

Original Research Article

Correlation of Pulmonary Function Tests with HRCT Findings in Chronic Obstructive Pulmonary Disease: A Cross-Sectional Study from a Tertiary Care Hospital in South India

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Abstract: *Background:* Chronic obstructive pulmonary disease (COPD) is characterised by persistent airflow limitation and heterogeneous structural lung abnormalities. High-resolution computed tomography (HRCT) provides detailed morphological assessment, but its correlation with spirometric indices in Indian populations remains incompletely characterised. *Objectives:* To evaluate the correlation between HRCT morphological findings and pulmonary function test (PFT) parameters in patients with COPD, and to assess whether HRCT features can predict the severity of airflow obstruction. *Methods:* This cross-sectional observational study was conducted in the Department of Pulmonary Medicine at a tertiary care hospital in South India over a six-month period (June–December 2015). Thirty-six patients with spirometry-confirmed COPD (post-bronchodilator FEV₁/FVC < 0.70) underwent HRCT thorax and PFT evaluation. HRCT findings emphysema severity, bronchial wall thickening (BWT), air trapping, and bronchiectasis were visually scored and correlated with FEV₁, FVC, FEV₁/FVC, and PEFR using Pearson's correlation coefficient. *Results:* The mean age was 58.2 ± 9.4 years, with a male predominance (83.3%). Emphysema was the most common HRCT finding (72.2%), followed by BWT (58.3%), air trapping (47.2%), and bronchiectasis (19.4%). Emphysema severity demonstrated a significant inverse correlation with FEV₁ (r = -0.56, p < 0.001), FVC (r = -0.38, p = 0.021), and FEV₁/FVC (r = -0.43, p = 0.009). BWT showed a negative correlation with FEV₁ (r = -0.42, p = 0.011). Air trapping correlated inversely with FEV₁/FVC (r = -0.48, p = 0.003). GOLD stage showed a significant positive association with emphysema grade (r = 0.52, p = 0.001). *Conclusion:* HRCT morphological features demonstrate significant correlation with spirometric indices in COPD. Emphysema severity and air trapping are the strongest predictors of airflow obstruction. HRCT may serve as a valuable adjunct to spirometry in the comprehensive evaluation of COPD severity.

Keywords: Chronic obstructive pulmonary disease, high-resolution computed tomography, pulmonary function tests.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable condition characterised by persistent respiratory symptoms and progressive airflow limitation due to significant exposure to noxious particles or gases [1]. It remains a leading cause of morbidity and mortality worldwide, with the Global Burden of Disease Study estimating that COPD accounted for approximately 3.2 million deaths globally in 2015 [2]. In India, the disease burden is particularly substantial, with an estimated 2774.64 prevalent cases per 100,000 population in 2015, representing a significant public health challenge [3]. The India State-level Disease Burden Initiative reported that COPD was responsible for 8.7% of total

deaths and 4.8% of total disability-adjusted life years (DALYs) in 2016 [4].

The diagnosis and severity assessment of COPD relies primarily on spirometry, with the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines providing a standardised framework for classification based on post-bronchodilator FEV₁/FVC ratio and percentage predicted FEV₁ [5]. However, spirometry provides only a functional assessment and does not capture the heterogeneous morphological and pathological changes that characterise COPD. The disease encompasses varying degrees of emphysema, small airway remodelling, bronchial wall thickening, and air trapping, which may

not be uniformly reflected in spirometric parameters [6].

High-resolution computed tomography (HRCT) has emerged as a valuable imaging modality for the detailed assessment of structural lung abnormalities in COPD. HRCT enables visualisation and quantification of emphysema distribution, bronchial wall dimensions, air trapping, and concomitant bronchiectasis [7]. Several studies have demonstrated that HRCT-derived parameters correlate with physiological measures of airflow obstruction, suggesting that imaging may provide complementary information regarding disease severity and phenotype [8,9]. The ability to identify specific morphological phenotypes emphysema-predominant, airway-predominant, or mixed has potential implications for targeted therapeutic approaches and prognostication [10].

