Original Article

Evaluation of Noncystic Fibrosis Bronchiectasis Using Clinical and Radiological Scorings in Children

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Abstract

OBJECTIVES: The aim of this study was to evaluate radiological, clinical, and demographic data of patients with noncystic fibrosis bronchiectasis and to compare high-resolution computed tomography (HRCT) scores based on the demographic and clinical characteristics.

MATERIALS AND METHODS: A total of 34 patients (18 male, 16 female) were assessed in terms of age at symptom onset, age at diagnosis, annual attack frequency, cough severity score, physical examination findings, and pulmonary function test results. Modified Bhalla scoring system (B total) and anatomical prevalence degree score (D total) were used for HRCT examination.

RESULTS: There was a strong negative correlation between forced expiratory volume at first second (FEV_1) and bronchial dilatation degree (SBRDIL). There was a moderate negative correlation of FEV_1, forced vital capacity (FVC), and maximum mid-expiratory flow rate (MEF; 25-75) with bronchiectasis degree (EXBRNC), bronchial wall thickness degree (SBWTHICK), and mucus accumulation in the major airways (PMPLA). The B total, D total, EXBRNC, and SBRDIL scores were significantly higher in patients with hemoptysis and sputum. In comparing B and D total scoring systems, B total provided better results in terms of rale, annual exacerbation frequency (AEF), cough severity score (CSS), and FEV_1 values.

CONCLUSION: As it is proved using HRCT, pulmonary function impairment, sputum production, hemoptysis, and increase in AEF strongly correlating with objective HRCT scoring can be accepted as markers for pathological changes due to bronchiectasis.

KEYWORDS: Bronchiectasis, modified Bhalla scoring system, high-resolution computed tomography

INTRODUCTION

Bronchiectasis is a chronic inflammatory lung disease, characterized by abnormal permanent enlargement of the bronchi with phlegmy cough and recurrent pulmonary infections [1]. It is a common result of many pulmonary diseases and is typically irreversible, unless detected in the prebronchiectasis stage [2]. It is still a significant problem in developing countries and low socio-economic regions of developed countries. However, while there are approximately 10-50 patients with bronchiectasis per 10,000 individuals in developing countries, there is no reliable information about its incidence and prevalence [3, 4]. The appropriate use of high-resolution computed tomography (HRCT) can result in improved diagnostic capabilities in patients. The severity of disease shows a wide spectrum. While some patients report only intermittent cough and infrequent lower respiratory tract infections, many others exhibit daily productive cough, odiferous green phlegm, frequent lower respiratory tract infections, and frequent presentation to the hospital due to hemoptysis [5]. All these situations negatively affect such children's quality of life, growth, and development and result in frequent hospital admission and need for medication.

Currently, the severity of bronchiectasis is initially determined noninvasively using physical examination, sputum culture, hospitalization incidence and duration, pulmonary function tests, and radiological evaluation [6]. Diagnosis of patients at an early stage before the development of irreversible lung damage is crucial.

There are many respiratory function impairments in bronchiectasis due to numerous morphological abnormalities [7]. Significant lung damage can develop before pulmonary function tests are able to detect these changes [8]. Children under school age and some patients with growth retardation cannot undergo standard spirometry. This exemplifies the need for new tools to evaluate bronchiectasis. Early diagnosis of the disease and significant improvement of prognosis can be achieved with the development of CT techniques. The evidence obtained from studies conducted on children with cystic fibrosis showed that

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HRCT can detect early lung injury before a decrease in FEV_1 and emergence of FVC are detected on pulmonary function tests [9]. Similar to bronchiectasis due to cystic fibrosis, these clinical clues obtained via HRCT will be instrumental in evaluating both diagnostic changes and their correlations during the follow-up of patients with noncystic fibrosis bronchiectasis. To date, there have been a limited number of detailed studies investigating children with noncystic fibrosis bronchiectasis in terms of the clinical and radiological features.

