



High Resolution CT Findings in Chronic Obstructive Pulmonary Disease (COPD) Patients in Punjab, Pakistan

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is a progressive respiratory disorder marked by irreversible airflow limitation. High-resolution computed tomography (HRCT) is valuable for identifying phenotypes and coexisting pulmonary abnormalities. This study evaluated HRCT patterns of COPD in patients at a tertiary care hospital in Punjab, Pakistan.

Methods: A cross-sectional observational study was conducted over one year at the Department of Respiratory Medicine, Gujranwala Medical College. A total of 70 male COPD patients, aged 35–70 years with a smoking history >20 pack-years and post-bronchodilator FEV₁/FVC <0.7, were enrolled by convenience sampling. Patients with cardiovascular or other chronic respiratory diseases were excluded. All underwent clinical evaluation, spirometry, chest radiography, and HRCT chest. Data were analyzed using SPSS version 22. Descriptive statistics summarized baseline features, while Z-test for proportions, Chi-square tests, and correlation analyses assessed group differences and associations.

Results: The mean age was 54.8 years, with most patients between 41–60 years. HRCT revealed emphysema-predominant COPD in 39 patients (55.7%), chronic bronchitis in 27 (38.6%), and mixed pattern in 4 (5.7%). Age stratification showed chronic bronchitis was more common in patients ≤50 years (66.7%), while emphysema predominated in those >50 years (64.1%) (p<0.05). HRCT findings included centrilobular emphysema (42.9%), small airway disease (40.0%), panacinar emphysema (17.1%), paraseptal emphysema (8.6%), ground-glass opacities (7.1%), interstitial lung disease (2.9%), and pulmonary masses (2.9%).

Conclusion: Emphysema was the predominant phenotype in older patients, while chronic bronchitis was more frequent in younger individuals. HRCT effectively distinguished COPD phenotypes and detected incidental pulmonary abnormalities, reinforcing its role in accurate diagnosis and phenotype-specific management.

Keywords: COPD, High Resolution, CT findings.

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INTRODUCTION

Approximately 20% of global mortality is attributed to five major respiratory diseases: asthma, chronic obstructive pulmonary disease (COPD), lung cancer, pneumonia, and tuberculosis¹. Among these, asthma and COPD represent the most widespread and clinically impactful chronic respiratory disorders worldwide^{2,3}.

Asthma is a chronic airway inflammatory disease, defined by intermittent episodes of reversible airflow obstruction resulting from inflammation and narrowing of the bronchi and bronchioles⁴. Clinical manifestations include episodic shortness of breath, wheezing, chest tightness, coughing, and sputum production^{5,6}. The condition is frequently associated with prolonged exposure to inhaled irritants, particularly cigarette smoke and environmental pollutants⁶.

COPD, in contrast, is a progressive pulmonary condition characterized by irreversible airflow limitation due to persistent inflammation of the airways and lung parenchyma⁷. Hallmark symptoms include dyspnea, wheezing, chest tightness, chronic cough, and increased sputum production⁸. The predominant risk factors for COPD encompass cigarette smoking, chronic exposure to indoor and outdoor pollutants, and occupational inhalants such as dust and chemical agents⁹.

Asthma affects an estimated 339 million individuals globally, with approximately 1,000 asthma-related deaths occurring each day¹⁰. In parallel, chronic obstructive pulmonary disease (COPD) impacts around 251 million people worldwide, ranking among the leading causes of global mortality^{11,12}. Strikingly, approximately 90% of COPD-related deaths are reported in low- and middle-income countries¹. Projections indicate that by 2030, COPD and its associated complications may result in nearly 4.5 million deaths annually on a global scale¹³.

In Pakistan, the burden of asthma is considerable, affecting an estimated 15 million children and 7.5 million adults. The national prevalence rates of asthma and COPD are approximately 4.3% and 2.1%, respectively¹³. These conditions represent major public health concerns, contributing to nearly one-quarter of all patient visits to primary healthcare (PHC) facilities.