Despite the growing body of literature on HRCT in COPD, data from Indian populations remain limited. The relative contribution of different HRCT features to airflow obstruction may vary across populations due to differences in exposure patterns, genetic susceptibility, and disease phenotypes [11]. Furthermore, the utility of HRCT in predicting spirometric severity in resource-limited settings where access to pulmonary function testing may be constrained warrants investigation. This study was therefore undertaken to evaluate the correlation between HRCT findings and pulmonary function test parameters in patients with COPD at a tertiary care hospital in South India.

OBJECTIVE

The primary objective of this study was to evaluate the correlation between morphological findings on HRCT thorax and pulmonary function test parameters in patients with COPD. Specifically, the study aimed to assess the relationship between HRCT features including emphysema severity, bronchial wall thickening, air trapping, and bronchiectasis and spirometric indices such as FEV₁, FVC, FEV₁/FVC ratio, and PEFR. The study also sought to determine whether HRCT-derived parameters could predict the severity of airflow obstruction as classified by GOLD staging.

The secondary objective was to characterise the spectrum of HRCT morphological abnormalities in COPD patients from a South Indian tertiary care setting and to identify the predominant imaging phenotypes. By establishing correlations between HRCT findings and spirometric parameters, this study aimed to provide evidence for the potential role of HRCT as a complementary tool in the comprehensive assessment of COPD severity, particularly in settings where spirometry may be unavailable or technically difficult to perform.

METHODOLOGY & MATERIALS

This cross-sectional observational study was conducted in the Department of Pulmonary Medicine at a tertiary care hospital in South India over a six-month period from June 2015 to December 2015. A total of 36 patients with established COPD were enrolled in the study after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to inclusion. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and followed good clinical practice guidelines.

Inclusion criteria included: (i) patients aged 40 years and above of either sex; (ii) patients with a confirmed diagnosis of COPD based on post-bronchodilator FEV₁/FVC < 0.70 as per GOLD 2014 guidelines [5]; (iii) patients with stable disease at the time of enrolment (no exacerbation within the preceding four weeks); and (iv) patients who were willing to undergo both pulmonary function testing and HRCT thorax.

Exclusion criteria comprised: (i) patients with a history of bronchial asthma or other chronic respiratory diseases such as interstitial lung disease, bronchiectasis as a primary diagnosis, or tuberculosis; (ii) patients with significant cardiac comorbidities or contraindications to HRCT; (iii) pregnant women; and (iv) patients with known hypersensitivity to contrast agents or those who had received iodinated contrast within the previous 48 hours.

Data Collection Procedure

Demographic data including age, sex, occupation, smoking history (pack-years), and biomass fuel exposure were recorded for all participants. A detailed clinical history and physical examination were performed. Pulmonary function testing was conducted using a calibrated spirometer (Medisoft, Belgium) according to American Thoracic Society/European Respiratory Society guidelines [12]. Post-bronchodilator FEV₁, FVC, FEV₁/FVC ratio, and PEFR were measured after administration of 400 µg salbutamol via a metered-dose inhaler with spacer. Predicted values were calculated using standard reference equations for the Indian population [13]. COPD severity was classified according to GOLD 2014 staging: Stage I (mild, FEV₁ ≥ 80% predicted), Stage II (moderate, FEV₁ 50–79% predicted), Stage III (severe, FEV₁ 30–49% predicted), and Stage IV (very severe, FEV₁ < 30% predicted) [5].

HRCT thorax was performed using a 128-slice multidetector CT scanner (Siemens Somatom Definition Flash, Germany) within two weeks of pulmonary function testing. Scanning parameters included: 120 kVp, 100 mAs, collimation 0.6 mm, pitch 1.2, and reconstruction with a high-spatial-frequency

algorithm. Images were acquired during a single breath-hold at end-inspiration in the supine position. Expiratory images were obtained at six levels (aortic arch, carina, bronchus intermedius, right inferior pulmonary vein, and 2 cm below the diaphragm) for assessment of air trapping. All images were evaluated independently by two experienced radiologists blinded to the spirometric results. Emphysema was visually scored on a semi-quantitative scale (0 = none, 1 = mild [$<25\%$], 2 = moderate [$25\text{--}50\%$], 3 = severe [$>50\%$]) at six anatomical levels, and a total emphysema score was calculated [14]. Bronchial wall thickening was assessed using the ratio of bronchial wall thickness to adjacent pulmonary artery diameter (BWT/PA ratio > 1 was considered abnormal) [15]. Air trapping was evaluated on expiratory images as the percentage of lung showing attenuation < -850 HU, visually scored from 0 to 3. Bronchiectasis was identified using standard criteria (bronchoarterial ratio > 1 , lack of tapering, and visible bronchi within 1 cm of the pleural surface).

