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Original Research Article

CORRELATION BETWEEN COMPUTED TOMOGRAPHY SEVERITY SCORE AND FORCED EXPIRATORY VOLUME IN ONE SECOND AMONG PATIENTS WITH BRONCHIECTASIS: A CROSS-SECTIONAL OBSERVATIONAL STUDY

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ABSTRACT

Background: Bronchiectasis is a chronic airway disorder characterized by irreversible bronchial dilatation, recurrent infection, airway inflammation, and variable airflow limitation. High-resolution computed tomography is central to diagnosis and severity assessment, while spirometry provides functional evaluation. **Materials and Methods:** This cross-sectional observational study included clinically or radiologically diagnosed bronchiectasis patients attending a tertiary-care respiratory medicine service. CT severity was assessed using a modified Bhalla scoring system incorporating bronchial dilatation, wall thickening, extent of bronchiectasis, mucus plugging, bronchial generation involvement, and mosaic attenuation. Spirometric indices included FEV1, FVC, and FEV1/FVC ratio. Correlation between total CT severity score and FEV1 percent predicted was assessed. **Result:** A total of 100 patients were analyzed. Mean age was 50.27 ± 19.18 years; 58% were male. Mean total CT severity score was 8.55 ± 3.01, and mean FEV1 was 73.63 ± 10.31% predicted. CT severity score showed a strong negative correlation with FEV1 percent predicted (Pearson $r = -0.850$, $p < 0.001$; Spearman $\rho = -0.846$, $p < 0.001$). **Conclusion:** Increasing radiological severity of bronchiectasis was strongly associated with declining FEV1, supporting the combined use of CT scoring and spirometry for clinical severity assessment.

INTRODUCTION

Bronchiectasis is defined by irreversible bronchial dilatation resulting from chronic airway inflammation, impaired mucociliary clearance, and recurrent infection. It is increasingly recognized as a clinically heterogeneous chronic respiratory disease associated with cough, sputum production, recurrent infective exacerbations, impaired quality of life, and progressive lung-function decline.[1,2] Contemporary guidelines recommend thin-section computed tomography as the diagnostic imaging modality of choice in suspected bronchiectasis because it enables direct visualization of bronchial dilatation, bronchial wall thickening, lack of normal tapering, and peripheral airway visibility.[2,3]

Radiological scoring systems provide a structured method for quantifying anatomical disease burden. The Bhalla and modified Bhalla scoring approaches, initially developed for detailed CT assessment of bronchiectatic airway changes, incorporate features such as severity and extent of bronchial dilatation, wall thickening, mucus plugging, sacculations, generations of bronchial divisions involved, and associated parenchymal abnormalities.[4,5] However, anatomical severity does not always translate directly into functional impairment, particularly in heterogeneous bronchiectasis phenotypes.

Spirometry remains an accessible and reproducible tool for assessing functional impairment in bronchiectasis. Forced expiratory volume in one second (FEV1) is incorporated into multidimensional bronchiectasis severity tools such as the FACED score and Bronchiectasis Severity Index, reflecting its clinical prognostic relevance.[6,7] Previous studies have reported variable relationships between CT severity and pulmonary function, with some demonstrating significant inverse associations between radiological extent and FEV1, while others found weaker or inconsistent correlations.[8,9]

The present study was designed to evaluate the relationship between CT severity score and FEV1 percent predicted among bronchiectasis patients in a tertiary-care setting. The primary objective was to assess whether increasing CT severity is associated with reduced FEV1. The study hypothesis was that CT severity score would show a significant negative correlation with FEV1 percent predicted.

