Balkan Med J 2025;42:429-39

Bronchiectasis in Children: A Comparative Analysis of Cystic Fibrosis and Non-Cystic Fibrosis Etiologies Using the Bhalla Score

Handan Kekeç[1], Tuğba Şişmanlar Eyüboğlu[1], Ayse Tana Aslan[1], Yasemin Duman[2], Volkan Medeni[3], Merve Yazol[4], Öznur Leman Boyunağa[4]

[1]Department of Pediatric Pulmonology, Gazi University Faculty of Medicine, Ankara, Türkiye
[2]Department of Pediatrics, Gazi University Faculty of Medicine, Ankara, Türkiye
[3]Department of Public Health, Gazi University Faculty of Medicine, Ankara, Türkiye
[4]Department of Radiology, Gazi University Faculty of Medicine, Ankara, Türkiye

Background: Childhood bronchiectasis (BE) is a chronic lung condition that remains under recognized, marked by irreversible widening of the bronchi, frequent respiratory infections, a persistent wet cough, and progressive lung damage, often leading to significant health burdens.

Aims: To evaluate children with cystic fibrosis (CF) and non-CF BE and to examine the association between clinical presentation and radiological severity of BE using the Bhalla scoring system.

Study Design: Retrospective observational study.

Methods: Children aged 0-18 years with a CT-confirmed diagnosis of BE were enrolled. Data on demographics, clinical characteristics, and imaging results were collected retrospectively from medical records. The Bhalla score was used to assess BE severity. Patients were categorized into CF-related and non-CF BE groups. The two groups were compared with respect to clinical features, growth z-scores, hospitalization frequency, and pulmonary function test outcomes.

Results: A total of 157 patients were analyzed. Among them, CF accounted for 23.6% of cases, and while the leading causes in the non-CF group were post-infectious BE (28%), immunodeficiency (19.8%), and primary ciliary dyskinesia (12.8%). The CF group presented at an earlier age, had a longer follow-up period, and experienced more frequent hospitalizations ($p < 0.001$). In the CF group, weight, height, and body mass index z-scores significantly improved from the initial to the final assessment ($p = 0.010$, $p = 0.006$, and $p = 0.026$, respectively), whereas no such improvement was observed in the non-CF group. Severe Bhalla scores were more frequently observed in the CF group ($p < 0.001$). Among CF patients, Bhalla scores showed a strong correlation with forced expiratory volume in one second (FEV_1) in univariate analysis ($r = 0.846$, $p < 0.001$), though this was not significant in multivariable analysis ($p = 0.434$). In the non-CF group, there was no correlation between Bhalla scores and final FEV_1 values ($p = 0.148$, $r = 0.212$).

Conclusion: The results underscore distinct clinical trajectories between CF and non-CF BE in children. Improvements in CF patients suggest the effectiveness of structured clinical management, whereas inconsistent outcomes in non-CF patients point to the need for standardized follow-up protocols. While the Bhalla score may indicate the extent of structural lung disease in CF, it does not independently predict lung function, and therefore should be used as a supplementary, not solitary, measure of disease severity.

INTRODUCTION

Childhood bronchiectasis (BE) is marked by abnormal dilation of the bronchi, with reported incidence rates ranging from 0.2 to 735 per 100,000 children.[1-3] Although generally considered irreversible, early diagnosis may occasionally lead to reversal. Clinically, BE is characterized by recurrent respiratory infections and a chronic productive cough persisting for more than 4 weeks. While cystic fibrosis (CF) is a well-known cause, non-CF etiologies-such as primary ciliary dyskinesia (PCD), post-infectious conditions, immunodeficiency, gastroesophageal reflux disease, aspiration

Corresponding author: Tuğba Şişmanlar Eyüboğlu, Department of Pediatric Pulmonology, Gazi University Faculty of Medicine, Ankara, Türkiye
e-mail: tsismanlar@yahoo.com/tugbaeyuboglu@gazi.edu.tr

Received: July 01, 2025 **Accepted:** July 31, 2025 **Available Online Date:** 01.09.2025 • **DOI:** 10.4274/balkanmedj.galenos.2025.2025-6-247

Available at www.balkanmedicaljournal.org

ORCID iDs of the authors: H.K. 0000-0001-8770-0939; T.Ş.E. 0000-0001-7284-4999; A.T.A. 0000-0002-5360-8517; Y.D. 0000-0002-4519-9688; V.M. 0000-0002-2544-5781; M.Y. 0000-0003-1437-8998; Ö.L.B. 0000-0002-5200-1588.

Cite this article as: Kekeç H, Şişmanlar Eyüboğlu T, Tana Aslan A, Duman Y, Medeni V, Yazol M, Boyunağa ÖL. Bronchiectasis in Children: A Comparative Analysis of Cystic Fibrosis and Non-Cystic Fibrosis Etiologies Using the Bhalla Score. Balkan Med J.; 2025; 42(5):429-39.

syndromes, post-infectious bronchiolitis obliterans, alpha-1 antitrypsin deficiency, exposure to tobacco smoke, and congenital anomalies-also play a significant role.[1,3-8] If not properly managed, BE can result in ongoing symptoms, frequent hospital admissions, and diminished quality of life.

High-resolution computed tomography (HRCT) of the thorax is the diagnostic gold standard, with BE defined by a bronchial-to-arterial ratio exceeding 0.8.[1] Radiologic scoring systems, such as the Bhalla score, are used to assess disease severity and its correlation with clinical status. Research involving patients with CF-associated BE has demonstrated a strong association between Bhalla scores and pulmonary function test (PFT) results, particularly forced expiratory volume in one second (FEV_1). In contrast, studies on non-CF BE have found negative correlations with both PFT results and body mass index (BMI).[9-12] Limited data indicate that individuals with non-CF BE may have poorer lung function and receive less respiratory physiotherapy.[13] Nevertheless, direct comparative analysis of clinical and radiological characteristics between CF and non-CF BE populations are limited.

This study seeks to evaluate children diagnosed with BE; compare demographic, clinical, spirometric, and radiologic parameters between CF and non-CF BE groups; and explore the association between BE severity and clinical characteristics.

MATERIALS AND METHODS

This study was a retrospective, single-center analysis. It included all patients aged 0-18 years who were admitted to the Pediatric Pulmonology Department between 2006 and 2023 and diagnosed with BE based on HRCT findings. All procedures involving human participants were conducted in accordance with the ethical standards of this study was approved by the Clinical Research Ethics Committee of Gazi University (approval number: 956, date: 11.12.2023) and the Declaration of Helsinki and its subsequent revisions.

Demographic and clinical information-including sex, presenting symptoms, exposure to tobacco smoke (including secondhand smoke), history of lower respiratory tract infections, growth parameter z-scores, age at first admission, age at BE diagnosis, duration of follow-up, PFT results, and radiological findings-was obtained from medical records.