Statistical Data Analysis

Data were analysed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD) and categorical variables as frequencies and percentages. The normality of data distribution was assessed using the Shapiro-Wilk test. Pearson's correlation coefficient was used to assess the relationship between HRCT parameters and pulmonary function test variables. A p -value < 0.05 was considered statistically significant. The correlation strength was interpreted as: weak ($r = 0.1\text{--}0.3$), moderate ($r = 0.3\text{--}0.5$), and strong ($r > 0.5$). Multiple linear regression analysis was performed to identify independent predictors of FEV₁ among HRCT parameters.

RESULTS

A total of 36 patients with COPD were enrolled in the study. The mean age of the study population was 58.2 ± 9.4 years (range: 42–76 years). There was a male predominance, with 30 patients (83.3%) being male and 6 (16.7%) female. The mean smoking index was 28.4 ± 18.2 pack-years, with 29

patients (80.6%) having a history of smoking. The remaining 7 patients (19.4%) were never-smokers with a history of biomass fuel exposure. According to GOLD staging, 3 patients (8.3%) were classified as Stage I, 11 (30.6%) as Stage II, 15 (41.7%) as Stage III, and 7 (19.4%) as Stage IV. The baseline characteristics and spirometric parameters of the study population are presented in Table 1.

HRCT evaluation revealed that emphysema was the most common morphological abnormality, present in 26 patients (72.2%). The mean emphysema score was 1.8 ± 1.1 . Bronchial wall thickening was observed in 21 patients (58.3%), with a mean BWT/PA ratio of 1.24 ± 0.32 . Air trapping was present in 17 patients (47.2%), with a mean score of 1.2 ± 0.9 . Bronchiectasis was identified in 7 patients (19.4%). The distribution of HRCT findings across different GOLD stages is shown in Table 2. Patients with advanced GOLD stages (III and IV) had significantly higher emphysema scores and more frequent bronchial wall thickening compared to those with milder disease ($p < 0.05$).

The correlation analysis between HRCT parameters and pulmonary function test indices revealed several significant associations (Table 3). Emphysema severity demonstrated a significant inverse correlation with FEV₁ ($r = -0.56$, $p < 0.001$), FVC ($r = -0.38$, $p = 0.021$), and FEV₁/FVC ratio ($r = -0.43$, $p = 0.009$). Bronchial wall thickening showed a significant negative correlation with FEV₁ ($r = -0.42$, $p = 0.011$) and a weaker but significant inverse correlation with FEV₁/FVC ($r = -0.35$, $p = 0.036$). Air trapping correlated inversely with FEV₁/FVC ($r = -0.48$, $p = 0.003$) and FVC ($r = -0.41$, $p = 0.013$). The presence of bronchiectasis was associated with lower FEV₁ ($r = -0.39$, $p = 0.019$). GOLD stage showed a significant positive correlation with emphysema grade ($r = 0.52$, $p = 0.001$) and air trapping score ($r = 0.45$, $p = 0.006$). Multiple linear regression analysis identified emphysema severity ($\beta = -0.48$, $p = 0.002$) and air trapping ($\beta = -0.31$, $p = 0.028$) as independent predictors of FEV₁.