MATERIALS AND METHODS

This hospital-based cross-sectional observational study was conducted in the Department of Respiratory Medicine at Trichy SRM Medical College Hospital and Research Centre, Tiruchirapalli, Tamil Nadu, India. The study included patients attending both outpatient and inpatient services who were clinically or radiologically diagnosed with bronchiectasis. Bronchiectasis was identified based on clinical presentation supported by computed tomography findings suggestive of permanent bronchial dilatation, lack of normal bronchial tapering, bronchial wall thickening, and peripheral visibility of bronchi. Patients with active pulmonary tuberculosis, emphysema, bullous lung disease, hemoptysis, acute coronary syndrome, and pregnant women were excluded from the study to avoid confounding of pulmonary function parameters and to ensure patient safety during spirometry.
The initial protocol estimated a minimum sample size of 40 patients based on a previously published study by Habesoglu et al., which reported a significant negative correlation between the extent of bronchiectasis and FEV1 predicted values ($r = 0.60$). Assuming a similar correlation coefficient, with 80% statistical power and a 5% level of significance, a minimum sample size of 40 was considered adequate to evaluate the relationship between CT severity and pulmonary function. However, for the final analysis, a total of 100 eligible patients were included using a consecutive sampling method during the study period, thereby improving the precision and reliability of the statistical analysis.
After obtaining written informed consent, all participants underwent detailed clinical evaluation including demographic profile, smoking history, duration of illness, symptom assessment, and general physical and respiratory examination using a structured proforma. Relevant clinical details such as cough, breathlessness, sputum production, hemoptysis, fever, clubbing, and associated comorbidities were documented. Routine investigations including chest radiography, computed tomography of the thorax, and pulmonary function testing were performed as part of standard clinical assessment.
Computed tomography severity was assessed using the modified Bhalla scoring system, which is a validated radiological scoring method used to quantify the structural severity of bronchiectasis. The scoring system included six parameters: severity of bronchial dilatation, bronchial wall thickening, extent of bronchiectasis, extent of mucus plugging, generation of bronchial divisions involved, and presence of mosaic attenuation pattern. Each parameter was graded from 0 to 3 depending on severity and extent, and the total score was calculated by summing all individual components. Based on the total score, CT severity was categorized as mild (score 1–9), moderate (score 10–14), and severe (score 15–18).
Pulmonary function was evaluated using spirometry following standard American Thoracic Society recommendations. The functional indices measured included forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio. These values were expressed as percentages of predicted values according to the patient's age, sex, and height. FEV1 percentage predicted was considered the primary functional marker of disease severity and was categorized as mild when greater than 80%, moderate when between 50% and 80%, severe when between 30% and 50%, and very severe when less than 30%.

The total CT severity score was categorized as:

CT Severity Category	Score Range
Mild	1–9
Moderate	10–14
Severe	≥15

Spirometric Assessment
Spirometry included FEV1 percent predicted, FVC percent predicted, and FEV1/FVC ratio. FEV1 severity was classified as:

FEV1 Category	FEV1 Percent Predicted
Mild	>80%
Moderate	50–80%
Severe	30–50%
Very severe	<30%

The primary objective of the study was to determine the correlation between total CT severity score and FEV1 percentage predicted. Secondary analysis included assessment of the relationship between individual CT score components and spirometric indices. Data were entered in Microsoft Excel and analyzed using statistical software. Continuous variables were expressed as mean with standard deviation or median with interquartile range depending on data distribution, while categorical variables were presented as frequencies and percentages. Pearson correlation analysis was used to assess the linear relationship between total CT severity score and FEV1 percentage predicted. Since CT severity scores are derived from ordinal components, Spearman rank correlation was also performed to confirm the strength of association. A p-value of less than 0.05 was considered statistically significant.
Ethical approval for the study was obtained from the Institutional Ethics Committee prior to commencement. All participants provided written informed consent before enrollment. Confidentiality of patient information was strictly maintained throughout the study, and all procedures were carried

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out in accordance with institutional ethical standards and the principles of the Declaration of Helsinki.