PFTs were conducted according to the American Thoracic Society/European Respiratory Society pediatric guidelines, measuring FEV_1, forced vital capacity (FVC), peak expiratory flow, and forced expiratory flow at 25-75% of vital capacity [forced expiratory flow $(FEF)_{25-75\%}$], and were expressed as percentages. The FEV_1/FVC ratio was assessed based on the patient's age, sex, and height.[14]

Patients were evaluated for underlying conditions contributing to BE, including CF, PCD, asthma, immunodeficiencies, post-infectious etiologies, and structural abnormalities, with non-CF cases classified accordingly. When available, results from sweat chloride tests, immunoglobulin (IgA, IgG, IgM, IgE) levels, sputum cultures, bronchoalveolar lavage fluid analyses, PFTs, high-speed video microscopy (HSVM), and genetic testing were recorded.

CF diagnosis was established based on clinical presentation, sweat chloride test results, and genetic testing[15], with patient follow-up conducted according to European Cystic Fibrosis Society Standards.[16] For the non-CF group, post-infectious BE was identified through patient history, medical records, respiratory viral panel results, microbiological testing, tuberculosis screening, and imaging studies.[17] A primary ciliary dyskinesia rule score (PICADAR) ≥ 5 prompted further evaluation for suspected PCD, which was diagnosed based on history, clinical features, HSVM findings, and genetic analysis when available.[18] Immunodeficiency was assessed using Ig levels, lymphocyte subtypes, nitroblue tetrazolium testing, complement levels, antibody response assessments, genetic analysis, and consultation with an immunologist.[19] Asthma diagnosis was determined through allergy consultation, clinical evaluation, spirometry, and in accordance with Global Initiative for Asthma guidelines.[20] Interstitial lung disease was diagnosed using clinical signs and symptoms, imaging findings, genetic studies, and lung biopsy when indicated.[21] Structural airway abnormalities were diagnosed based on findings from flexible bronchoscopy.

In our pediatric pulmonology clinic, CF and non-CF BE patients are seen for symptom-related visits or scheduled follow-up every 3-6 months. Treatment for non-CF BE patients targets the underlying condition, and both groups are routinely referred for physiotherapy.

Computed tomography (CT) images were transferred to an imaging workstation and evaluated in a single session by two radiologists, one of whom was a senior pediatric radiologist with over 20 years of experience. The Bhalla score, used to grade BE severity as mild, moderate, or severe, was calculated based on the average of both radiologists' assessments. The radiologists were provided with limited clinical information and conducted their evaluations in a blinded manner.

Computed tomography protocols and scanner

Chest CT scans were performed with or without contrast depending on clinical indications, using either a 16-slice scanner (LightSpeed VCT, GE) or a 192-slice dual-source CT (SOMATOM Force, Siemens). Standard thoracic protocols were employed to image the lungs from the apex to the diaphragm. Low-dose protocols included a gantry rotation time of 0.25-0.50 sec, a pitch of 1.0-1.5, and a tube voltage between 80 and 100 kVp, with automatic adjustments based on patient's size and age. Iterative reconstruction algorithms (ASIR or ADMIRE) were applied. Lung images were reconstructed using a slice thickness of 0.625-1 mm without gaps, employing the Bl57d kernel. Coronal and sagittal reformatted images were obtained for all patients.

Bhalla scores were determined from thoracic HRCT scans acquired at the time of BE diagnosis. Due to the retrospective nature of the study, follow-up CT imaging was not routinely available. To limit cumulative radiation exposure in pediatric patients, repeat imaging was generally avoided. As such, radiological assessment reflects structural findings at diagnosis, with no CT-based updates available during follow-up.

The Bhalla scoring system evaluates nine subcomponents to quantify disease severity, including BE severity, peribronchial thickening, extent of BE, extent of mucus plugging, presence of sacculations or abscesses, generation of involved bronchial segments, number of cystic spaces (bubbles), presence of emphysema, and areas of collapse or consolidation.[22] Each category contributes to a maximum composite score of 25 points, though the final two parameters do not reach the maximum of 3 points, making the effective highest score 22. The final Bhalla score is calculated by subtracting the cumulative score from 25, resulting in a possible range of 3-25. Lower scores correspond to more severe radiologic abnormalities, while higher scores indicate milder findings. Radiologic severity is categorized as mild (16-25 points), moderate (9-15 points), or severe (3-8 points).[23]

Statistical analysis

All data were analyzed using IBM SPSS Statistics version 22.0 (IBM, Armonk, NY, USA). The distribution of continuous variables was assessed both visually-through histograms and probability plots-and analytically using the Shapiro-Wilk test. Continuous variables were expressed as mean ± standard deviation when normally distributed, or as median (range) when not normally distributed. Categorical variables were summarized as frequencies and percentages. For comparisons between groups, Student's t-test and Mann-Whitney U test were applied depending on data distribution. Within-group comparisons were conducted using the paired t-test and Wilcoxon signed-rank test. All analyses were performed using complete-case data; no imputation methods were used for missing values. Because clinical parameters varied across participants, the sample size differed for each analysis. To adjust for type I error due to multiple subgroup comparisons in univariate analysis, the Bonferroni correction was applied. No correction for multiple comparisons was used in regression analyses, as these models were based on specific hypotheses and included a limited number of variables. Adjusted p-values for comparisons are provided in the respective tables. In addition to univariate analyses, multiple linear regression models were constructed to evaluate the independent contributions of Bhalla score, age at diagnosis, age at initial admission, follow-up duration, smoking exposure, immunodeficiency, CF status, and baseline PFT and growth z-scores to final pulmonary function and anthropometric outcomes. Separate models were created for CF and non-CF subgroups to evaluate differences in associations according to etiology. Correlations were assessed using Pearson's correlation coefficient for normally distributed variables and Spearman's coefficient for non-normally distributed variables. Correlation strength was interpreted as follows: very weak ($r \leq 0.2$) to very strong ($r > 0.8$). A p -value < 0.05 was considered statistically significant.

The final study cohort consisted of 157 patients: 37 with CF and 120 with non-CF BE. Given the retrospective design and the inclusion of multiple predictors in the regression models, a post-hoc power analysis was conducted. Assuming a medium effect size ($f^2 = 0.15$) and seven predictors, the available sample size provided a statistical power of approximately 0.90 at an alpha level of 0.05, indicating sufficient power to detect moderate effects in the full cohort.

RESULTS

A total of 157 patients were included in the analysis, with 77 (49%) males and 80 (51%) females. The median age at first admission was 95 months (range, 1-215), and the median age at BE diagnosis was 111 months (range, 16-215). The most frequently reported symptoms at presentation were cough, sputum production, and wheezing. Underlying diagnoses for all patients with BE were categorized as follows: 37 patients (23.6%) had CF, while the remaining 120 patients had non-CF BE, which included 44 (28 %) post-infectious cases, 31 (19.8%) with immunodeficiency, 20 (12.8%) with PCD, 11 (7%) with asthma, and 14 (8.8%) with other diagnoses. Three patients (1.9%) reported active smoking, and 40 patients (25.5%) had passive exposure to cigarette smoke. Based on Bhalla scoring, 84 patients (53.5%) had mild, 54 (34.4%) had moderate, and 19 (12.1%) had severe radiological severity. Among the 37 children with CF-related BE, only 3 were diagnosed through the CF newborn screening program. Demographic and clinical characteristics for all patients are summarized in Table 1.