Table 1: Baseline Characteristics and Spirometric Parameters of the Study Population (n = 36)

Parameter	Value
Age (years), mean $\pm$ SD	58.2 ± 9.4
Male, n (%)	30 (83.3%)
Female, n (%)	6 (16.7%)
Smoking index (pack-years), mean $\pm$ SD	28.4 ± 18.2
Biomass exposure, n (%)	7 (19.4%)
FEV ₁ (% predicted), mean $\pm$ SD	48.6 ± 16.2
FVC (% predicted), mean $\pm$ SD	62.4 ± 14.8
FEV ₁ /FVC ratio, mean $\pm$ SD	54.2 ± 10.6
PEFR (L/min), mean $\pm$ SD	198.4 ± 72.6
GOLD Stage I, n (%)	3 (8.3%)
GOLD Stage II, n (%)	11 (30.6%)
GOLD Stage III, n (%)	15 (41.7%)
GOLD Stage IV, n (%)	7 (19.4%)

Table 2: Distribution of HRCT Findings by GOLD Stage

HRCT Finding	GOLD I (n=3)	GOLD II (n=11)	GOLD III (n=15)	GOLD IV (n=7)	p-value
Emphysema, n (%)	1 (33.3%)	6 (54.5%)	13 (86.7%)	6 (85.7%)	0.018
Mean emphysema score	0.7 ± 0.6	1.2 ± 0.8	2.1 ± 1.0	2.6 ± 0.9	0.004
Bronchial wall thickening, n (%)	1 (33.3%)	5 (45.5%)	10 (66.7%)	5 (71.4%)	0.042
Air trapping, n (%)	0 (0%)	4 (36.4%)	8 (53.3%)	5 (71.4%)	0.031
Bronchiectasis, n (%)	0 (0%)	2 (18.2%)	3 (20.0%)	2 (28.6%)	0.089

Table 3: Correlation Between HRCT Parameters and Pulmonary Function Test Indices

HRCT Parameter	FEV ₁	FVC	FEV ₁ /FVC	PEFR
Emphysema score	r = -0.56, p < 0.001	r = -0.38, p = 0.021	r = -0.43, p = 0.009	r = -0.32, p = 0.054
Bronchial wall thickening	r = -0.42, p = 0.011	r = -0.29, p = 0.086	r = -0.35, p = 0.036	r = -0.26, p = 0.124
Air trapping score	r = -0.44, p = 0.007	r = -0.41, p = 0.013	r = -0.48, p = 0.003	r = -0.36, p = 0.031
Bronchiectasis	r = -0.39, p = 0.019	r = -0.31, p = 0.065	r = -0.28, p = 0.098	r = -0.22, p = 0.198
GOLD stage	r = -0.72, p < 0.001	r = -0.58, p < 0.001	r = -0.51, p = 0.001	r = -0.45, p = 0.006

DISCUSSION

This study demonstrates that HRCT morphological findings correlate significantly with pulmonary function test parameters in patients with COPD. The principal finding was that emphysema severity, as assessed by visual HRCT scoring, showed the strongest inverse correlation with FEV₁ ($r = -0.56$, $p < 0.001$). This finding is consistent with previous studies that have reported significant correlations between emphysema extent and airflow obstruction. The relationship between emphysema and FEV₁ reflects the loss of elastic recoil and destruction of alveolar attachments that characterise emphysematous lung destruction, leading to dynamic airway collapse during expiration [16]. The moderate strength of this correlation suggests that while emphysema contributes substantially to airflow limitation, other factors such as small airway disease also play important roles.

Bronchial wall thickening demonstrated a significant negative correlation with FEV₁ ($r = -0.42$, $p = 0.011$), supporting the concept that airway remodelling contributes to airflow obstruction in COPD. This finding aligns with studies by Nakano *et al.* and Hasegawa *et al.*, which reported that airway wall dimensions measured on CT correlate with physiological measures of obstruction [17,18]. The pathophysiology underlying this relationship involves thickening of the airway wall due to inflammation, fibrosis, and smooth muscle hypertrophy, leading to luminal narrowing and increased resistance. Notably, in our study, bronchial wall thickening was more prevalent in advanced GOLD stages, suggesting that airway remodelling is a progressive phenomenon associated with disease severity.

Air trapping, assessed on expiratory HRCT images, showed significant inverse correlations with FEV₁/FVC ($r = -0.48$, $p = 0.003$) and FVC ($r = -0.41$, $p = 0.013$). This finding is particularly relevant as air trapping reflects small airway disease and is considered an early manifestation of COPD pathophysiology. The stronger correlation of air trapping with FEV₁/FVC ratio compared to FEV₁ alone suggests that air trapping may be more closely related to the obstructive

component of the disease than to the restrictive component. These results are consistent with the findings of Lee *et al.*, who reported that CT measures of air trapping correlated best with FEV₁/FVC in smokers with and without COPD [19].