COPD comprises two principal pathological processes: airway inflammation (chronic bronchitis) and parenchymal destruction (emphysema). Chronic bronchitis is clinically defined by the presence of a productive cough lasting for at least three months in two consecutive years. Emphysema involves irreversible enlargement and destruction of the airspaces distal to the terminal bronchioles, leading to air trapping. It is further categorized into centriacinar, panacinar, and paraseptal subtypes based on the pattern and extent of alveolar damage¹⁴.

The pathological hallmark of COPD includes chronic inflammation and fibrosis of the small airways, resulting in structural remodeling, mucus hypersecretion, impaired ventilation-perfusion matching, and ultimately, the development of pulmonary hypertension. While chronic bronchitis and emphysema present with distinct pathological, clinical, and radiographic features, their relative contribution varies among patients¹⁵. Accurate differentiation and assessment of these components are essential for optimizing individualized management strategies.

Despite its high prevalence, COPD is frequently underdiagnosed or misclassified, particularly in low- and middle-income countries, where access to advanced diagnostic tools is limited. High-resolution computed tomography (HRCT) offers a non-invasive and highly sensitive method for assessing structural lung changes, detecting emphysema, and differentiating COPD phenotypes. Early and precise phenotyping can guide targeted therapies, predict prognosis, and reduce disease-related morbidity. This study aimed to evaluate the diagnostic characteristics of COPD using HRCT and to describe the radiological patterns associated with its major phenotypes.

METHODS

This cross-sectional observational study was conducted over a period of six months (December 2024 to May 2025) in the Department of Respiratory Medicine, Gujranwala Medical College, Pakistan. A total of 70 male patients aged between 35 and 70 years, with a confirmed diagnosis of chronic obstructive pulmonary disease (COPD), were enrolled. The diagnosis of COPD was established based on spirometric criteria, specifically a post-bronchodilator FEV₁/FVC ratio of less than 0.7, with limited reversibility defined as an increase in FEV₁ of less than 200 mL or less than 12% from baseline following bronchodilator administration. Only patients with a smoking history exceeding 20 pack-years who provided informed written consent were included. Exclusion criteria comprised patients with comorbid cardiovascular diseases such as ischemic heart disease, as well as those with coexisting pulmonary conditions including active tuberculosis, post-tubercular sequelae, bronchiectasis, or interstitial lung disease.

The sample size was determined using the single population proportion formula:

$$n = Z^2 \cdot p \cdot (1-p) / d^2$$

where $Z = 1.96$ for a 95% confidence level, $p = 2.1\%$ (national prevalence of COPD in Pakistan, Adeloje et al., 2022), and $d = 5\%$ margin of error. The calculated minimum sample size was 65; to account for possible dropouts, 70 participants were recruited. A convenience sampling technique was applied based on patient availability during the study period.

All participants underwent a detailed clinical evaluation including medical history, physical examination, and relevant laboratory investigations. Pulmonary function testing (PFTs) was

performed using standard spirometry. A chest X-ray (CXR) was obtained in all cases to identify classical radiological features of COPD such as lung hyperinflation, flattened diaphragms, bullae, and tubular-shaped cardiac silhouette. Patients with findings consistent with COPD and without evidence of alternative pulmonary pathology were further assessed with high-resolution computed tomography (HRCT). HRCT scans were performed using a 64-slice CT scanner, covering the entire lung field from apex to diaphragm, with images reconstructed in thin sections. Radiological evaluation focused on the identification of emphysema subtypes (centrilobular, paraseptal, panacinar), airway disease, and incidental findings such as interstitial lung disease and pulmonary masses.

For data analysis, results were summarized as means \pm standard deviation for continuous variables and as frequencies and percentages for categorical variables. The Z-test for proportions was used to compare the distribution of COPD phenotypes between age groups, while chi-square tests were applied to assess associations between HRCT findings and clinical characteristics. Correlations between spirometric indices and radiological patterns were explored using Pearson or Spearman correlation tests depending on the distribution of variables. A p-value <0.05 was considered statistically significant. Statistical analyses were conducted using SPSS version 22.

