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Clinico-Radiological Evaluation of Chest in Cases of Emphysema – A Prospective Study

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Abstract

Background; Emphysema is a major component of chronic obstructive pulmonary disease (COPD), characterised by irreversible destruction of alveolar walls, enlargement of air spaces, and progressive airflow limitation. Pulmonary function tests (PFT) assess functional impairment, whereas chest radiography and high-resolution computed tomography (HRCT) provide anatomical evaluation of emphysematous changes. The present study was undertaken to evaluate the clinicoradiological profile of emphysema using PFT, chest X-ray, and HRCT and to correlate imaging findings with clinical severity.

Materials and Methods: This prospective observational study was conducted in the Department of Radio diagnosis, Imaging and Interventional Radiology, Muzaffarnagar, Medical College, Muzaffarnagar, Uttar Pradesh, over a period of 18 months. A total of 30 patients clinically suspected or diagnosed with emphysema were included. All patients underwent

detailed clinical evaluation, pulmonary function testing, chest radiography, and HRCT examination. Spiro metric parameters including forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio were assessed. Chest radiographs were evaluated for emphysematous changes and signs of hyperinflation. HRCT findings including type of emphysema, hyperinflation, bullae, mosaic attenuation, tracheal index, thoracic cage ratio, and sterno-aortic distance were analyzed. Statistical analysis was performed using SPSS version 22.0, and $p<0.05$ was considered statistically significant.

Results; The study population showed a male predominance, with 27 (90%) males and 3 (10%) females. The mean age of patients was 58.93 ± 10.76 years, with the majority belonging to the 51–60 years age group. Farmers constituted the largest occupational group (53.33%). Smoking exposure was present in most patients, with moderate smoking history being the commonest category (70%). Cough and expectoration were present in all patients, followed by breathlessness (90%) and wheezing (83.33%).

On pulmonary function testing, moderate airflow obstruction (FEV1 30–49% predicted) was observed in 53.33% of patients, while severe obstruction (FEV1 <30% predicted) was seen in 33.33%. Chest radiography showed emphysematous changes in 63.33% of cases and increased bronchovascular markings in 53.33%.

HRCT demonstrated para septal emphysema as the most common finding (83.33%), followed by hyperinflation and centriacinar emphysema (70% each). Emphysematous bullae were present in 53.33% of patients. Moderate emphysema was the most common severity category (63.33%). Significant association was observed between emphysema severity and HRCT findings of hyperinflation ($p=0.008$), tubular heart appearance ($p=0.005$), and bullae formation ($p=0.033$). A significant correlation was also observed between FEV1 category and clinical severity of emphysema ($p=0.021$).

Conclusion; Combined assessment using pulmonary function tests, chest radiography, and HRCT provides a comprehensive approach for diagnosis and severity assessment of emphysema. HRCT demonstrates superior ability in detecting and characterizing structural lung abnormalities and shows significant correlation with clinical severity. Integration of functional and radiological parameters may improve evaluation and management of patients with emphysema.

Keywords: Emphysema, Chronic Obstructive Pulmonary Disease, Pulmonary Function Test, HRCT, Chest Radiography, FEV1.

Introduction

Emphysema is a major component of chronic obstructive pulmonary disease (COPD), characterized by persistent airflow limitation and irreversible destruction of the alveolar walls with enlargement of air spaces distal to the terminal bronchioles. It results in loss of elastic recoil, air trapping, and progressive impairment of gas exchange, leading to significant morbidity and mortality worldwide [1,2].

COPD remains one of the leading causes of global disease burden and mortality. The disease is primarily associated with cigarette smoking, although other factors such as biomass fuel exposure, occupational exposure, and genetic predisposition, particularly alpha - 1 antitrypsin deficiency, also contribute to its development[3].

Smoking-related emphysema commonly affects the upper lobes and is usually centrilobular in distribution,

whereas alpha-1 antitrypsin deficiency is associated with panacinar emphysema predominantly involving the lower lobes[4].

