function.[16]

Spirometry, the most widely available lung function test, measures the volume of air expired during a maximal expiratory effort. The forced vital capacity (FVC) is the total amount of air exhaled following a maximal inspiration. The forced expiratory volume timed (FEV_t) is the volume of air forcefully exhaled after a given time, t. For accurate results, the maximal inhalation should be close to total lung capacity, followed by a rapid rise to peak flow on exhalation; there should be a maximal forced effort throughout expiration down to or close to residual volume.[17]

Despite the importance of spirometry, studies suggest that children with asthma infrequently receive such testing. Although specialists, compared with primary care physicians, are more likely to refer patients for such testing.[9]

Spirometric lung function tests are playing a key role in the diagnosis and management of asthma in children.[18] Normal lung function is one of the goal of asthma management in international guidelines.[19,20]

Furthermore, the long term cohort studies have established that lung function test results in children with asthma are correlated with asthma severity and with lung function impairment in adulthood.[21] There is evidence that spirometric measurement of lung function including FEVI, FVC, FEVI/FVC and PEFR are decreased in asthmatic children than those of the apparently healthy children.[22]

The successful management of asthma requires grading the severity of the disease according to the frequency and severity of symptoms and functional impairment.[2] The NAEPP (NATIONAL Asthma Education and Prevention Programme) offers a stepwise approach to management based on asthma severity categorized as mild intermittent, mild persistent, moderate persistent, severe persistent asthma.[1]

Considering the usefulness of spirometer in the diagnosis of asthma and scarcity of the literature regarding the role of spirometer in the diagnosis of Asthma especially in Indian context, the present study was undertaken to assess pulmonary function test changes in asthmatic child using spirometry and its diagnostic and prognostic value. The objectives of the study, to assess pulmonary function

test changes in asthmatic child using spirometry and its diagnostic and prognostic value.

METHODS

The present study was conducted at Department of Paediatrics, Ashwini Rural Medical College, Hospital and Research Centre, Kumbhari during the study period of 2015 to 2016. Children presenting symptoms suggestive of asthma were included in the study.

Selection Criteria

Inclusion Criteria

Children presenting with signs and symptoms of asthma, both sex and children aged between 5 to 12 years.

Exclusion criteria

History of pneumonia, Congenital heart disease, Acute exacerbation of asthma, Patients with oral steroids, Hospitalization during last four weeks were excluded from the study.

Ethical clearance was obtained for the study and children fulfilling the selection criteria were selected and their next of kin or legal guardians were briefed about the nature of the study and a written informed consent was obtained from the selected patients.

Data collection procedure

Demographic characteristics such as sex and age were recorded. Further they were interviewed for the history and symptoms.

Following the interview the children were subjected to the through clinical examination for vitals, anthropometry and clinical signs. These findings were recorded on a predesigned and pretested proforma.

Investigations

The selected children underwent investigations such as complete blood count (CBC) and erothrocyte sedimentation rate (ESR). Imaging studies such as chest X-ray was done to rule out the presence of tuberculosis.

Procedure

Based on the history, presenting signs and symptoms and clinical examination finding the diagnosis of asthma was confirmed. The severity of the asthma was assessed by symptom severity that is, duration of symptoms (day and night symptoms), interference with normal activity and number of exacerbations per year based on National Asthma Education and Prevention Programme guidelines.[23]

Further these children were subjected to pulmonary function test changes using spirometer. FEVI, FEVI/FVC ratio and PEFR were recorded. Based on these variables the severity of the asthma was assessed.

Statistical analysis

The data obtained was coded and entered into Microsoft Excel spreadsheet. The categorized data was expressed as rates, ratios and percentages. Continuous data was expressed as mean ± standard deviation (SD). Percentage agreement was used to find the difference between clinical and spirometry diagnosis of asthma.

RESULTS

The present study was conducted Department of Paediatrics, Ashwini Rural Medical College, Hospital and Research Centre, Kumbhari during the study period of 2015 to 2016. A total of 100 children presenting symptoms suggestive of asthma were included in the study. Majority of the children were belonging to age 8 years. The mean age was 7.35 ± 1.43 years and presented in (Table 1). Boys and girls contributed almost equal in the present study (Table 2).

Table 1: Age distribution.

Age group (year)	Number	Percentage
5	11	11
6	22	22
7	15	15
8	30	30
9	18	18
10	3	3
11	1	1
Total	**100**	**100**

Table 2: Sex distribution.

Sex	Number	Percentage
Boy	49	49
Girl	51	51
Total	**100**	**100**

Table 3: Clinical presentation.