Cystic fibrosis is separately assessed among diseases causing bronchiectasis because of its different clinical and pathological features. The aim of this study was to evaluate the radiological, clinical, and demographic data of patients with noncystic fibrosis bronchiectasis and to compare HRCT (Modified Bhalla and anatomical prevalence) degree scores with demographic and clinical characteristics [10-13].

METHODS

Study Subjects and Design
A total of 34 patients aged 6 months to 20 years who were admitted to the Pediatric Allergy-Immunology and Pediatric Pulmonology polyclinics in Akdeniz University between 2003 and 2015 and diagnosed with bronchiectasis based on clinical and HRCT findings were included in the study. Children with cystic fibrosis were excluded based on sweat test and/or genetic mutation analysis results. Children with a previous history of lobectomy or pneumonectomy were also excluded. Ethics Committee approval for the study was obtained from Akdeniz University Clinical Research Ethics Committee, and written informed consent was obtained from the participants.

Patients' age, sex, age at diagnosis, age at symptom onset, family history, cough severity score (CSS), annual exacerbation frequency (AEF), cough, sputum, hemoptysis, and physical examination findings (clubbing, chest deformity, hypoxia, rale, and rhonchi) were assessed by a pediatric pulmonologist. Sputum culture results were recorded, and the underlying etiologies of bronchiectasis were investigated. For adaptable children aged >5 years, spirometry (ZAN 100 Spiromed, Germany) was performed within a week of HRCT during a nonacute state. All HRCTs were interpreted by a radiologist with 25 years of experience in thoracic radiology (A.G.) who was blinded to the children's clinical status. In each patient, exacerbation frequency was calculated as the number of exacerbations that occurred in the preceding 12 months and was determined based on patient history and review of clinical charts. Acute exacerbation of bronchiectasis was assessed by an increase in cough and sputum amount/purulency, chest pain, shortness of breath as described by family members or the child, rale, rhonchi, wheezing, hypoxia symptoms, increases CRP levels, increased neutrophil proportion, and impairement in respiratory function tests [14]. Patients' CSSs were obtained by scoring daytime cough symptoms from 0 to 5 (0=no cough; 1=1 or 2 short coughing episodes in a day; 2=> 2 short coughing episodes in a day; 3=frequent coughing but does not affect school or other activities; 4=frequent cough affecting school or other activities; and 5=severe cough inhibiting most activities) [15].

Radiological Evaluation
High-resolution computed tomography was performed using a Toshiba Aquilion (Tokyo, Japan) scanner. After a scout view, 1-mm collimation sections were obtained at intervals of 7 or 10 mm as appropriate for the child's size. The protocol for HRCT required an exposure time of 0.4 s, with scans at 100-200 mA and 120 kV. Scans were performed in the supine position. Children aged <5 years and older children who were unable to cooperate with the breath-holding maneuver were scanned under general anesthesia, with images captured during a suspended inspiration. Older cooperative children were asked to hold their breath during a maximal inspiration. Expiratory scans were not used.

Bronchiectasis was confirmed if the inside bronchial diameter was greater than that of the adjacent (apparently normal) artery (ratio >1) according to Webb et al. [16]. Bronchiectasis severity, bronchial dilation degree, bronchial wall thickness degree, mucus accumulation in major and small airways, and reduction in parenchymal attenuation were scored separately for each lung lobe (total of 6 lobes considering lingula as a separate lobe) according to the modified Bhalla system [10-12]. The scores of each lobe were added and total scores according to the Bhalla system were identified as B total in this study. A second scoring was conducted by the same radiologist evaluating anatomical prevalence of bronchiectasis separately for each of the six lobes as following: degree 0=no bronchiectasis; 1=mild (<25% of the lobe); 2=moderate (25%-50% of the lobe); and 3=severe (>50% of the lobe) [13]. The scores of each lobe were added, and a general score for anatomical prevalence degree of bronchiectasis was obtained, which was called as D total in this study.