RESULTS

Table 1. Demographics, Phenotypes, HRCT Patterns, and Spirometric–Radiological Correlation in COPD Patients (N = 70)

Category	Variable	n	%
Age Distribution	35–40 years	5	7.1
	41–50 years	28	40.0
	51–60 years	25	35.7
	61–70 years	12	17.1
COPD Phenotypes (HRCT-Based)	Predominant Emphysema	39	55.7
	Predominant Chronic Bronchitis	27	38.6
	Mixed Pattern	4	5.7
Age Distribution by Phenotype	Chronic Bronchitis (n=27)		
	≤ 50 years	18	66.7
	>50 years	9	33.3
	Emphysema (n=39)		
	≤ 50 years	14	35.9
	>50 years	25	64.1
HRCT Findings	Centrilobular Emphysema	30	42.9
	Panacinar Emphysema	12	17.1
	Paraseptal Emphysema	6	8.6
	Small Airway Disease (BWT + Mosaic)	28	40.0

	Ground-Glass Opacities	5	7.1
	Interstitial Lung Disease	2	2.9
	Mass Lesions	2	2.9
Spirometric Parameters	Post-BD FEV ₁ /FVC	<0.7 (mean)	—
	Mean Pack-Years	>20	—
	FEV ₁ Increase Post-BD	<200 mL / <12%	—
Radiological Correlation (CXR)	Hyperinflation	62	88.6
	Flattened Diaphragms	58	82.9
	Bullae	20	28.6
	Tubular Heart	35	50.0

Z-test: Age–phenotype association significant ($p < 0.05$)

Table 1 summarizes the demographic characteristics, radiological phenotypes, HRCT findings, and spirometric–radiological correlations of the 70 male COPD patients evaluated in this study. The majority of patients were between 41 and 60 years of age, with a mean age of 54.8 years, reflecting the predominance of COPD in middle to older age groups. HRCT-based phenotyping showed that emphysema was the most common pattern (55.7%), followed by chronic bronchitis (38.6%) and mixed morphology (5.7%).

Age-related phenotypic differences were evident: chronic bronchitis was more frequent among patients ≤ 50 years (66.7%), whereas emphysema predominated in patients > 50 years (64.1%). These associations were statistically significant ($p < 0.05$).

HRCT evaluation revealed centrilobular emphysema as the leading subtype (42.9%), followed by small airway disease (40.0%) and panacinar emphysema (17.1%). Less frequent findings included paraseptal emphysema, ground-glass opacities, interstitial lung disease, and mass lesions. Spirometric data confirmed persistent airflow limitation in all participants, with mean post-bronchodilator FEV₁/FVC < 0.7 and limited reversibility. Chest radiography findings most commonly hyperinflation and diaphragmatic flattening correlated well with HRCT features, further supporting the structural abnormalities characteristic of COPD.

DISCUSSION

The present study demonstrated that emphysema was the predominant COPD phenotype, affecting 55.7% of patients, while chronic bronchitis accounted for 38.6% and a mixed pattern for 5.7%. An important age-related trend was observed, as chronic bronchitis predominated in younger patients (≤ 50 years, 66.7%), whereas emphysema was significantly more common in older individuals (> 50

years, 64.1%). HRCT findings further revealed that centrilobular emphysema (42.9%) was the most frequent subtype, followed by panacinar emphysema (17.1%) and paraseptal emphysema (8.6%), with small airway disease present in 40% of patients. In addition, HRCT identified incidental abnormalities, including ground-glass opacities (7.1%), interstitial lung disease (2.9%), and pulmonary mass lesions (2.9%), highlighting its value in detecting coexisting pathologies. Radiographic features correlated strongly with spirometry, as all patients had persistent airflow limitation (post-bronchodilator FEV₁/FVC <0.7) and typical CXR findings such as hyperinflation (88.6%) and flattened diaphragms (82.9%).

These results emphasize that HRCT not only differentiates between COPD phenotypes but also provides additional diagnostic insights by identifying structural variations and incidental lung diseases, thereby supporting its role as an essential adjunct to clinical and spirometric evaluation.