Clinical signs	Number	Percentage
Cough	100	100
Breathing difficulty	100	100
Chest tightness	23	23
Fever	11	11
Recurrent wheeze	100	100

In the present study, the commonest presentations included cough, breathing difficulty and recurrent wheeze in all the children (100%) followed by chest tightness (23%) and fever (11%) presented in (Table 3). In the

present study, most of the children (35%) presented with two daytime symptoms followed by one symptom (33%) and seven symptoms (32%). For nighttime symptoms, among 35% of children, three nighttime symptoms per months were recorded whereas one nighttime symptom per months was present in 34% of children. Frequency of symptoms was high in 6% children (Table 4).

Table 4: Symptoms.

Symptoms	Number	Percentage
Daytime		
1	33	33
2	35	35
7	32	32
Night time		
1 per night	1	1
1 per week	34	34
2 per week	18	18
2 per month	6	6
3 per month	35	35
Frequently	6	6

In the present study, 5% of the children reported extremely limited normal activity. However, children 36%, 35% and 24% children reported no limitation, minor limitation and some limitation respectively (Table 5).

Table 5: Interference with normal activity.

Interference	Number	Percentage
Extremely limited	5	5
Some limitation	24	24
Minor limitation	35	35
None 36	36	36

In the present study, 38% children were clinically diagnosed with mild persistent asthma and 23% with moderate persistent asthma. Severe persistent and intermittent asthma was diagnosed among 8% and 31% of children respectively (Table 6).

In the present study on the spirometry, 69% children had FEV1 more than 80% and 25% children had FEV1 between 60 to 80%. However, 6% children had FEV1 less than 60%. In the present study, 48% children showed the FEV1/FVC with more than 85% whereas 22% children had between 81 to 85%. And 21% children had 75 to 80%. In 9% children, the FEV1/FVC was less than 75% (Table 7).

Table 6: Clinical diagnosis.

Diagnosis	Number	Percentage
Mild persistent	38	38
Moderate persistent	23	23
Severe persistent	8	8
Intermittent	31	31

Table 7: Pulmonary function parameters.

Parameters	Number	Percentage
FEV1 (%)		
> 80	69	69
60 - 80	25	25
< 60	6	6
FEV1 / FVC (%)		
> 85	48	48
81 - 85	22	22
75 - 80	21	21
< 75	9	9

Table 8: Diagnosis based on spirometry.

Diagnosis	Number	Percentage
Mild persistent	37	37
Moderate persistent	23	23
Severe persistent	6	6
Intermittent	34	34

Table 9: Correlation of clinical and spirometry diagnosis.

Diagnosis	Total cases	Clinical diagnosis		Spirometry diagnosis		Clinical differential diagnosis		Positive correlation	
		No.	%	No.	%	No.	%	No.	%
Mild persistent	37	38	38	37	38	1	2.70	36	97.30
Moderate persistent	23	23	23	23	23	0	0	23	100
Severe persistent	6	8	8	6	6	2	33.33	6	76.77
Intermittent	34	31	31	34	34	3	8.82	31	91.18

In the present study based on spirometry, 37% children were diagnosed to have mild persistent asthma and 34% children had intermittent asthma. The moderate persistent asthma was diagnosed in 23% children and 6% children had severe persistent asthma (Table 8). In the present study, the clinical and spirometry diagnosis of

moderate asthma showed total positive correlation (100%). The positive correlation of mild persistent and intermittent asthma was limited to 97.30% and 91.18%. Severe persistent asthma positively correlated in 76.77% (Table 9).

DISCUSSION

The urgent issue in asthma management strategy is early diagnosis. Under diagnosis of asthma leads to under treatment that causes progressive remolding in the airway mucosa. Recent studies have demonstrated (on the basis of broncho alveolar lavage) inflammatory changes even in mild persistent asthma.[24] Though asthma can be diagnosed on clinical grounds, poor compliance and difficulty in monitoring are the impedence in successful management. Recent studies indicate that upto 70% of patients with asthma do not comply with treatment.[25] So all older children should be subjected to spirometry in the initial evaluation of the disease. In the majority, the demonstration of the objective deviation of the observed value (>20%) from the predidted value by spirometer confirms asthma. When Spirometry values are normal and asthma is strongly suspected the response to bronchodilator aerosol is measured (Bronchodilator challenge test). Reversible airway obstruction characterized by a rise in the FEVI and / or FVC by atleast 12% from pre-to post bronchodilator), is characteristic of asthma.[26]

In the present study, equal distribution of sex was observed with 51% males and 49% females. The male to female ratio was 1.04:1.