RESULTS

A total of 100 patients with clinically and radiologically confirmed bronchiectasis were included in the study. The mean age of the study population was 50.27 ± 19.18 years, with ages ranging from 18 to 85 years. The median age was 51.5 years (interquartile range: 34.75–68.0 years). Male patients constituted the majority of the study population, accounting for 58%, while females represented 42%. Smoking history was present in 40% of the patients, whereas 60% were non-smokers. The mean duration of illness was 9.41 ± 6.02 years, indicating that most patients had a chronic disease course at the time of evaluation.

Table 1: Baseline Characteristics

Variable	Result
Age, mean ± SD, years	50.27 ± 19.18
Age, median (IQR), years	51.5 (34.75–68.0)
Male sex	58 (58%)
Female sex	42 (42%)
Smokers	40 (40%)
Non-smokers	60 (60%)
Disease duration, mean ± SD, years	9.41 ± 6.02

The radiological severity of bronchiectasis was assessed using the modified Bhalla scoring system. The mean total CT severity score was 8.55 ± 3.01, with a median score of 9.0 (IQR: 6.0–10.0), suggesting that the majority of patients belonged to the mild-to-moderate severity group. Spirometric evaluation showed that the mean FEV1 was 73.63 ± 10.31% predicted, while the mean FVC was 78.83 ± 11.44% predicted. The mean FEV1/FVC ratio was 93.74 ± 6.99. These findings indicate that most patients had moderate airflow limitation despite variable radiological severity.

Table 2: Radiological and Spirometric Parameters

Variable	Mean ± SD	Median (IQR)
Total CT severity score	8.55 ± 3.01	9.0 (6.0–10.0)
FEV1 percent predicted	73.63 ± 10.31	73.73 (67.10–81.05)
FVC percent predicted	78.83 ± 11.44	78.09 (71.31–87.74)
FEV1/FVC ratio	93.74 ± 6.99	93.85 (88.93–97.93)

When CT severity was categorized, 64% of patients were classified as having mild disease, 35% had moderate disease, and only 1% had severe bronchiectasis. Similarly, based on FEV1 grading, 27% of patients had mild airflow limitation and 73% had moderate impairment. No patients were found in the severe or very severe FEV1 categories, reflecting the predominance of stable ambulatory bronchiectasis cases in the study.

Table 3: Distribution of CT and FEV1 Severity Categories

Category	n (%)
CT mild	64 (64%)
CT moderate	35 (35%)
CT severe	1 (1%)
FEV1 mild	27 (27%)
FEV1 moderate	73 (73%)
FEV1 severe	0
FEV1 very severe	0

The primary objective of the study was to determine the relationship between CT severity score and FEV1 percentage predicted. Pearson correlation analysis demonstrated a strong negative correlation between total CT severity score and FEV1 ($r = -0.850$, $p < 0.001$), indicating that increasing radiological severity was associated with worsening pulmonary function. Since CT severity scores are derived from ordinal variables, Spearman rank correlation was also performed and showed a similarly strong inverse association ($\rho = -0.846$, $p < 0.001$), further confirming the consistency of this relationship.

Table 4: Correlation between CT Severity Score and FEV1

Test	Correlation Coefficient	p value
Pearson correlation	−0.850	<0.001
Spearman correlation	−0.846	<0.001

A progressive decline in mean FEV1 was observed across increasing CT severity categories. Patients with mild CT severity had a mean FEV1 of 78.86 ± 7.93%, while those with moderate disease had a significantly lower mean FEV1 of 64.68 ± 6.82%. The single patient with severe CT disease had an

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FEV1 of 52.74%, demonstrating marked functional impairment with increasing structural lung damage.

Table 5: Mean FEV1 decreased across CT severity categories

CT Severity Category	n	Mean FEV1 ± SD
Mild	64	78.86 ± 7.93
Moderate	35	64.68 ± 6.82
Severe	1	52.74

Further analysis of individual CT score components revealed statistically significant negative correlations with FEV1 across all domains. Bronchial wall thickening showed the strongest inverse relationship ($\rho = -0.509$, $p < 0.001$), followed by bronchial dilatation ($\rho = -0.424$, $p < 0.001$), generation of bronchial divisions involved ($\rho = -0.394$, $p < 0.001$), and mucus plugging ($\rho = -0.372$, $p < 0.001$). Extent of bronchiectasis and mosaic attenuation also demonstrated significant negative associations, although of relatively lower magnitude.