Statistical Analysis
Analysis was conducted using SPSS (Statistical Package for Social Sciences) version 21.0 (IBM Corp.; Armonk, NY, USA) software. Descriptive statistics were presented by percentage, mean, and standard deviation, median, minimum, and maximum values. The normality assumption was controlled using the Shapiro-Wilk test in the analysis of difference between the measures of both the groups. The Mann-Whitney U test was used for evaluating non-normally distributed data, and the Student's t test was used for normally distributed data. The Kruskal-Wallis test was used in nonparametric comparison of three stage group; the Bonferroni-Dunn test was used for significant cases as the post hoc test. The Spearman correlation test was used for determining the relationships among nonnormally distributed continuous variables, whereas the Pearson correlation test was used for normally distributed continuous variables. A significance level of 95% (or error margin of $\alpha=0.05$) was used for determining the differences in analyses. For the Spearman correlation coefficient (r), 0.90-1.00 was accepted as a very strong correlation, 0.70-0.89 as strong correlation, 0.50-0.69 as moderately strong correlation, 0.30-0.49 as weak correlation, 0-0.29 as no correlation, and negative values as an inverse correlation. The post hoc power analysis showed that when the correlation between B total and FEV_1 was used (r=-0.56, $\alpha=0.05$) and the total number of samples was 29, the power of the study was 0.94.

RESULTS

Patients

The mean age of the 34 patients (18 male, 16 female) included in this study was 13.69±4.67 years (range: 5-20 years). The mean age at the onset of symptoms was 3.78±4.06 years (0.5-16 years), and the mean age at diagnosis was 9.61±4.84 years (1-18 years). The mean difference between the age at the onset of symptoms and at diagnosis was 5.84±3.96 years. The most frequent complaint at diagnosis was cough (98.3%). A total of 26 patients (76.5%) had a complaint of sputum at presentation. Hemoptysis was noted in 5 patients (14.7%), clubbing in 5 (14.7%), and oxygen dependency in 1 (2.9%). There was a family history of bronchiectasis in 3 (8.8%) patients. There was no etiology of bronchiectasis in 10 patients (29%); however, immunodeficiency was detected in 7 (20.6%), PSD in 5 (14.7%), previous infection in 5 (14.7%), asthma in 4 (11.8%), and other causes in 3 (bronchiolitis obliterans, rheumatic disease, and foreign body aspiration in 1 patient each). The mean frequency of annual exacerbation was 2.00±1.41, and the mean CSS was 2.00±1.26. Five patients could not undergo SFT as their young age prevented successful testing. In patients undergoing SFT, the mean FEV_1 was 72.51%±22.31%, mean FVC was 67.35%±21.32%, and mean maximum mid-expiratory flow rate (MEF; 25-75) was 72.90%±30.44%. There was no bacterial isolation in sputum culture in 30.7% of patients (8/26), whereas *Haemophilus influenzae* was isolated from 12 (46.1%), *Streptococcus pneumoniae* from 3 (11.5%), *Staphylococcus aureus* from 1 (3.8%), *Moraxella catarrhalis* from 1 (3.8%), and *Klebsiella pneumoniae* from 1 (3.8%) patient.

Radiological Scores

There was a positive and significant correlation of age of patients with B and D total scores (r=0.379, p=0.032 and r=0.371, p=0.037, respectively), but there was no correlation with CSS. There was a positive and weak correlation between age at diagnosis and B total (r=0.351, p=0.049). There was no correlation of age at the onset of symptoms with D total CSS, B total, or sub parameters.

The CSS, B total, SBRDIL, and EXDECAT values were higher in patients with rales than those in patients without rales (p=0.048, p=0.015, p=0.030, p=0.017, respectively) on physical examination. The B total, D total, EXBRNC, and SBRDIL values were significantly higher in patients with hemoptysis and sputum than in those without hemoptysis and sputum (Table 1).

There was a statistically significant negative strong correlation of FEV_1 with SBRDIL; negative and moderate correlation with B Total, EXBRNC, SWTHICK, and PMPLA; and statistically significant negative weak correlation with EXDECAT and D total. There was a statistically significant negative moderate correlation of FVC with D total, B total, EXBRNC, SBRDIL, SWTHICK, and PMPLA. There was a statistically significant negative moderate correlation of MEF 25-75 with EXBRNC, SBRDIL, SWTHICK, and PMPLA (Table 2).