TABLE 1. Demographic and Clinical Data of All Patients.

		n = 157 (%)
Female		80 (51)
Male		77 (49)
Age of initial admission (month) ‡		95 (1-215)
Age at BE diagnosis (month) ‡		111 (16-215)
Presenting symptom		
Cough		108 (68.8)
Sputum		96 (61.1)
Wheezing		45 (28.7)
Dyspnea		36 (22.9)
Fever		25 (15.9)
Chest pain		8 (5.1)
Tachypnea		7 (4.5)
Hemoptysis		7 (4.5)
Underlying diagnosis of BE		
CF		37 (23.6)
Non-CF		120 (76.4)
Post infectious		44 (28)
Immunodeficiency		31 (19.8)
PCD		20 (12.8)
Asthma		11 (7)
Neuromotor disease with aspiration		4 (2.5)
Congenital lung disease		4 (2.5)
Foreign body aspiration		3 (1.9)
Interstitial lung disease		2 (1.3)
Autoimmune disease		1 (0.6)
Cigarette smoking		3 (1.9)
Secondhand smoking exposure		40 (25.5)
History of operation for BE		12 (7.6)
Bhalla score	Mild	84 (53.5)
	Moderate	54 (34.4)
	Severe	19 (12.1)

BE, bronchiectasis; CF, cystic fibrosis; PCD, primary ciliary dyskinesia.
‡, [median (minimum-maximum)].

Patients were grouped into CF and non-CF BE categories and compared across demographic, clinical, and radiological variables. No significant difference in sex distribution was observed between groups ($p = 0.956$). The CF BE group had an earlier age at first admission, a longer duration of follow-up, and a longer interval between initial admission and BE diagnosis ($p < 0.001$). At the time of first admission, the CF BE group showed significantly lower z-scores for body weight, height, and BMI; however, no significant differences in these growth parameters were noted at the final evaluation (initial, $p < 0.001$, $p = 0.003$, $p = 0.001$; final, $p = 0.386$, $p = 0.660$, $p = 0.137$, respectively). The CF BE group also had higher rates of sputum culture colonization and smoking exposure ($p < 0.001$, $p = 0.002$). All patients who underwent surgical intervention for BE belonged to the non-CF group. A comparison of demographic, clinical, and spirometric data between the CF and non-CF BE groups is presented in Table 2.

In the CF BE group, there were statistically significant improvements in weight, height, and BMI z-scores when comparing initial and final growth measurements ($p = 0.010$, $p = 0.006$, $p = 0.026$, respectively). In contrast, no significant changes were observed in these parameters within the non-CF BE group. Additionally, no significant differences were found between initial and final PFT values in either group. A comparison of growth z-scores at initial admission and final follow-up between the CF and non-CF BE groups is presented in Table 3.

TABLE 2. Demographic, Clinical, and Spirometry Data Comparison of the Groups CF and Non-CF BE.

	CF n = 37 (%)	Non-CF n = 120 (%)	*p*
Female n (%) Male n (%)	19 (51.4) 18 (48.6)	61 (50.8) 59 (49.2)	0.956
Age at initial admission (months) ‡	7 (1-193)	118 (12-215)	**< 0.001**
Age at diagnosis of BE (months) ‡	108 (26-202)	120 (16-215)	0.151
Follow-up time (months) ‡	124 (21-191)	9 (0-144)	**< 0.001**
Time between initial admission and diagnosis of BE (months) ‡	62 (1-153)	12 (1-106)	**< 0.001**
Initial admission weight z-score ‡	-2.27 (-6.8-0.8)	-1.03 (-0.93-1.87)	**< 0.001**
Initial admission height z-score ‡	-1.82 (-5.75-1.10)	-0.84 (-6.12- 2.58)	**0.003**
Initial admission BMI z-score ‡	-2.10 (-5,25-1.71)	-0.83 (-4.8- 6.02)	**0.001**
Final visit weight z-score ‡	-1.44 (-6.23-1.11)	-1.20 (-6.31-2.57)	0.386
Final visit height z-score ‡	-0.90 (-3.91-1.72)	-0.87 (-4.91-1.44)	0.660
Final visit BMI z-score ‡	-1.18 (-5.94-1.92)	-0.93 (-5.25-2.41)	0.137
Number of hospital admissions ‡	72 (1-220)	3 (1-122)	**< 0.001**
Secondhand smoking exposure ‡	14 (37.8)	26 (21.7)	**0.002**
Segmentectomy/lobectomy n (%)	0	12 (10)	-
Sputum culture colonization n (%)	21 (56.8)	3 (2.5)	**< 0.001**
	S. aureus (13) *P. aeruginosa* (6) *H. influenzae* (2)	*H. influenzae* (2) *P. aeruginosa* (1)	
Spirometry	CF (n = 27)	Non-CF (n = 62)	
Initial admission $FEV_{1\%}$ ‡	78 (36-123)	77 (30-131)	0.850
Initial admission $FVC_{\%}$ ‡	81 (33-120)	80 (34-125)	0.783
Initial admission FEV_1/FVC ‡	94 (67-109)	96 (48-118)	0.179
Initial admission $FEF_{25-75\%}$ ‡	75 (21-139)	70 (12-148)	0.566
Final visit $FEV_{1\%}$ ‡	80 (33-123)	78 (33-146)	0.947
Final visit $FVC_{\%}$ ‡	79 (32-117)	80 (29-160)	0.978
Final visit FEV_1/FVC ‡	99 (72-115)	98 (61-122)	0.523
Final visit $FEF_{25-75\%}$ ‡	73 (26-131)	71 (5-142)	0.772

BE, bronchiectasis; CF, cystic fibrosis; BMI, body mass index; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; FEF_{25-75}, forced expiratory flow between 25% and 75% of FVC.
‡, [median (minimum-maximum)].

Among the 12 patients who underwent surgical intervention for BE, the median age at first admission was 129 months (range, 60-215), at diagnosis 134 months (range, 30-215), and at follow-up 20 months (range, 0-144). For the 145 patients who did not undergo surgery, the corresponding values were 93 months (range, 1-207), 110 months (range, 16-209), and 18 months (range, 0-191). There were no statistically significant differences between surgical and non-surgical groups in these variables (p = 0.072, p = 0.282, p = 0.974). All patients who underwent surgery belonged to the non-CF BE group.

The CF BE group had a significantly lower mean Bhalla score compared to the non-CF BE group, indicating more severe radiological involvement. Despite the lower mean score, a greater proportion of patients with CF had severe radiologic classifications. Additionally, the mean Bhalla score was significantly lower among patients with sputum culture colonization compared to those without. Comparative data on mean Bhalla scores and severity classifications between CF and non-CF BE groups, as well as between colonized and non-colonized patients, are shown in Table 4.