Clinical manifestations of emphysema are variable and depend on the extent of airway obstruction and parenchymal destruction. Progressive dyspnea, chronic cough, sputum production, wheezing, and reduced exercise tolerance are common presentations. The severity of airflow obstruction is traditionally assessed using pulmonary function tests, particularly forced expiratory volume in one second (FEV1) and the FEV1/ FVC ratio, according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria[5].

Although pulmonary function testing provides an objective assessment of airflow limitation, it does not provide information regarding the anatomical distribution and morphological changes of emphysema. Chest radio graphy is commonly used as an initial imaging modality; however, its sensitivity is limited, particularly in early disease. Radiographic signs such as hyperinflation, flattened diaphragms, increased retrosternal air space, and bullous changes may suggest emphysema but are not specific[6].

High-resolution computed tomography (HRCT) has emerged as the most sensitive imaging technique for detecting and characterizing emphysema. HRCT allows assessment of the type, distribution, and severity of emphysematous changes, including centriacinar, panacinar, and para septal patterns. It also provides quantitative parameters such as tracheal index, thoracic cage ratio, and sterno-aortic distance, which reflect chronic hyperinflation and structural changes associated with emphysema[7,8].

Correlation between radiological findings and pulmonary function parameters is important for accurate diagnosis, severity assessment, treatment planning, and prognostic evaluation. Therefore, the present study was undertaken to evaluate the clinico-radiological profile of emphysema patients using pulmonary function tests, chest radiography, and HRCT and to correlate imaging findings with clinical severity.

Materials And Methods

Study Design and Setting

This prospective observational study was conducted to evaluate the role of pulmonary function tests (PFT), chest radiography, and computed tomography (CT) in the assessment of emphysema and to correlate radio logical findings with clinical parameters.

The study was carried out in the Department of Radio diagnosis, Imaging and Interventional Radiology, Muzaffar nagar Medical College, Muzaffar nagar, Uttar Pradesh, India. The study duration was 18 months, comprising 12 months of patient recruitment and data collection, followed by 6 months of data analysis.

Study Population and Sample Size

The study included patients referred to the Department of Radio diagnosis, Imaging and Interventional Radiology with a probable clinical diagnosis of chronic obstructive pulmonary disease (COPD)/emphysema. The study population consisted of both outpatient department (OPD) and inpatient department (IPD) patients who were clinically suspected or diagnosed with emphysema and referred for CT evaluation.

A total of 30 patients were included in the study. A consecutive sampling technique was used, including all eligible OPD and IPD patients fulfilling the selection criteria.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethical Committee of Muzaffar nagar

Medical College. Written informed consent was obtained from all participants before enrollment in the study.

Inclusion Criteria

Patients fulfilling the following criteria were included:

1. Patients with clinical suspicion of emphysema and those undergoing spirometric evaluation.
2. Patients who provided informed consent for participation in the study.

Exclusion Criteria

Patients with respiratory diseases other than emphysema were excluded from the study.

Study Procedure

After obtaining informed consent, a detailed clinical history and relevant physical examination were performed for each participant. All patients underwent pulmonary function testing, chest radiography, and high-resolution computed tomography (HRCT) evaluation.

Pulmonary function testing was performed using the Smart PFT CO Transfer system. Chest radiographs were obtained using an Allengers 600 mA X-ray machine. HRCT examinations were performed using a Siemens Somatom Scope 16-slice multi detector CT (MDCT) scanner.

Pulmonary Function Test Evaluation

The diagnosis and severity assessment of airflow limitation were based on spirometric parameters, including:

- Forced expiratory volume in one second (FEV1)
- Forced vital capacity (FVC)
- FEV1/FVC ratio

The severity of COPD was graded according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria, with FEV1 serving as the primary parameter for assessment.

Chest Radiographic Evaluation

All patients underwent postero anterior (PA) chest radiography. The following radiological features suggestive of emphysema were evaluated:

1. Increased lung volume, defined as a distance of ≥29.9 cm between the dome of the right hemi diaphragm and the first rib.
2. Flattening of the right hemi diaphragm with a height of <1.5 cm.
3. Position of the right hemi diaphragm at or below the level of the anterior seventh rib.
4. Bulging of the lateral costophrenic angles.
5. Visualization of diaphragmatic slips.
6. Tubular appearance of the heart.
7. Evidence of lung destruction, including bullae and increased lung lucencies.