Table 1. Comparison of hemoptysis, sputum, and HRCT scores*

	Hemoptysis Present Mean+SD	Hemoptysis Absent Mean+SD	p	Sputum Present Mean±SD	Sputum Absent Mean±SD	p
D total	8.83±3.48	5.00±3.40	0.044	6.82±3.43	3.30±3.16	0.010
B total	40.83±6.27	24.04±12.43	0.002	31.95±12.37	16.70±8.30	0.001
EXBRNC	9.50±3.88	5.58±3.83	0.022	7.64±3.73	3.40±3.37	0.005
SBRDIL	7.50±2.81	3.81±2.94	0.018	5.64±3.01	2.00±2.10	0.003
SBWTHICK	6.67±3.50	4.85±2.34	0.196	5.95±2.59	3.50±1.90	0.008
PMPLA	3.00±1.78	1.58±1.44	0.063	1.30±1.49	1.30±1.49	0.150
PMPSA	3.33±1.21	2.38±2.00	0.194	3.00±1.82	1.60±1.77	0.052
EXDECAT	7.33±1.75	5.92±3.47	0.451	6.68±3.52	5.10±2.33	0.146

EXBRNC: bronchiectasis degree; SBRDIL: bronchial dilatation degree; SBWTHICK: bronchial wall thickness degree; PMPLA: obstruction in major airways by mucus; PMPSA: obstruction in small airways by mucus; EXDECAT: reduced attenuation degree; *: Bold, p≤0.05; Bold italic, p≤0.01

Table 2. Comparison of pulmonary function test findings with HRCT scores*

	FEV_1 (%)	FVC (%)	MEF (25-75) (%)
D TOTAL	-0.462 (p=0.012)	-0.522 (p=0.004)	-0.380 (p=0.042)
B TOTAL	-0.560 (p=0.002)	-0.590 (p=0,001)	-0.475 (p=0.009)
EXBRNC	-0.658 (p=0.000)	-0.615 (p=0.000)	-0.537 (p=0.003)
SBRDIL	-0.713 (p=0.000)	-0.667 (p=0.000)	-0.557 (p=0.002)
SBWTHICK	-0.575 (p=0.001)	-0.575 (p=0.001)	-0.595 (p=0.001)
PMPLA	-0.562 (p=0.002)	-0.555 (p=0.002)	-0.441 (p=0.017)
PMPSA	-0.280 (p=0.141)	-0.310 (p=0.102)	-0.012 (p=0.950)
EXDECAT	-0.463 (p=0.011)	-0.428 (p=0.020)	-0.488 (p=0.007)

EXBRNC: bronchiectasis degree; SBRDIL: Bronchial dilatation degree; SBWTHICK: bronchial wall thickness degree; PMPLA: obstruction in major airways by mucus; PMPSA: obstruction in small airways by mucus; EXDECAT: reduced attenuation degree; *: Bold, p≤0.05; Bold italic, p≤0.01

Table 3. Comparison of HRCT scores with cough severity score and annual exacerbation frequency*

	Cough severity score	Annual exacerbation frequency
D TOTAL	0.483 (p=0.006)	0.483 (p=0.005)
B TOTAL	0.533 (p=0.002)	0.621 (p=0.000)
EXBRNC	0.593 (p=0.000)	0.501 (p=0.003)
SBRDIL	0.602 (p<0.001)	0.591 (p=0.000)
SBWTHICK	0.653 (p<0.001)	0.511 (p=0.003)
PMPLA	0.369 (p=0.041)	0.325 (p=0.069)
PMPSA	0.350 (p=0.054)	0.289 (p=0.108)
EXDECAT	0.383(p=0.034)	0.275 (p=0.128)