In the CF BE group, a moderate negative correlation was observed between the Bhalla score and age at initial admission. The Bhalla score demonstrated a strong positive correlation with initial FEV_1 (r = 0.637, p = 0.003) and FVC (r = 0.619, p = 0.004), as well as with final visit FVC (r = 0.749, $p < 0.001$) and forced expiratory flow between 25% and 75% (FEF_{25-75}) (r = 0.695, $p < 0.001$). A very strong positive correlation was also found between the Bhalla score and final FEV_1 values (r = 0.846, $p < 0.001$). Furthermore, a weak positive correlation was identified between the Bhalla score and BMI z-score at the final visit (r = 0.373, p = 0.049). Higher Bhalla scores reflect milder radiologic findings.

In the non-CF BE group, weak positive correlations were found between the Bhalla score and initial weight (r = 0.235 p = 0.015), height (r = 0.239 p = 0.014), and BMI z-scores (r = 0.277 p = 0.004), as well as with final weight (r = 0.278 p = 0.014) and height z-scores (r = 0.358 p = 0.001). However, no significant correlation was observed between the Bhalla score and PFT values in children with non-CF BE. Correlations between growth metrics, spirometry results, and Bhalla scores for both CF and non-CF groups are presented in Table 5.

Multivariate linear regression models predicting final parameters for the CF and non-CF groups are summarized in Table 6. In the CF group, initial values significantly predicted final weight (p = 0.009) and height (p = 0.001) z-scores. The model demonstrated a strong fit, with R^2 values ranging from 0.406 to 0.997. In the non-CF group,

TABLE 3. Comparison of the İnitial Admission and Final Visit Growth z-Scores Between the CF and Non-CF BE Groups.

	Initial admission	Final visit	*p*
Weight z-score ‡			
CF BE	-2.27 (-6.8-0.8)	-1.44 (-6.23-1.11)	**0.010**
Non-CF BE	-1.03 (-0.93-1.87)	-1.20 (-6.31-2.57)	0.579
Height z-score ‡			
CF BE	-1.82 (-5.75-1.10)	-0.90 (-3.91-1.72)	**0.006**
Non-CF BE	-0.84 (-6.12- 2.58)	-0.87 (-4.91-1.44)	0.414
BMI z-score ‡			
CF BE	-2.10 (-5.25-1.71)	-1.18 (-5.94-1.92)	**0.026**
Non-CF BE	-0.83 (-4.8- 6.02)	-0.93 (-5.25-2.41)	0.738
FEV1 ‡			
CF BE	78 (36-123)	80 (33-123)	0.853
Non-CF BE	77 (30-131)	78 (33-146)	0.204
FVC ‡			
CF BE	81 (33-120)	79 (32-117)	0.494
Non-CF BE	80 (34-125)	80 (29-160)	0.294
FEV1/FVC ‡			
CF BE	94 (67-109)	99 (72-115)	0.108
Non-CF BE	96 (48-118)	98 (61-122)	0.162
FEF_{25-75} ‡			
CF BE	75 (21-139)	73 (26-131)	0.934
Non-CF BE	70 (12-148)	71 (5-142)	0.258

BE, bronchiectasis; CF, cystic fibrosis; BMI, body mass index; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; FEF_{25-75}, forced expiratory flow between 25% and 75% of FVC.
‡, [median (minimum-maximum)].

initial values significantly predicted all final growth and respiratory outcomes (all $p < 0.001$). The Bhalla score was negatively associated with final height z-score ($p = 0.026$) and positively associated with final BMI z-score ($p = 0.038$). Immunodeficiency was negatively associated with final height z-score and positively associated with the FEV_1/FVC ratio ($p = 0.038$, $p = 0.048$). Smoking exposure showed a positive association with final FEF_{25-75} ($p = 0.018$). The model fit for the non-CF group ranged from moderate to strong, with R^2 values between 0.475 and 0.74 Thoracic CT findings in patients with CF are illustrated in Figure 1.

TABLE 4. Comparison of the Bhalla Score and Score Severity Between the CF and Non-CF BE Groups Between the Colonized and Non-Colonized Sputum Culture Patients.

	CF BE (n = 37)	Non-CF BE (n = 120)	*p*
Bhalla score ‡	11.6 ± 6.7	16.3 ± 4.6	**0.001**
Mild n (%)	10 (27)	74 (61.7)	
Moderate n (%)	14 (37.8)	40 (33.3)	**< 0.001**
Severe n (%)	13 (35.1)	6 (5)	
	Sputum colonization (n = 24)	No colonization (n = 133)	*p*
Bhalla score ‡	11 ± 7.18	16 ± 4.95	**0.006**
Mild n (%)	6 (25)	78 (58.2)	
Moderate n (%)	9 (37.5)	45 (33.6)	**< 0.001**
Severe n (%)	9 (37.5)	10 (7.5)	

BE, bronchiectasis; CF, cystic fibrosis; BMI, body mass index.
‡, [median (minimum-maximum)].

TABLE 5. Correlation of the Growth Parameters, Spirometry Data and Bhalla Score Between the CF and Non-CF BE Groups.

	Total Bhalla score			
	CF BE		non-CF BE	
	r	*p*	r	*p*
Initial admission weight z-score	-0.118	0.548	**0.235**	**0.015**
Initial admission height z-score	0.151	0.443	**0.239**	**0.014**
Initial admission BMI z-score	-0.181	0.357	**0.277**	**0.004**
Final visit weight z-score	0.310	0.109	**0.278**	**0.014**
Final visit height z-score	0.211	0.282	**0.358**	**0.001**
Final visit BMI z-score	**0.373**	**0.049**	0.159	0.165
Age at initial admission (months)	**-0.405**	**0.040**	-0.018	0.848
Age at diagnosis of BE (months)	-0.089	0.666	-0.035	0.703
Follow-up time (months)	-0.084	0.718	-0.080	0.398
Initial admission FEV_1	**0.637**	**0.003**	0,063	0.625
Initial admission FVC	**0.619**	**0.004**	0.064	0.629
Initial admission FEV1/FVC	0.272	0.247	0.073	0.578
Initial admission FEF_{25-75}	0,391	0.088	-0.022	0.864
Final visit FEV_1	**0.846**	**< 0.001**	0.212	0.148
Final visit FVC	**0.749**	**< 0.001**	0.143	0.333
Final visit FEV_1/FVC	0.305	0.178	0.112	0.449
Final visit FEF_{25-75}	**0.695**	**< 0.001**	0.146	0.326

BE, bronchiectasis; CF, cystic fibrosis; BMI, body mass index; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; FEF_{25-75}, forced expiratory flow between 25% and 75%.

TABLE 6. Multivariate Linear Regression Model Predicting Final Parameters in CF Group and Non-CF Group.