In the present study the commonest presentations cough, searching difficulty and recurrent wheeze in all the children (100%). The other presentations included chest tightness (23%) and fever (11%). The respiratory distress was present in 68% children. Like other studies the present research revealed that majority of studied children presented with a combination of respiratory symptoms rather than a single symptom.[27] However, A study from Saudi Arabia reported that. dyspnea rather than wheeze and cough was the most common symptoms in infants below one year of age.[28] Overall, like other studies the core symptoms such as wheeze, chest tightness and cough in decreasing frequency were the most frequently reported manifestations in older children in this research.[27,29] In the present study 35% of the children presented with two daytime symptoms and 33% with one symptom. Seven symptoms were noted among 32% of children. Among 35% of children three nighttime symptoms per months were recorded whereas one nighttime symptom per months was in 34% of children (66%) reported two or more exacerbations per years whereas in 34% less than or equal in one exacerbations were noted. Of the 100 children, 5% children reported extremely limited normal activity. However, in 36%, 35% and 24% children had no limitation and some limitation respectively. Based on these observations and National Asthma Education and Prevention programme guidelines, 38% children were clinically diagnosed with mild persistent asthma and 23% with moderate persistent asthama.[23] Severe persistent and intermittent asthma was diagnosed among 8% and 31% children respectively.

Although numerous epidemiological studies have been carried out all over the world; the magnitude of the problem of asthma has not been defined with certainty. Indeed, bronchial asthma prevalence studies lack consistency, possibly because of the ill-defined diagnostic criteria, non-standardized study protocols, and different methodologies. These have made international and even national comparison difficult, which incidentally have significant ethnic and regional variations. An increasing morbidity and mortality, as well as healthcare burden from asthma have been recognized lately[30]. In recent years, a majority of the researchers are using a questionnaire suggested by the 50-nation International study of Bronchial Asthma and Allergy in Children (ISSAC).[31]

In the present study based in the spirometry, 69% children had FEV1 more than 80% and 25% children had FEV1 between 60 to 80%. However, 6% children had FEV1 less than 60%. Of the 100 children studied, 48% children showed the FEV1 to FVC with more than 85% whereas 22% children had 81% to 85% and 21% children had 75% to 80%. In 9% children, the FEV1 to FVC was less than 75%. The mean FEV1 values were 76.68 ± 10.03 percent and FEV1 to FVC values were 82.40 ± 8.12 percent. The mean PEFR values were 81.85 ± 9.89 percent. Based in these findings 37% of children were diagnosed to have mild persistent asthma and 34% children had intermittent asthma. The moderate persistent asthma was diagnosed in 23% children and 6% children had severe persistent asthma. In a study from Chandigarh, India on 11 males (55%) and 9 females (45%) with mean age 9.33 ± 1.24 years, the majority (85%) had moderate persistent asthma[32].

In the present study, the clinical and spirometry diagnosis of moderate asthma showed total positive correlation (100%). The positive correlation of mild persistent and intermittent asthma was limited to 97.30 % and 91.18%. Severe persistent asthma positively correlated in 76.77%. Studies comparing clinical and spirometry are scarce.

Shrivastava A, et.al studied PFTs in children with respiratory disorders and in normal children. He found that FCC was normal in asthmatic children, decreased in restrictive diseases as in pneumonia and empyema. FVC remains normal in mild and moderate obstruction. It may be decreased in severe obstruction and in restrictive lung diseases it is reduced as FVC represents lung parenchyma and asthma is disease of airways so in asthma FVC remains normal except in severe asthma where FVC may be decreased due to worsening of air trapping.[33,34] And in restrictive lung conditions there is less of lung tissue so FVC is decreased.

In studies by Bacharier et. al. Paull et.al. in asthmatic children between 5-18 of age found normal FEVI values (many over 90% predicted) in a majority of the children, but study by Strunk et al. had a study with objective of effect of mild to moderate childhood asthma on lung growth found that FEVI was lower for boys with asthma than for boys without asthma.[34-36] In asthma diffuse narrowing of the airways results in profound physiologic consequences. This narrowing has been thought an occur disproportionately in the small bronchi[37]. Although recent studies suggest a prominent role for large and medium airways.[37,38] As a result, lung function tests are abnormal, with an increase in airway resistance and a decline in maximal expiratory flow.[37] In obstructive lung conditions the airways are narrowed usually causing an increase in time it takes to empty the lungs. So FEVI is reduced in asthma.