EXBRNC: Bronchiectasis degree; SBRDIL: Bronchial dilatation degree; SBWTHICK: Bronchial wall thickness degree; PMPLA: Obstruction in major airways by mucus; PMPSA: Obstruction in small airways by mucus; EXDECAT: Reduced attenuation degree; *: Bold, p≤0.05; Bold italic, p≤0.01

There was a statistically significant negative weak correlation of CSS with FEV_1, FVC, and MEF (25-75) (r=-0.434; p=0.006, r=-0.439, p=0.005; r=-0.489, p=0.002, respectively). CSS had a statistically significant positive moderate correlation with B total, EXBRNC, SBRDIL, and SBWTHICK and a statistically significant positive weak correlation with D total, PMPLA, and EXDECAT. There was a statistically significant positive moderate correlation of annual exacerbation with B total, EXBRNC, SBRDIL, and SBWTHICK (Table 3).

DISCUSSION

High-resolution computed tomography remains the gold standard for the definitive diagnosis of bronchiectasis. There have been few studies in the literature investigating the advantages of HRCT in the diagnosis of bronchiectasis and correlation of HRCT with the clinical findings of patients [13, 17]. We compared HRCT findings and clinical characteristics of patients with noncystic fibrosis bronchiectasis in this study.

Consistent with the literature, the proportion of male patients was slightly higher than that of female patients (52.9% male, 47.1% female) in this study [18]. The mean age at diagnosis in this study (13.69±4.67 years) was higher than those in previously published studies [2,19-21]. The age at symptom onset in this study was found to be consistent with that in the literature [5]. It was noteworthy that most patients presented to the hospital due to very longstanding complaints. The difference between the age at symptom onset and at diagnosis was 5.84±3.96 years. Because patients presented from both rural and urban areas, there was a possibility of some late admissions. These findings suggested that the disease should be suspected in patients with findings, such as chronic productive cough and persisting rales, and an examination for bronchiectasis should be promptly conducted.

The most frequent complaint upon presentation is cough in patients with bronchiectasis. A diagnosis of bronchiectasis should be considered in cases with chronic, persistent, and productive cough [18]. In developing countries, such as Tur-

key, if the long-term complaint history cannot be realized, crucial diagnosis may be delayed [20]. The most frequent complaint was cough in our patients (98.3%), followed by sputum production (76.5%).

The incidence of hemoptysis in pediatric patients has been reported to be between 4% and 10% [5,22,23]. Hemoptysis was detected in 14.7% of the patients in our study; this proportion was slightly higher than that in the literature, which may have been caused due to the progression of bronchiectasis because of late diagnosis.

The majority of patients with bronchiectasis in the literature were idiopathic cases (33.3%-49%). In our study, 29% of patients with bronchiectasis were idiopathic cases [5,24,25]. We suspected that the reason for fewer idiopathic bronchiectasis cases in our study could be that our patients underwent a detailed etiological examination in a comprehensive university hospital, which is better equipped to make such a diagnosis.

High-resolution computed tomography is the most reliable objective imaging method for the diagnosis of bronchiectasis and to assess its severity. Eastham et al. [2] reported a ten-fold increase in the diagnosis of noncystic fibrosis bronchiectasis using HRCT. HRCT provides detailed information about the airway size and wall thickness. Because this method provides information about hyperinflation due to air involvement, edema, and fibrosis, it is considered to be a very sensitive investigational tool to detect structural changes in the lungs. Evaluation of bronchiectasis using HRCT is also important in terms of scoring radiological findings, comparing data associated with bronchiectasis, and providing information about its prevalence and severity.

Similar to the literature, HRCT scores were also found to be associated with SFT results. There was a negative correlation of total HRCT score with FEV_1, FVC, and MEF (25-75) in our patients.