	Weight z-score			Height z-score			BMI z-score			FEV_1			FVC			FEV_1/FVC			FEF_{25-75}		
CF group	Beta	95% CI lower upper	*p* -value	Beta	95% CI lower upper	*p* -value	Beta	95% CI lower upper	*p* -value	Beta	95% CI lower upper	*p* -value	Beta	95% CI lower upper	*p* -value	Beta	95% CI lower upper	*p* -value	Beta	95% CI lower upper	*p* -value
Bhalla score	-0.330	-0.205 0.048	0.204	0.039	-0.100 0.118	0.861	-0.343	-0.193 0.048	0.217	-0.259	-9.922 8.169	0.434	-0.288	-5.417 3.182	0.380	0.134	-0.966 1.359	0.278	-0.177	-6.355 4.516	0.542
Age at initial admission	-0.077	-0.021 0.017	0.816	-0.294	-0.024 0.008	0.307	-0.014	-0.018 0.018	0.969	-0.531	-1.800 1.408	0.365	-0.553	-0.940 0.488	0.307	0.083	-0.228 0.255	0.612	-0.930	-1.632 0.613	0.190
Age at diagnosis	0.023	-0.017 0.019	0.926	0.271	-0.006 0.024	0.204	-0.285	-0.026 0.009	0.293	0.146	-1.192 1.354	0.567	0.295	-0.327 0.685	0.268	-0.170	-0.230 0.149	0.224	0.317	-0.525 1.039	0.293
Follow-up duration	0.202	-0.011 0.023	0.488	0.291	-0.006 0.022	0.244	-0.112	-0.019 0.013	0.712	-0.370	-2.014 1.714	0.492	-0.408	-1.030 0.657	0.441	-0.060	-0.302 0.281	0.728	-0.891	-1.875 0.780	0.218
Smoking	-0.162	-2.270 1.244	0.541	0.028	-1.376 1.550	0.900	-0.218	-2.297 1.070	0.448	-0.164	-135.566 121.644	0.616	-0.161	-61.217 45.689	0.596	0.890	-6.415 38.912	0.070	0.469	-48.981 109.679	0.242
Initial value	**0.608**	**0.141 0.803**	**0.009**	**0.719**	**0.275 0.888**	**0.001**	0.472	-0.002 0.699	0.051	0.788	-1.643 3.061	0.163	0.634	-0.415 1.691	0.121	0.136	-0.889 1.172	0.331	0.573	-0.632 2.208	0.140
Model R^2		0.479			0.623			0.406		0.976				0.933		0.997			0.909		
Non-CF group																					
Bhalla score	0.029	-0.045 0.065	0.710	**-0.155**	**-0.093 -0.006**	**0.026**	**0.201**	**0.004 0.121**	**0.038**	-0.012	-1.397 1.263	0.919	-0.012	-1.332 1.217	0.927	0.028	-0.667 0.812	0.842	-0.064	-2.176 1.244	0.581
Age at initial admission	-0.162	-0.024 0.014	0.627	-0.398	-0.026 0.005	0.185	-0.234	-0.025 0.014	0.550	-0.199	-0.636 0.439	0.711	0.041	-0.486 0.523	0.941	0.250	-0.253 0.368	0.707	0.012	-0.687 0.702	0.983
Age at diagnosis	0.378	-0.008 0.028	0.255	0.583	0.001 0.028	0.051	0.280	-0.011 0.025	0.469	0.196	-0.412 0.596	0.712	-0.018	-0.486 0.471	0.975	-0.093	-0.309 0.268	0.887	0.167	-0.551 0.751	0.756
Follow-up duration	-0.059	-0.009 0.004	0.467	0.008	-0.005 0.006	0.908	-0.006	-0.007 0.007	0.953	0.008	-0.182 0.193	0.952	0.100	-0.105 0.233	0.444	0.064	-0.087 0.129	0.692	0.072	-0.178 0.312	0.582
Smoking	-0.004	-0.561 0.532	0.958	-0.057	-0.641 0.261	0.403	0.067	-0.329 0.766	0.428	0.199	-3.050 28.683	0.109	0.141	-6.620 23.748	0.258	-0.033	-10.396 8.323	0.822	**0.305**	**4.616 45.713**	**0.018**
Immuno deficiency	-0.083	-0.856 0.232	0.257	-0.141	**-0.917 -0.028**	**0.038**	**0.014**	**-0.524 0.615**	**0.874**	**0.044**	-14.000 19.996	0.721	0.003	-17.042 17.479	0.979	**0.333**	**0.108 22.565**	**0.048**	0.121	-12.352 33.620	0.351
Initial value	**0.850**	**0.787 1.174**	**< 0.001**	**0.792**	**0.645 0.927**	**< 0.001**	**0.808**	**0.602 0.984**	**< 0.001**	**0.788**	**0.585 1.163**	**< 0.001**	**0.767**	**0.517 1.093**	**< 0.001**	**0.473**	**0.114 0.605**	**0.006**	**0.639**	**0.407 0.951**	**< 0.001**
Model R^2		0.688			0.743			0.556		0.637			0.619			0.475			0.644		

CI, confidence interval; CF, cystic fibrosis; BMI, body mass index; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; FEF_{25-75}, forced expiratory flow between 25% and 75%.

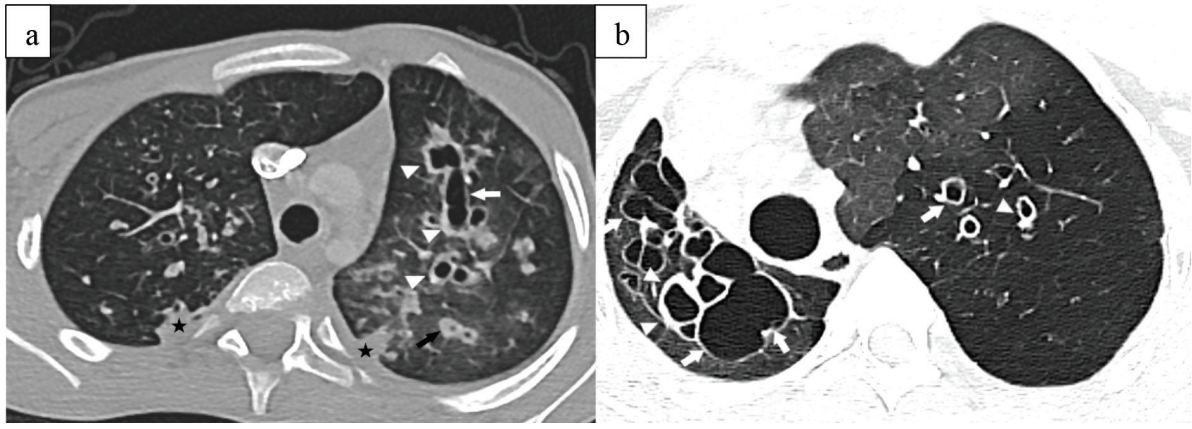

FIG. 1. (a) Cystic bronchiectasis (white arrow) with accompanying peribronchial thickening (white arrowhead) in the left lung on thoracic CT. Ground-glass opacities and subpleural consolidation areas (indicated by a black star), more prominent in the left lung, are also observed. A mucus plug is visible within one of the bronchiectatic airways (indicated by the black arrow). (b) Large cystic bronchiectasis (white arrow) with peribronchial thickening (white arrowhead) observed in the right lung. Notable volume loss and rightward shift of mediastinal structures are also present. In the left lung, finer-caliber bronchiectasis (indicated by the white arrow) and mosaic attenuation are observed.
CT, computed tomography.