Bacharier et al FEVI/ FVC ratios at age 10 years, in asthmatics, 79% (mean with a range 76-83%) compared with 87% (mean with a range 85-89%) for the control subjects.[34] The FEVI/FVC ratio represents exaggeration of dysanapsis that occurs in asthma. Dysanapsis in the lung is a normal phenomenon caused by disproportionate growth of airways and lung parenchyma. The extent of dysanapsis in asthma (as represented by abnormal FEVI/ FVC) is highly correlated with the degree of arway hyperresponsiveness.[34,39]

Overall the present study showed the role of spirometry in accurate diagnosis of asthma in children enabling appropriate management. The limitations of the study were smaller sample size, the study with follow up would have yielded better results including outcome and prognosis and asthma triggers were not considered which would have helped us for the better management.

CONCLUSION

In the present study in the spirometry, 69% children had FEV1 more than 80% and 25% children had FEV1 between 60 to 80%. However, 6% children had FEV1 less than 60%. The FEV1/FVC in 48% children was more than 85%, 22% children had 81 to 85%, 21% children had 75 to 80% and 9% children had FEV1/FVC less than 75%. The mean FEV1 values were 78.68 ± 10.03 percent and FEV1/FVC values were 82.40 ± 8.12 percent. The mean PEFR values were 81.85 ± 9.89 percent.

Based on spirometry, 37% of children were diagnosed with mild persistent asthma, 34% with intermittent asthma, moderate persistent asthama 23% and 6% with sever persistent asthma. The clinical and spirometry diagnosis of moderate asthma showed total positive correlation (100%). The positive correlation of mild persistent and intermittent asthma was limited to 97.30% and 91.18%. Severe persistent asthma positively correlated in 76.77%. Hence it may be concluded that, the spirometry is not only helps to diagnose the asthma accurately, but also helps in assessing the severity which has the key role in the successful management.

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REFERENCES

1. Pocket guide for Asthma management and prevention (for adults and children older than 5 years). USA: Global Initiative for Asthma (GINA):2009.
2. Bhogal S, Zemek R, Ducharme FM. Written action plans for asthma in children. Cochrane Database Syst Rev. 2006;3(3).
3. Pocket guide for Asthma management and prevention (for adults and children older than 5 years). USA: Global Initiative for Asthma;2011.
4. Akinbami L. Centers for Disease Control and Prevention National Center for Health Statistics. The state of Childhood asthma in United States 1980-2005. Adv Data. 2006;381:1-24.
5. Goldman L, Ausiello D, Cecil Textbook of Medicines;23rd ed, Philadelphia; Sauders Elsevier;2007:1.
6. El-Khedr SM. The impact of Peak Flow Meter Training in Enhancing Self-Efficacy of Asthmatic Children. J Am Sci. 2012;8(1):1-12.
7. Jojnston S, Pattemore P. Community study of role of viral infections in exacerbation of asthma in 9-11 year old children. Br Med J. 1995;310:1225-8.
8. Kleigman RM, Stanton BF. Textbook of Pediatrics. 19th ed., Philadelphia:Saunders-Elsevier;2011.
9. Britton J, Lewis S. Objective measures and the diagnosis of asthma:we need a simple diagnostic test-but don't yet have one. BMJ. 1998;317:227-8.
10. Mason RJ, Broaddus CV, Martin T, King T, Schraufnagel D, Murray JF. et al. Murray and Nadel's textbook of respiratory medicine. 5th ed. Philadelphia: Saunders/Elsevier;2010.
11. Godfrey S, Springer C. Cut; off points defining normal and asthmatic bronchial reactivity to exercise and inhalation challenges in children and young adults. Eur Respir J. 1999;14:659-68.
12. Martinez FD, Wright AL, Taussig LM. Asthma and wheezing in the first six years of life. The Group Health Medical Associates. N Engl J Med. 1995;332:133-8.
13. Cane RS, Ranganathan SC, McKenzie SA. What do parents of wheezy children understand by 'wheeze'? Arch Dis Child. 2000;82:327-32.
14. Chang AB. Isolated cough:probably not athama. Arch Dis Child. 1999;80:211-13.
15. Antony S, Douglas S, Gorden LA, Croflon and douglas's Respiratory diseases, 5th ed. Oxford Blackwell Science Lts. 2000;1.
16. Nystad W, Samuelson SO, Nafstad P, Edvardsen E, Stensrud T, Jaakkola JJ. Feasibility of measuring