Table 6: Correlation of individual CT score components with FEV1

CT Component	Spearman ρ	p value
Bronchial dilatation	−0.424	<0.001
Bronchial wall thickening	−0.509	<0.001
Extent of bronchiectasis	−0.278	0.005
Mucus plugging	−0.372	<0.001
Bronchial generation involvement	−0.394	<0.001
Mosaic attenuation	−0.228	0.022

Overall, the results clearly demonstrated that worsening CT severity in bronchiectasis was associated with significant deterioration in pulmonary function, particularly FEV1 percentage predicted. These findings support the clinical value of combining radiological severity scoring with spirometric assessment for a more comprehensive evaluation of disease severity in bronchiectasis patients.

DISCUSSION

This cross-sectional study demonstrated a strong inverse relationship between CT severity score and FEV1 percent predicted among patients with bronchiectasis. Patients with higher radiological severity had lower spirometric function, supporting the study hypothesis that structural airway damage on CT is associated with functional impairment.

The observed negative correlation is biologically plausible. Bronchiectasis involves chronic airway inflammation, impaired secretion clearance, recurrent infection, and progressive airway remodeling. Increasing bronchial dilatation, wall thickening, mucus plugging, and peripheral airway involvement can contribute to airflow limitation through luminal narrowing, dynamic airway collapse, small-airway obstruction, and ventilation heterogeneity.[1,2] Mosaic attenuation may reflect small-airway disease and regional air trapping, which can further contribute to reduced expiratory airflow.

The findings are consistent with prior studies reporting associations between radiological bronchiectasis burden and pulmonary function impairment. Habesoglu et al. reported that radiological extent and severity on HRCT were associated with functional impairment in bronchiectasis.[8] Earlier work has also shown significant relationships between CT-based bronchiectasis severity and FEV1, although the strength of association has varied across populations and scoring systems.[9] Conversely, Eshed et al. found stronger associations between HRCT score and health-status measures than with pulmonary function indices, highlighting that bronchiectasis severity is multidimensional and cannot be fully represented by spirometry alone.[10]

A notable finding in the present analysis is that bronchial wall thickening had the strongest individual correlation with FEV1 among CT components. This may reflect the functional importance of airway inflammation and luminal narrowing rather than bronchial dilatation alone. Mucus plugging and distal bronchial generation involvement were also significantly associated with lower FEV1, suggesting that both airway obstruction and peripheral disease extent influence spirometric impairment.

The study has several strengths. It used a structured CT scoring system, included objective spirometric parameters, and analyzed both total CT severity and individual CT components. The dataset also exceeded the originally planned sample size, improving statistical precision.

However, limitations should be acknowledged. First, the study was cross-sectional, preventing causal inference. Second, the severe CT category included only one patient, limiting comparisons across severity strata. Third, potential confounders such as etiology, prior tuberculosis, microbiology, exacerbation frequency, treatment status, and comorbidities were not available for adjusted analysis. Fourth, interobserver agreement for CT scoring was not assessed. Finally, spirometry is effort-dependent and may vary according to patient technique and disease stability.

Clinically, these findings support integrated assessment of bronchiectasis using both radiological and functional parameters. CT scoring may help quantify anatomical burden, while FEV1 provides complementary information regarding physiological impairment. Together, these measures may assist in disease stratification, follow-up planning, and identification of patients requiring closer monitoring.

CONCLUSION

In this cross-sectional study of bronchiectasis patients, total CT severity score showed a strong negative correlation with FEV1 percent predicted. Higher radiological severity was associated with greater pulmonary function impairment. These findings support the combined use of structured CT scoring and spirometry in bronchiectasis severity assessment.

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