High-Resolution Computed Tomography (HRCT) Evaluation

HRCT images were analyzed for characteristic findings of emphysema, including:

1. Hyperinflation of lung fields: assessed by increased retrosternal space and elongation of the anterior Junctional line.
2. Bullae formation: representing areas of lung parenchymal destruction.
3. Flattening of the diaphragm.
4. Patterns of emphysema: including centriacinar, panacinar, and para septal emphysema.
5. Tracheal index: measured as the ratio of transverse diameter to anteroposterior diameter of the trachea at a level 1 cm above the aortic arch. A tracheal index <0.67 was considered suggestive of saber sheath trachea.
6. Thoracic cage ratio: calculated as the ratio of anteroposterior diameter to transverse diameter of the thorax, assessed at the level of the carina and 5 cm

below the carina. A value >0.75 was considered suggestive of emphysema.

7. Sterno-aortic distance: measured at the level of the carina between the posterior surface of the sternum and anterior border of the aorta. A distance ≤4 cm was considered suggestive of emphysema.

8. Mosaic attenuation pattern: defined as heterogeneous lung attenuation with alternating areas of normal, increased, or decreased attenuation.

Data Collection and Statistical Analysis

All clinical, pulmonary function, radiographic, and CT findings were systematically recorded and analyzed. Data were entered into Microsoft Excel and statistically evaluated using SPSS version 22.0 for Windows (SPSS Inc., Chicago, USA).

Continuous variables were expressed as mean and standard deviation. Statistical comparisons were performed using Student's *t*-test and chi-square test wherever appropriate. A p-value <0.05 was considered statistically significant.

Results and Observations

The present prospective study included 30 patients with clinically suspected or diagnosed emphysema who underwent clinical evaluation, pulmonary function testing, chest radiography, and HRCT examination. The findings were analyzed and correlated with disease severity.

Table 1: Baseline Demographic Characteristics of Study Population (N=30)

Variables	N	%
Gender		
Male	27	90.0
Female	3	10.0
Age group (years)		
<40	1	3.33
41–50	3	10.0
51–60	15	50.0
>60	11	36.67
Mean age (years)	58.93 ± 10.76	
Occupation		
Farmer	16	53.33
Housewife	3	10.0
Business	7	23.33
Labour	3	10.0
Private/Government job	1	3.33

The study population showed male predominance (90%), with most patients belonging to the 51–60 years age group (50%). Farmers constituted the largest occupational group (53.33%).

Table 2: Biomass Exposure and Smoking History (N=30)

Variables	N	%
Biomass exposure		
No	23	76.67
Yes	7	23.33
Charcoal for cooking/heating	5	16.67
Crop residues (straw/grass)	2	6.67
Smoking history		
Non-smoker	2	6.67
Mild (1 cigarette/day)	2	6.67
Moderate (<1 pack/day)	21	70.0
Severe (>1 pack/day)	5	16.67

Most patients had a history of smoking, with moderate smoking exposure being the commonest category (70%). Biomass exposure was reported in 23.33% of patients.

Table 3: Duration of Illness and Clinical Presentation (N=30)

Variables	N	%
Duration of illness (years)		

<5	1	3.33
6–10	6	20.0
11–20	14	46.67
>20	9	30.0
Symptoms		
Cough	30	100
Expectoration	30	100
Breathlessness	27	90.0
Wheeze	25	83.33
Fever	7	23.33
Signs		
Cyanosis	6	20.0
Pursed lip breathing	4	13.33
Intercostal indrawing	4	13.33
Flapping tremor	2	6.67

Most patients had a prolonged disease duration, with 46.67% having illness duration of 11–20 years. Cough and expectoration were present in all patients.

Table 4: Pulmonary Function Test Findings (N=30)

Parameters	N	%
FEV1 (% predicted)		
<30%	10	33.33
30–49%	16	53.33
50–80%	4	13.33
DLCO		
Normal	27	90.0
<80% predicted	3	10.0

Moderate airflow obstruction (FEV1 30–49%) was the most common spirometric finding.