The finding that GOLD stage showed a significant positive correlation with emphysema grade ($r = 0.52$, $p = 0.001$) indicates that HRCT can serve as a surrogate marker of disease severity. This is particularly relevant in resource-limited settings where access to pulmonary function testing may be limited. The observation that emphysema and air trapping were independent predictors of FEV₁ in multiple regression analysis further supports the utility of HRCT in predicting physiological impairment. Our results are consistent with those of the ECLIPSE study, which demonstrated that CT-quantified emphysema and airway wall thickness are associated with FEV₁ decline and exacerbation frequency [20].

The prevalence of bronchiectasis in our study population was 19.4%, which is comparable to previously reported rates in COPD patients from Indian studies [21]. The presence of bronchiectasis was associated with lower FEV₁ ($r = -0.39$, $p = 0.019$), suggesting that coexistent bronchiectasis contributes to airflow obstruction and may represent a distinct phenotype with prognostic implications. This finding is consistent with studies that have reported that COPD-bronchiectasis overlap is associated with more severe disease, frequent exacerbations, and poorer outcomes [22].

The study has several clinical implications. First, HRCT provides valuable information about the morphological phenotype of COPD, which may guide therapeutic decisions. For example, patients with emphysema-predominant disease may benefit from lung volume reduction procedures, while those with airway-predominant disease may respond better to bronchodilator therapy [10]. Second, the correlation between HRCT findings and spirometric parameters suggests that HRCT may be useful in estimating the severity of airflow obstruction when spirometry is

unavailable or technically difficult to perform. Third, the identification of bronchiectasis on HRCT has implications for management, as these patients may require more aggressive airway clearance and antibiotic therapy.

LIMITATIONS OF THE STUDY

This study has several limitations that should be acknowledged. First, the sample size of 36 patients was relatively small, which limits the generalisability of the findings and the statistical power to detect weaker correlations. A larger multicentre study would be necessary to confirm these results and to establish reference values for HRCT parameters in the Indian population. Second, the study was conducted at a single tertiary care centre, which may introduce selection bias, as patients referred to tertiary care facilities may have more severe or complex disease compared to those managed in primary care settings. Third, visual scoring of HRCT findings is inherently subjective and may be associated with interobserver variability, although all scans were evaluated by two experienced radiologists with good agreement. Fourth, quantitative CT analysis using density masks and software-based measurements was not performed, which could have provided more objective and reproducible data. Fifth, the cross-sectional design precludes assessment of longitudinal changes in HRCT findings and their relationship to disease progression. Finally, pulmonary function testing was performed using standard reference equations for the Indian population, but the accuracy of these equations in the local population may vary. Despite these limitations, the study provides valuable preliminary data on the correlation between HRCT findings and PFT parameters in a South Indian COPD population.

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CONCLUSION

In conclusion, this study demonstrates that HRCT morphological findings correlate significantly with pulmonary function test parameters in patients with COPD. Emphysema severity, bronchial wall thickening, and air trapping all showed significant inverse correlations with spirometric indices, with

emphysema severity emerging as the strongest predictor of airflow obstruction. The presence of bronchiectasis was associated with more severe airflow limitation, suggesting that this overlap phenotype warrants particular clinical attention. GOLD stage showed significant positive correlation with emphysema grade, indicating that HRCT can serve as a surrogate marker of disease severity when spirometry is unavailable. These findings support the role of HRCT as a valuable complementary tool in the comprehensive evaluation of COPD.

The clinical implications of these findings are significant. HRCT provides detailed morphological information that complements functional assessment by spirometry, enabling identification of distinct COPD phenotypes with potential therapeutic and prognostic implications. In resource-limited settings where access to pulmonary function testing may be constrained, HRCT may serve as an alternative or adjunctive modality for assessing disease severity. Future longitudinal studies with larger sample sizes and quantitative CT analysis are warranted to validate these findings and to further elucidate the relationship between structural lung changes and physiological impairment in COPD. The integration of HRCT-derived parameters into routine clinical assessment may ultimately facilitate more personalised and targeted management approaches for patients with this heterogeneous disease.

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