lung function in preschool children. Thorax 2002;57:1021-7.
17. Dundas I, Mckenzie S. Spirometry for children 3-6 years old. CurrOpinPulm Med CME. 2006;12(1)28-33.
18. Eugene Y, Woojung K, Byoung CK, Sung YC, Myung HS, Kyu EK. Relationship among pulmonary function, bronchial hyper responsiveness, and atopy in children with clinically stable asthma. Lung. 2006;184(2):73-9.
19. Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention. Publication No. 02-3659. Washington, DC: National Institutes of Health, National Heart, Lung and Blood Institutes;2002.
20. British Thoratic Society British guideline on the management of asthma. Thorax. 2003;58(1):17-28.
21. Rasmussen F, Taylor DR, Flannery EM, Cowan JO, Greene JM, Herbison GP, et al. Risk factors for airway remolding in asthma manifested by a low post broncholidator FEV1/vital capacity ratio: A longitudinal Population study from childhood to adulthood. AmJ Respir Crit Care Med. 2002;165:1480-8.
22. Ubick CS. Backey V, Markers of impaired growth of pulmonary function in children and Adolescents, Am Jr ESPIR Crit Care Med. 1999;160:40-4.
23. National Asthma Education and Prevention Program: Expert panel Report 3(EPR 3); Guidelines for the diagnosis and management of asthma-summary report 2007. J Allergy Clin Immunol. 2007;120(5):94-138.
24. Laitinen LA, Laitenen A, Haahtela T, Airway mucosal inflammation even in patients with newly diagnosed asthma. Am Rev Respir Dis. 1993;147:697-704.
25. Mellins RB, Zimmerman B, Clark NM. Patient compaliance. Am Rev Respir Dis. 1992;146:137-77.
26. Shelledy D, Stroller JK, introduction to clinical diagnostic thinking. In: Stoller JK, Bakow ED, Longworth DL, eds. Critical Diagnostic Thinking in Respiratory Care–A Case Based Approach. Philadelphia : WB Saunders;2002:1-38.
27. Wainwright C, Isles AF. Respiratory emergencies in children . Modern Med.1999;16:34-45.
28. Al-Ghamdy YS, Al-Haddad NS. Socio-clinical profile of children with asthma in Al-Majmaah Health Province, Saudi Med J. 2002;21(9):847-51.
29. Al- FrayhAR, AlNahdi M, Bener A, Al-Jawadi TQ. In:Epidemiology of asthma and allergic rhinitis in two coastal areas of Saudi Arabian school children. J All Immunol. 1989;21:389-93.
30. Pal R, Dahal S, Pal S. Prevalence of Bronchial Asthma in Indian J Comm Med. 2009;34:310-6.
31. International study of Bronchial Asthma and allergies in childhood (ISAAC) Worldwide variations in the prevalence of Bronchial Asthma symptoms. Euro Respir J. 1998;12:315-15.
32. Singh M, Mathew JL, Malhi P, Sriniwas BR Kumar L, Comparison of Improvement in quality of life score with objective parameters of pulmonary function in indian asthmatic children receiving inhaled corticosteroid therapy. Indian Pediatr. 2004:41:1143-7.
33. Education NA, Program P. Lung, Asthma BISEPpotMo. Expert Panel report 2: guidelines for the diagnosis and management of asthma: DIANE Publishing. 1998.
34. Bacharier NA, Strunk RC, Mauger D, White D, Lemanske RF, Sorkness CA. Classifying asthma severity in children: Mismatch between symptoms, medication use, and lung function. Am J Respir Crit Care Med. 2004;170(4):426-32.
35. Paull K, Cover R, Jain N, Gelfand EW, Spahn JD. Do NHLBI lung function criteria apply to children? A cross sectional evaluation of childhood asthma at National Jewish Medical and Research Center, 1999-2002. Pediatr Pulmonol. 2005;39(4):311-7.
36. Strunk RC, Weiss ST, Yates KP, Tonascia J, Zeiger RS, Szefler SJ. Mild to moderate asthma affects lung growth in children and adolescents. J Allergy Clin Immunol. 2006;118(5):1040-7.
37. Lugogo N, Que LG, Fertal D, Monica Kraft. Asthma In: Mason RJ, Broaddus VC, Martin TR, King TE, Schraufnagel DE, Murray JF, Nadel JA, editors. Mason:Murray and Nadel's Textbook of Respiratory Medicine 5th ed. Philadelphia:saunders Elsevier;2010:883-914.
38. Brown RH, Pearse DB, Pyrgos G, Liu MC, Togias A, Permutt S. The structural basis of airways hyper responsiveness in asthma. J Applied Physiol. 2006;101(1):30.
39. Weiss ST, Van Natta ML, Zeiger RS. Relationship between increased airway responsiveness and asthma severity in the childhood asthma management program. Am J Respir Crit Care Med. 2000;162(1):50.

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