DISCUSSION

This study revealed notable differences between CF and non-CF BE patients in terms of clinical presentation, radiological findings, and growth parameters. Patients with CF-related BE presented at a younger age, had longer follow-up durations, and exhibited lower initial growth z-scores. However, no significant differences in weight, height, or BMI z-scores were observed at the final visit, indicating the effectiveness of consistent follow-up and nutritional support. In contrast, non-CF BE patients did not demonstrate significant improvements in growth parameters, suggesting possible shortcomings in ongoing care. Additionally, while the Bhalla score may capture structural lung involvement in CF patients, it does not independently predict pulmonary function outcomes and should therefore be considered a complementary, rather than standalone, measure of disease severity.

Determining the underlying cause of BE in both CF and non-CF patients is essential, as addressing the root condition can enhance patient outcomes. A history of lower respiratory tract infections is linked to long-term pulmonary complications and may contribute to chronic lung disease and impaired pulmonary function. Research on non-CF BE has demonstrated that post-infectious etiologies are most prevalent in developing nations, while immunodeficiencies are more commonly reported in developed countries.[24] The prevalence of post-infectious BE reported in the literature varies significantly, ranging from 4% to 94.5% across studies.[25-29] In the present study, the leading causes of non-CF BE were post-infectious origin (28%) and immunodeficiency (19.8%). The high rate of post-infectious BE in our cohort aligns with data from other developing regions. As such, emphasis should be placed on the prevention and effective treatment of pneumonia, particularly through vaccination and early therapeutic intervention, to facilitate the detection of BE during potentially reversible stages.[30]

Growth and nutritional status are important markers of disease severity and treatment response in children with chronic conditions. Multiple studies have shown associations between growth metrics and pulmonary function.[31-34] In CF, impaired growth can result from factors such as infections, malabsorption, and chronic inflammation. Elevated neutrophil elastase activity and abnormalities in the GH-insulin-like growth factor 1 axis have been linked to growth failure in CF.[35-37] In the current study, children with CF BE demonstrated significant improvements in weight, height, and BMI z-scores during follow-up-contrary to expectations-whereas no such improvement was observed among non-CF BE patients. This contrast may reflect the more structured monitoring and nutritional support integrated into CF care. In comparison, growth surveillance may be less emphasized in non-CF BE management, highlighting the need for a standardized follow-up protocol similar to that used in CF.

Spirometry, especially FEV_1, is a key tool in managing chronic lung disease, as decreases in lung function often precede clinical and radiologic signs, enabling early therapeutic action. FEV_1 is also used to stage disease severity and assess lung transplant eligibility. Previous research has documented a correlation between FEV_1 and HRCT scores in CF patients.[9,11,31,38-40] In line with these findings, our univariate analysis showed a strong correlation between Bhalla scores and spirometric measures (FEV_1, FVC, FEF_{25-75}) in CF patients. However, this association did not persist in multivariable analysis, suggesting that, although structural lung abnormalities are significant, lung function is also shaped by other clinical variables, including disease duration, nutritional condition, and age at diagnosis. No such correlation was found in patients with non-CF BE. This absence of correlation may be due to the heterogeneous nature of the non-CF BE group, which comprises diverse underlying conditions such as PCD, post-infectious BE, immunodeficiencies, and other rare diseases-each with unique radiological presentations, anatomical distributions, and patterns of progression.[4,7] Unlike CF,

which generally follows a progressive and uniform course with diffuse lung involvement, non-CF BE can remain stable over time, particularly in cases with localized or less severe disease. In addition, milder airway involvement in certain subgroups may account for the lack of a significant relationship with spirometry values. As a result, in contrast to CF, the degree of radiological abnormality in non-CF BE does not always align with the extent of functional impairment. The Bhalla score may better reflect disease severity in conditions with more aggressive radiological progression, such as CF. Clinically, this indicates that while the Bhalla score is helpful in assessing structural lung changes and may indirectly relate to pulmonary function-particularly in CF-it should not be used in isolation to assess functional status. Instead, it is best applied as a supplemental measure, particularly when spirometry is unavailable, or within a broader evaluation framework that integrates clinical, radiological, and functional data, especially given the complex and varied presentations of non-CF BE.

Multivariate regression analysis showed that initial clinical parameters-particularly baseline z-scores for weight, height, BMI, and PFT results-were the most reliable predictors of long-term outcomes. In the CF group, these baseline values were significantly associated with final weight and height z-scores, while no other variables were independently linked to final outcomes. This underscores the importance of early clinical status in shaping long-term nutritional results in children with CF-related BE. Factors such as age at diagnosis, duration of follow-up, and smoking exposure were not independently significant in this group, emphasizing that early nutritional intervention may be more impactful than later influences in determining growth patterns. In the non-CF group, initial measurements consistently predicted all final growth and lung function parameters, underscoring their strong prognostic value in this heterogeneous population. The Bhalla score was significantly related to final height and BMI z-scores but showed no associations with PFT outcomes, suggesting that in non-CF patients, structural lung abnormalities may have a greater impact on nutritional status than on respiratory function. Notably, immunodeficiency was inversely associated with final height and positively associated with the FEV_1/FVC ratio, indicating complex or potentially compensatory effects of immune dysfunction on growth and pulmonary physiology. Smoking exposure was unexpectedly positively associated with FEF_{25-75}, a result that should be interpreted cautiously given its divergence from anticipated physiological responses. These findings highlight the multifaceted and variable progression of pediatric BE and support the importance of thorough early assessment-including assessments of growth, immune function, and imaging-for accurate prognosis and tailored management.

Respiratory tract colonization by bacteria contributes to inflammation, impaired mucociliary clearance, and deterioration of lung function.[41] Persistent infections and repeated exacerbations can lead to irreversible airway remodeling, increasing disease severity.[39,42] In our study, sputum culture colonization was more common in CF BE patients, who also had more severe radiological changes as reflected by lower Bhalla scores. This is consistent with existing literature, as individuals with CF are more prone to chronic bacterial colonization due to defective mucociliary clearance and elevated airway surface viscosity. These ongoing infections in CF BE likely drive the increased disease burden observed, as indicated by their radiological severity. This association may offer additional value in assessing BE severity.