Similar to our study, Habesoğlu et al. [12] used a modified Bhalla score in HRCT scoring of adult patients with noncystic fibrosis bronchiectasis and found a negative strong correlation of FEV_1 and FVC with the degree of bronchiectasis, bronchial dilatation severity, bronchial wall thickening severity, and parenchymal attenuation reduction. They found no relationship between mucus accumulation in airways and SFT values in patients with bronchiectasis. Therefore, mucus accumulation in the airways was not found to be a primary reason for impairment in SFT. They reported the degree of bronchiectasis prevalence and reduction of attenuation in the lung parenchyma to be the primary determinants for the decrease in FEV_1 and FVC. In our study, there was a negative strong correlation between FEV_1 and the degree of bronchial dilatation. There was a negative moderate correlation of FEV_1, FVC, and MEF (25-75) with bronchiectasis severity, bronchial wall thickness degree, and mucus accumulation in major airways. These findings showed that pathological changes in the bronchial morphology of patients with bronchiectasis cause both obstructive and restrictive disorders of respiratory functions.

Sheehan et al. [26] correlated HRCT data obtained at two different times from 48 adult patients with bronchiectasis with SFT using the same modified Bhalla scoring system. They stated that the variation in the mucus load over time in the small airways may be responsible for changes in SFT. There have been no pediatric studies in the literature that have investigated the relationship between mucus load and SFT. In our study, there was no correlation between mucus accumulation in small airways and SFT values in children with bronchiectasis.

In a study by Ooi et al. [13] conducted on 60 adult patients in China, there was a negative moderate correlation of anatomical prevalence of bronchiectasis with FEV_1 and MEF (25-75) based on the D total scoring system, as in our study. D total was found to be associated with FEV_1, FVC, and MEF (25-75) in our study. There was a statistically significant negative weak correlation of D total with FEV_1 and MEF (25-75) and statistically significant negative moderate correlation of D total with FVC.

B total, D total, EXBRNC, and SBRDIL scores of patients with hemoptysis and sputum were found to be significantly higher than those of patients without hemoptysis and sputum. In addition, SWTHICK scores of patients with sputum were higher than those of patients without sputum. These scores indicated the prevalence of the disease, due to which they were probably higher in patients with hemoptysis and sputum.

The B total, EXDECAT, and SBRDIL scores were higher in patients with rale than in those without rale in physical examination. This finding was indicative of disease severity; therefore, it is important to utilize HRCT for the diagnosis of bronchiectasis in patients with rale observed during follow-up examinations.

There was a statistically significant positive moderate correlation of AEF with B total, SBRDIL, SBWTHICK, and EXBRNC. There was a statistically significant positive moderate correlation of CSS with B total, SBRDIL, SBWTHICK, and EXBRNC. These comparisons have not been performed in the literature. These results demonstrated the effectiveness of HRCT in indicating disease severity.

Comparing D total with B total, with the latter including more parameters and more complex scoring, B total scoring showed better correlation with clinical and pulmonary function test parameters, such as rale, AEF, CSS, and FEV_1, in pediatric patients with bronchiectasis. Therefore, the B total scoring system is significantly superior for HRCT scoring.

High-resolution computed tomography is an objective and gold standard method for the evaluation of disease severity in bronchiectasis follow-ups. The correlation of clinical findings with HRCT findings is good. As it is proved using HRCT, pulmonary function impairment, sputum production, hemoptysis, and increase in AEF strongly correlating with objective HRCT scoring can be accepted as markers for pathological changes due to bronchiectasis.