Table 5: Chest X-ray Findings in Study Population (N=30)

Chest X-ray Findings	N	%
Emphysematous changes	19	63.33
Increased bronchovascular markings	16	53.33
Flattening of diaphragm	9	30.0
Right descending pulmonary artery ≥16 mm	3	10.0
Cardiomegaly	2	6.7
Tubular heart shadow	2	6.7

Emphysematous changes were the most frequent radiographic abnormality observed.

Table 6: HRCT Findings in Study Population (N=30)

CT Findings	N	%
Para septal emphysema	25	83.33
Hyperinflation of lung fields	21	70.0
Centriacinar emphysema	21	70.0
Emphysematous bullae	16	53.33
Mosaic attenuation pattern	9	30.0
Panacinar emphysema	5	16.67
Tubular heart	2	6.67

Para septal emphysema was the most common HRCT finding, followed by hyperinflation and centriacinar emphysema.

Table 7: Severity Distribution of Emphysema (N=30)

Severity	N	%
Mild	3	10.0
Moderate	19	63.33
Severe–Very severe	8	26.67

Most patients had moderate emphysema severity (63.33%).

Table 8: Mean HRCT Quantitative Parameters

CT Parameters	Mean ± SD
Tracheal index	0.78 ± 0.09
Thoracic cage ratio	69.23 ± 2.06
Sterno-aortic distance	3.67 ± 0.32

Table 9: Correlation of Spirometric Severity with Emphysema Severity

FEV1 (% predicted)	Mild (N=3)	Moderate (N=19)	Severe–Very Severe (N=8)
<30%	0	4	6
30–49%	0	14	2
50–80%	3	1	0

p=0.021 (Statistically significant)

A significant association was observed between FEV1 category and emphysema severity.

Table 10: Association of Imaging Findings with Emphysema Severity

Findings	Mild (N=3)	Moderate (N=19)	Severe–Very Severe (N=8)	p value
Chest X-ray				
Increased bronchovascular markings	1	8	7	0.12
Emphysematous changes	1	7	11	0.07
Right descending pulmonary artery ≥16 mm	0	1	2	0.13
Cardio megaly	0	0	2	0.10
HRCT				
Hyperinflation	2	15	8	0.008*
Tubular heart	2	10	8	0.005*
Mosaic attenuation	1	3	5	0.17
Centriacinar emphysema	2	12	7	0.08
Para septal emphysema	1	9	5	0.26
Panacinar emphysema	0	2	3	0.15
Bullae	0	10	6	0.033*

Statistically significant association observed for hyperinflation, tubular heart, and bullae.

Discussion

The present prospective study evaluated 30 patients with clinically suspected or diagnosed emphysema using clinical assessment, pulmonary function testing, chest radiography, and HRCT. The study aimed to assess the correlation between imaging findings and clinical severity of emphysema.

Gender Distribution

In the present study, emphysema showed a marked male predominance, with males constituting 90% of cases and females accounting for 10%. This higher prevalence among males may be attributed to greater exposure to cigarette smoking, occupational hazards, and outdoor air pollution. Similar male predominance has been reported by Sharma et al., who observed that 78.6% of emphysema patients were males [9]. Bhaumik et al. also reported male predominance, with approximately 90% of their study population being male [10]. Singh et al. observed a higher proportion of male patients in their study, supporting the association between male gender and increased risk of emphysema [11].

Age Distribution

The mean age of patients in the present study was 58.93 ± 10.76 years, with the majority of patients belonging to the 51–60 years age group. This indicates that emphysema is more frequently encountered among late middle-aged and elderly individuals.

Similar findings were reported by Singh et al., who documented a mean age of 60.4 ± 6.5 years among COPD patients[11].

Bhaumik et al. reported a mean age of 60 ± 6.33 years, which was comparable to the present study [10]. Age-related decline in lung function and cumulative exposure to risk factors contribute to increasing severity of COPD with advancing age[12].