Timely diagnosis and the implementation of advanced therapies, including respiratory physiotherapy, contribute to improved outcomes and help slow the progression of BE. When medical management proves insufficient, surgical options such as segmentectomy or lobectomy may be appropriate, particularly for patients with localized disease and persistent symptoms.[43] Previous studies have indicated that 17.5%-23.4% of non-CF BE patients undergo surgical treatment.[27,44] In our study, surgery was performed in 10% of non-CF BE cases. Surgical intervention was not considered for CF BE patients, as lung transplantation remains the definitive option in advanced stages of the disease.

Our results also emphasize the influence of cigarette smoke exposure, which was significantly more prevalent among CF BE patients. Smoke exposure is a key contributor to BE development[45] and has been shown to impair CFTR function[46,47], potentially worsening disease severity in CF patients. These factors may help explain the earlier onset and greater severity of BE observed in the CF population.

The retrospective design of the study and the inability to obtain PFT data for all patients were among its key limitations. A major limitation is that it was a single-center, retrospective study, which may have introduced selection bias and limited the broader applicability of the results. In addition, the non-CF BE group included a range of underlying conditions, and the small number of patients in each subgroup limited the ability to perform detailed comparisons or draw definitive conclusions regarding individual etiologies. Some subgroup analyses-particularly those involving surgical patients or less common non-CF causes-were based on small sample sizes, potentially reducing both generalizability and statistical power. The presence of missing data for certain clinical parameters may also have decreased the power of some analyses. This limitation should be kept in mind when interpreting non-significant results. Furthermore, Bhalla scores were derived solely from HRCT scans taken at the time of BE diagnosis. Due to the lack of consistent follow-up imaging in the retrospective records, the scores do not reflect structural changes that may have occurred over time. This may partly account for the absence of a significant correlation with final PFT findings, especially within the non-CF BE group.

In conclusion, CF and non-CF BE patients demonstrate distinct clinical, radiological, and functional characteristics. While individuals with CF BE tend to show more pronounced radiologic abnormalities, their growth parameters improve over time with structured and sustained care. In contrast, patients with non-CF BE may benefit from more focused interventions to enhance long-term outcomes. Implementing standardized follow-up practices-including growth tracking, nutritional support, and prompt infection management-should be emphasized in the care of non-CF BE patients. Radiological assessment using the Bhalla score can offer valuable insights into structural lung involvement, particularly when spirometry cannot be performed; however, it should be assessed in

conjunction with clinical and functional findings. A personalized, multidisciplinary approach remains critical to optimizing long-term outcomes in pediatric BE. To further clarify differences in etiology, disease course, and treatment strategies, future multicenter prospective studies with clearly defined subgroup classifications are warranted.

Ethics Committee Approval: This study was approved by the Clinical Research Ethics Committee of Gazi University (approval number: 956, date: 11.12.2023).

Informed Consent: Retrospective study.

Data Sharing Statement: The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Authorship Contributions: Concept- H.K.; Design- T.Ş.E., A.T.A.; Supervision- T.Ş.E., A.T.A.; Materials- H.K.; Data Collection or Processing- H.K., Y.D., M.Y., Ö.L.B.; Analysis or Interpretation- V.M., M.Y., Ö.L.B.; Literature Review- H.K.; Writing- H.K.; Critical Review- T.Ş.E., A.T.A.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding: The authors declared that this study received no financial support.