REFERENCES

1. Dagli E. Non-cystic fibrosis bronchiectasis. Paediatr Respir Rev 2000;1:64-70. [CrossRef]
2. Eastham KM, Fall AJ, Mitchell L, et al. Paediatric lung disease: the need to redefine non-cystic fibrosis bronchiectasis in childhood. Thorax 2004;59:324-7. [CrossRef]
3. Fishman AP, Elais JA, Fishman JA, et al. Fishman's Pulmonary Diseases and Disorders. 3rd ed. New York: McGraw-Hill 1998.p.2045-69.
4. Marostica PJC, Fischer GB. Non cystic-fibrosis bronchiectasis: a perspective from South America Pediatr Respir Rev 2006;7:275-80. DOI:10.1016/j.prrv.2006.04.008. [CrossRef]
5. Karadağ B, Karakoc F, Ersu R. Non-cystic fibrosis bronchiectasis in children: a persisting problem in developing countries. Respiration 2005;72:233-8. [CrossRef]
6. Chang AB, Masel JP, Boyce NC, et al. Non-CF bronchiectasis: clinical and HRCT evaluation. Pediatr Pulmonol 2003;35:477-83. [CrossRef]
7. Pande JN, Jain BP, Gupta RG, et al. Pulmonary ventilation and gas exchange in bronchiectasis. Thorax 1971;26:727-33. [CrossRef]
8. Ip M, Lauder IP, Wong WY, et al. Multivariate analysis of factors affecting pulomary function in bronchiectasis. Respiration 1993;60:45-50. [CrossRef]
9. Tiddens HA. Detecting early structural lung damage in cystic fibrosis. Pediatr Pulmonol 2002;34:228-31. [CrossRef]
10. Bhalla M, Turcios N, Aponte V, et al. Cystic fibrosis: scoring system with thin-section CT. Radiology 1991;179:783-8. [CrossRef]
11. McDonnell MJ, Ahmed M, Das J, et al. Hiatal hernias are correlated with increased severity of non-cystic fibrosis bronchiectasis. Respirology 2015;20:749-57. [CrossRef]
12. Habesoğlu MA, Tercan F, Ozkan U, et al. Effect of radiological extent and severity of bronchiectasis on pulmonary function. Multidiscip Respir Med 2011;6:284-90. [CrossRef]
13. Ooi GC, Khong PL, Chan-Yeung M, et al. High-resolution CT quantification of bronchiectasis: clinical and functional correlation. Radiology 2002;225:663-72. [CrossRef]
14. Chang AB, Bilton D. Exacerbations in cystic fibrosis: 4-Non-cystic fibrosis bronchiectasis. Thorax 2008;63:269-76. [CrossRef]
15. Chung KF. Cough: Causes, Mechanisms and Therapy, Blackwell Publishing 2008.p.40.
16. Webb WR, Muller NL, Naidich DP. High-resolution CTof the lung. Philadelphia: Lippincott, Williams & Wilkins; 2001.p.71-193.
17. Chang AB, Masel JP, Boyce NC, et al. Non-CF bronchiectasis: clinical and HRCT evaluation. Pediatr Pulmonol 2003;35:477-83. [CrossRef]

18. Karakoc F, Dagli E, Günay I, et al. The outcome and long-term follow-up of children with bronchiectasis. Eur Respir J 1997;10:338.

19. Munro KA, Reed PW, Joyce H, et al. Do New Zealand Children With Non-Cystic Fibrosis Bronchiectasis Show Disease Progression? Pediatr Pulmonol 2011;46:131-8. [CrossRef]

20. Twiss J, Metcalfe R, Edwards E, et al. New Zealand national incidence of bronchiectasis "too high" for a developed country. Arch Dis Child 2005;90:737-40. [CrossRef]

21. Li AM, Sonnappa S, Lex C, et al. Non-CF bronchiectasis: does knowing the etiology lead to changes in management? Eur Respir J 2005;26:8-14. [CrossRef]

22. Callahan CW, Redding GJ. Bronchiectasis in children: orphan disease or persistent problem? Pediatr Pulmonol 2002;33:492-6. [CrossRef]

23. Lewiston NJ. Bronchiectasis. In: Hilman BC (ed). Pediatric Respiratory Disease. Philadelphia: WB Saunders 1993.p.222-9.

24. Karakoc GB, Yilmaz M, Altintas DU, et al. Bronchiectasis: Still a problem. Pediatr Pulmonol 2001;32:175-8. [CrossRef]

25. Dogru D, Nik-Ain A, Kiper N, et al. Bronchiectasis: The consequence of late diagnosis in chronic respiratory symptoms. J Trop Pediatr 2005;51:362-5. [CrossRef]

26. Sheehan RE, Wells AU, Copley SJ, et al. A comparison of serial computed tomography and functional change in bronchiectasis. Eur Respir J 2002;20:581-7. [CrossRef]