Occupational Exposure and Biomass Exposure

Farmers represented the largest occupational group in the present study (53.33%). Biomass exposure was documented in 23.33% of patients, with charcoal exposure being the most common source.

Biomass fuel exposure is a recognized risk factor for COPD, particularly in developing countries where indoor air pollution remains prevalent. Adityavadan et al. reported biomass exposure in approximately 20% of COPD patients, which is comparable to the present findings [13]. Sharma et al. also reported a higher prevalence of emphysema among farmers and laborers, suggesting the role of occupational exposure[9].

Smoking History

Smoking was an important risk factor in the present study. Moderate smoking exposure was observed in 70% of patients, while severe smoking exposure was seen in 16.67%. Cigarette smoking remains the strongest established environmental risk factor for emphysema.

Chung et al. and Celli et al. demonstrated a strong relationship between smoking exposure and COPD severity [12,14]. Sowmya et al. reported increasing COPD severity with increasing pack-years of smoking, supporting the dose-dependent relationship between tobacco exposure and airflow limitation[15].

Clinical Features

Cough and expectoration were present in all patients in the present study, followed by breathlessness (90%) and wheezing (83.33%). These findings reflect the typical clinical presentation of chronic airflow limitation and airway inflammation.

Adityavadan et al. reported cough and expectoration in all patients, with breathlessness and wheezing being common symptoms, showing similarity with the present findings[13]. Sharma et al. also reported cough and dyspnea as the predominant symptoms among COPD patients[9].

Pulmonary Function Test Findings

In the current study, moderate airflow obstruction (FEV1 30–49%) was the most common spirometric category, observed in 53.33% of patients. Severe obstruction was present in 33.33% of cases.

A significant association was observed between FEV1 category and emphysema severity (p=0.021), indicating that worsening airflow limitation correlates with increasing disease severity. Pulmonary function testing remains an important tool for functional assessment and grading of COPD severity according to GOLD recommendations[5].

Chest Radiographic Findings

Emphysematous changes were the most frequent chest X-ray finding, seen in 63.33% of patients, followed by increased bronchovascular markings (53.33%) and flattened diaphragm (30%).

Although chest radiography has limited sensitivity in early emphysema, characteristic signs such as hyperinflation, flattened diaphragms, and vascular attenuation can support diagnosis. Adityavadan et al. reported emphysematous changes in 60% of patients and increased bronchovascular markings in 48%, which were comparable with the current study[13].

HRCT Findings

HRCT demonstrated a higher detection rate of emphysematous changes compared with chest radio

graphy. Para septal emphysema was the most common pattern (83.33%), followed by centriacinar emphysema and hyperinflation (70% each). Bullae were identified in 53.33% of patients.

Centriacinar emphysema is strongly associated with smoking and is considered the most common morphological subtype of emphysema [16]. Sharma et al. reported centriacinar emphysema in 90%, para septal emphysema in 54%, and bullae in 63% of patients, demonstrating comparable HRCT findings [9].

In the present study, HRCT findings of hyperinflation, tubular heart appearance, and bullae showed significant association with emphysema severity ($p<0.05$). HRCT therefore provides valuable anatomical information and helps in assessment of disease progression.

Quantitative CT Parameters

The mean tracheal index, thoracic cage ratio, and sterno-aortic distance in the present study were 0.78 ± 0.09, 69.23 ± 2.06, and 3.67 ± 0.32, respectively.

Quantitative CT parameters are useful indicators of chronic hyperinflation. Hagen and Kolbenstvedt reported that increased sterno-aortic distance is suggestive of emphysema, particularly at the carinal level [17]. These measurements may complement conventional CT assessment in evaluating emphysematous changes.

Conclusion

The present study demonstrates that emphysema is predominantly observed among elderly male patients with significant smoking exposure. HRCT was superior to chest radiography in detecting and characterizing emphysematous changes. Significant correlation was observed between spirometric severity and HRCT findings such as hyperinflation, tubular heart, and bullae. Therefore, combined evaluation using clinical assessment, pulmonary function tests, chest radiography, and HRCT provides a comprehensive approach for diagnosis and severity assessment of emphysema.

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