REFERENCES

1. Chang AB, Fortescue R, Grimwood K, et al. European Respiratory Society guidelines for the management of children and adolescents with bronchiectasis. *Eur Respir J*. 2021;58:2002990. [CrossRef]
2. Chang AB, Bush A, Grimwood K. Bronchiectasis in children: diagnosis and treatment. *Lancet*. 2018;392:866-879. [CrossRef]
3. McCallum GB, Binks MJ. The epidemiology of chronic suppurative lung disease and bronchiectasis in children and adolescents. *Front Pediatr*. 2017;5:27. [CrossRef]
4. Schäfer J, Griese M, Chandrasekaran R, Chotirmall SH, Hartl D. Pathogenesis, imaging and clinical characteristics of CF and non-CF bronchiectasis. *BMC Pulm Med*. 2018;18:79. [CrossRef]
5. Nathan AM, de Bruyne JA, Eg KP, Thavagnanam S. Review: Quality of life in children with non-cystic fibrosis bronchiectasis. *Front Pediatr*. 2017;5:84. [CrossRef]
6. Mocelin HT, Fischer GB, Piccini JD, Baú R, Andrade CF, Lukrafka JL. Surgical treatment of non-cystic fibrosis bronchiectasis in children and adolescents: a review. *Paediatr Respir Rev*. 2023;46:57-62. [CrossRef]
7. Poeta M, Maglione M, Borrelli M, Santamaria F. Non-cystic fibrosis bronchiectasis in children and adolescents: Neglected and emerging issues. *Pediatr Neonatol*. 2020;61:255-262. [CrossRef]
8. Chandrasekaran R, Mac Aogáin M, Chalmers JD, Elborn SJ, Chotirmall SH. Geographic variation in the aetiology, epidemiology and microbiology of bronchiectasis. *BMC Pulm Med*. 2018;18:83. [CrossRef]
9. Pereira FF, Ibiapina Cda C, Alvim CG, Camargos PA, Figueiredo R, Pedrosa JF. Correlation between Bhalla score and spirometry in children and adolescents with cystic fibrosis. *Rev Assoc Med Bras (1992)*. 2014;60:216-221. [CrossRef]
10. Park J, Kim S, Lee YJ, et al. Factors associated with radiologic progression of non-cystic fibrosis bronchiectasis during long-term follow-up. *Respirology*. 2016;21:1049-1054. [CrossRef]
11. Sarıoğlu F, Şirin S, Güleryüz H, Asilsoy S. The assessment of the correlation between Thorax computed tomography and clinical findings in children with cystic fibrosis. *J DEU Med*. 2020;33:235-244. [CrossRef]
12. Marchant JM, Masel JP, Dickinson FL, Masters IB, Chang AB. Application of chest high-resolution computer tomography in young children with cystic fibrosis. *Pediatr Pulmonol*. 2001;31:24-29. [CrossRef]
13. Prentice BJ, Wales S, Doumit M, Owens L, Widger J. Children with bronchiectasis have poorer lung function than those with cystic fibrosis and do not receive the same standard of care. *Pediatr Pulmonol*. 2019;54:1921-1926. [CrossRef]
14. Graham BL, Steenbruggen I, Miller MR, et al. Standardization of spirometry 2019 update. An official American Thoracic Society and European Respiratory Society Technical Statement. *Am J Respir Crit Care Med*. 2019;200:70-88. [CrossRef]
15. Castellani C, Duff AJA, Bell SC, et al. ECFS best practice guidelines: the 2018 revision. *J Cyst Fibros*. 2018;17:153-178. [CrossRef]
16. De Wachter E, De Boeck K, Sermet-Gaudelus I, et al. ECFS standards of care on CFTR-related disorders: towards a comprehensive program for affected individuals. *J Cyst Fibros*. 2024;23:388-397. [CrossRef]
17. Gupta AK, Lodha R, Kabra SK. Non cystic fibrosis bronchiectasis. *Indian J Pediatr*. 2015;82:938-944. [CrossRef]
18. Shoemark A, Dell S, Shapiro A, Lucas JS. ERS and ATS diagnostic guidelines for primary ciliary dyskinesia: similarities and differences in approach to diagnosis. *Eur Respir J*. 2019;54:1901066. [CrossRef]
19. Bousfiha A, Moundir A, Tangye SG, et al. The 2022 update of IUIS phenotypical classification for human inborn errors of immunity. *J Clin Immunol*. 2022;42:1508-1520. [CrossRef]
20. Levy ML, Bacharier LB, Bateman E, et al. Key recommendations for primary care from the 2022 Global Initiative for Asthma (GINA) update. *NPJ Prim Care Respir Med*. 2023;33:7. [CrossRef]
21. Bush A, Cunningham S, de Blic J, et al. European protocols for the diagnosis and initial treatment of interstitial lung disease in children. *Thorax*. 2015;70:1078-1084. [CrossRef]
22. Bhalla M, Turcios N, Aponte V, et al. Cystic fibrosis: scoring system with thin-section CT. *Radiology*. 1991;179(3):783-788. [CrossRef]
23. Bedi P, Chalmers JD, Goeminne PC, et al. The BRICS (bronchiectasis radiologically indexed CT score): a multicenter study score for use in idiopathic and postinfective bronchiectasis. *Chest*. 2018;153:1177-1186. [CrossRef]
24. Li AM, Sonnappa S, Lex C, et al. Non-CF bronchiectasis: does knowing the aetiology lead to changes in management? *Eur Respir J*. 2005;26:8-14. [CrossRef]
25. Brower KS, Del Vecchio MT, Aronoff SC. The etiologies of non-CF bronchiectasis in childhood: a systematic review of 989 subjects. *BMC Pediatr*. 2014;14:4. [CrossRef]
26. Kapur N, Stroil-Salama E, Morgan L, et al. Factors associated with "Frequent Exacerbator" phenotype in children with bronchiectasis: the first report on children from the Australian Bronchiectasis Registry. *Respir Med*. 2021;188:106627. [CrossRef]
27. Karadag B, Karakoc F, Ersu R, Kut A, Bakac S, Dagli E. Non-cystic-fibrosis bronchiectasis in children: a persisting problem in developing countries. *Respiration*. 2005;72:233-238. [CrossRef]
28. Kapur N, Masters IB, Chang AB. Exacerbations in noncystic fibrosis bronchiectasis: clinical features and investigations. *Respir Med*. 2009;103:1681-1687. [CrossRef]
29. Lee E, Shim JY, Kim HY, et al. Clinical characteristics and etiologies of bronchiectasis in Korean children: amulticenter retrospective study. *Respir Med*. 2019;150:8-14. [CrossRef]
30. Kapur N, Karadag B. Differences and similarities in non-cystic fibrosis bronchiectasis between developing and affluent countries. *Paediatr Respir Rev*. 2011;12:91-96. [CrossRef]
31. Bastardo CM, Sonnappa S, Stanojevic S, et al. Non-cystic fibrosis bronchiectasis in childhood: longitudinal growth and lung function. *Thorax*. 2009;64:246-251. [CrossRef]
32. Peterson ML, Jacobs DR Jr, Milla CE. Longitudinal changes in growth parameters are correlated with changes in pulmonary function in children with cystic fibrosis. *Pediatrics*. 2003;112:588-592. [CrossRef]
33. Calella P, Valerio G, Thomas M, et al. Association between body composition and pulmonary function in children and young people with cystic fibrosis. *Nutrition*. 2018;48:73-76. [CrossRef]
34. Nathan AM, Muthusamy A, Thavagnanam S, Hashim A, de Bruyne J. Chronic suppurative lung disease in a developing country: impact on child and parent. *Pediatr Pulmonol*. 2014;49:435-440. [CrossRef]
35. Brownell JN, Bashaw H, Stallings VA. Growth and nutrition in cystic fibrosis. *Semin Respir Crit Care Med*. 2019;40:775-791. [CrossRef]
36. Lavi E, Gileles-Hillel A, Zangen D. Somatic growth in cystic fibrosis. *Curr Opin Endocrinol Diabetes Obes*. 2020;27:38-46. [CrossRef]
37. Cantin AM, Hartl D, Konstan MW, Chmiel JF. Inflammation in cystic fibrosis lung disease: pathogenesis and therapy. *J Cyst Fibros*. 2015;14:419-430. [CrossRef]
38. Assis I, Camargos PA, Reis FJ, Sulmonett N, Carneiro AP. Assessing correlations between spirometry and Shwachman-Kulczycki score in children and adolescents. *Pediatr Pulmonol*. 2003;36:305-309. [CrossRef]

39. Rybacka A, Goździk-Spychalska J, Rybacki A, Piorunek T, Batura-Gabryel H, Karmelita-Katulska K. Congruence between pulmonary function and computed tomography imaging assessment of cystic fibrosis severity. *Adv Exp Med Biol*. 2018;1114:67-76. [CrossRef]
40. Demirkazik FB, Ariyürek OM, Ozçelik U, Göçmen A, Hassanabad HK, Kiper N. High resolution CT in children with cystic fibrosis: correlation with pulmonary functions and radiographic scores. *Eur J Radiol*. 2001;37:54-59. [CrossRef]
41. Chawla K, Vishwanath S, Manu MK, Lazer B. Influence of pseudomonas aeruginosa on exacerbation in patients with bronchiectasis. *J Glob Infect Dis*. 2015;7:18 22. [CrossRef]
42. Khani Nozari F, Modaresi M, Allahverdi B, Shirzadi R, Fattahi M. Association between sputum culture results and pulmonary changes in children with cystic fibrosis. *Iran J Microbiol*. 2023;15:759-764. [CrossRef]
43. Kutlay H, Cangir AK, Enön S, et al. Surgical treatment in bronchiectasis: analysis of 166 patients. *Eur J Cardiothorac Surg*. 2002;21:634-637. [CrossRef]
44. Kumar A, Lodha R, Kumar P, Kabra SK. Non-cystic fibrosis bronchiectasis in children: clinical profile, etiology and outcome. *Indian Pediatr*. 2015;52:35-37. [CrossRef]
45. Detorakis EE, Lasithiotaki I, Dailiani K, Raissaki M. HRCT findings in secondhand smokers with respiratory symptoms. *Jpn J Radiol*. 2023;41:153-163. [CrossRef]
46. Marklew AJ, Patel W, Moore PJ, et al. Cigarette smoke exposure induces retrograde trafficking of CFTR to the endoplasmic reticulum. *Sci Rep*. 2019;9:13655. [CrossRef]
47. Hanrahan JW, Abu-Arish A, Wong FH, et al. Chronic obstructive pulmonary disease and the modulation of CFTR by acute exposure to cigarette smoke. *Am J Physiol Cell Physiol*. 2022;323:1374-1392. [CrossRef]