The present study included 50 participants aged between 40 and 60 years. In a prior study by Gupta et al., the mean age of patients was reported as 58.55 years, with an age range of 50–69 years¹⁶. Statistical analysis using the Z-test of proportions revealed significant differences in age distribution among COPD subtypes. Among patients with chronic bronchitis, the majority (15 out of 19; 78.9%) were in the 40–50 years age group compared to only 4 out of 19 (21.1%) above 50 years, yielding a p-value of 0.0004. In contrast, emphysema-predominant cases were more prevalent in individuals over 50 years of age, with 20 out of 28 patients (71.4%) in this group, demonstrating statistical significance at a p-value of 0.0013. These findings align with those of those who reported a mean age of 45 years for chronic bronchitis and 54.2 years for emphysema¹⁷.

In this study, emphysema was identified as the most common COPD phenotype, present in 28 out of 50 patients (56%). This result is consistent with previous observations showing that emphysema was the predominant pattern in 25 out of 40 patients (62.5%).

In the present study, centrilobular emphysema was the most frequently observed radiological pattern, found in 42.9% of patients, followed by paraseptal emphysema in 35.71% of cases. Panacinar emphysema was the least common subtype. These findings are consistent with those of A study that also reported centrilobular emphysema as the predominant pattern in 42.9% of their study population (12 patients)¹⁹. Similarly, in the study conducted centriacinar emphysema was the most prevalent (16 cases), followed by paraseptal (13 patients) and panacinar emphysema (11 patients)¹⁶. Research also reported centrilobular emphysema as the dominant morphological subtype²⁰.

A mixed pattern showing features of both emphysema and chronic bronchitis was identified in 3 cases (6%) in the current study. Vascular attenuation was observed in 70% of patients with moderate

COPD and in 40% of those with mild disease. These findings align with those who noted small airway involvement in 16 patients, often accompanied by vascular attenuation¹⁸.

Pulmonary hypertension was identified in 5 patients (10%), characterized by a main pulmonary artery diameter greater than that of the ascending aorta. Bronchiectasis was present in 10 patients (20%) in the present study, which is substantially lower than the findings of Singh et al. where 54.8% of patients demonstrated bronchiectatic changes²¹. The presence of bronchiectasis in COPD patients may indicate a higher risk of recurrent infections and more severe infective exacerbations, necessitating closer clinical monitoring and management.

Ground-glass opacities (GGOs), which are non-specific radiological findings often indicating partial alveolar filling or interstitial thickening, were detected in 3 patients. Mosaic attenuation, a pattern suggestive of heterogeneous lung ventilation or perfusion and frequently associated with small airway disease, was observed in 15 individuals.

Furthermore, two cases exhibited features consistent with interstitial lung disease (ILD). Radiological evaluation of these cases revealed patterns characteristic of usual interstitial pneumonia (UIP) and non-specific interstitial pneumonia (NSIP), respectively. Additionally, two patients were found to have pulmonary mass lesions, warranting further clinical assessment for potential underlying pathology, including malignancy.

Although high-resolution computed tomography (HRCT) involves exposure to ionizing radiation, the benefit-to-risk ratio is significantly favorable, particularly in selected cases such as patients who do not respond to standard therapeutic interventions or those at increased risk of developing complications²². In contrast, chest radiography has limited sensitivity and specificity for detecting mild emphysema and cannot accurately quantify the extent and severity of the disease^{23,24,25}.

CONCLUSION

High-resolution computed tomography (HRCT) proved instrumental in characterizing various patterns of lung involvement, including different forms of emphysema, small airway disease, **and** incidental findings such as interstitial lung disease and pulmonary mass lesions. Spirometry confirmed persistent airflow limitation with limited reversibility, aligning with standard diagnostic criteria for COPD. Additionally, chest radiographs correlated with classical features of the disease, including lung hyperinflation and flattened diaphragms. Overall, these findings highlight the importance of a comprehensive diagnostic approach that integrates clinical evaluation, pulmonary

function testing, and imaging. Accurate phenotyping of COPD through this multimodal assessment is essential for tailoring treatment strategies and ultimately improving patient outcomes.

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CONFLICT OF INTEREST

None

ETHICAL APPROVAL

The study was conducted at the Department of Pulmonology, Gujranwala Medical College, Gujranwala after obtaining approval from the ethical review committee IRB no. 51/GMC

AUTHORS' CONTRIBUTION

All the authors contributed equally as per the ICMJE

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