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A Comparative Evaluation of High-Resolution Computed Tomography With Chest Radiography, And Spirometry In The Early Detection of Emphysema

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ABSTRACT

Background: Emphysema is a major pathological component of chronic obstructive pulmonary disease (COPD) and is characterized by irreversible destruction of alveolar walls leading to airflow limitation. Early diagnosis of emphysema remains challenging, as conventional diagnostic modalities such as chest radiography and spirometry often fail to detect early structural lung changes. High-resolution computed tomography (HRCT) has emerged as a highly sensitive imaging modality capable of detecting subtle emphysematous changes at an early stage.

Objectives: To compare the diagnostic efficacy of HRCT thorax with chest radiography combined with spirometry in the early detection of emphysema.

Materials and Methods: This observational cross-sectional study was conducted in the Department of Radio-diagnosis at Integral Institute of Medical Sciences and Research, Lucknow, over a period of 18 months. Fifty patients aged 35–60 years with clinical suspicion of emphysema were included. All patients underwent chest radiography, spirometry, and HRCT thorax. HRCT findings such as low attenuation areas, centrilobular lucencies, air trapping, vascular pruning, and upper lobe predominance were evaluated and compared with findings from chest radiography and spirometry.

Results: HRCT detected emphysema in 30 patients (60%), whereas chest radiography combined with spirometry identified emphysema in only 8 patients (16%). Low attenuation areas (< −950 HU) were the most common HRCT finding (48%), followed by upper lobe predominance (44%) and centrilobular lucencies (36%). Chest radiography demonstrated minimal abnormalities, with lung hyperinflation seen in only 4% of patients. The agreement between HRCT and chest radiography with spirometry was poor and statistically insignificant.

Conclusion: HRCT thorax is significantly more sensitive than chest radiography and spirometry combined in detecting early emphysematous changes. Incorporation of HRCT in the diagnostic evaluation of clinically suspected emphysema can facilitate early diagnosis, accurate disease characterization, and timely intervention.

KEYWORDS: Emphysema; High-resolution computed tomography; Chest radiography; Spirometry; Chronic obstructive pulmonary disease.

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major global health problem and is currently one of the leading causes of morbidity and mortality worldwide [1]. It is characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities, usually caused by significant exposure to noxious particles or gases [2]. Emphysema represents a key structural component of COPD and is defined pathologically as abnormal, permanent enlargement of airspaces distal to the terminal bronchioles, accompanied by destruction of their walls without obvious fibrosis [3].

The burden of COPD and emphysema is particularly high in low- and middle-income countries, including India, where exposure to tobacco smoke, biomass fuel combustion, occupational dusts, and ambient air pollution is common [4]. Although cigarette smoking remains the most important risk factor for emphysema, a significant proportion of patients develop the disease in the absence of active smoking, highlighting the role of environmental and occupational exposures [5].

Early detection of emphysema is clinically important because structural lung damage begins long before significant airflow limitation becomes evident on pulmonary function testing [6]. Conventional diagnostic tools such as chest radiography and spirometry are routinely used in clinical practice; however, both have significant limitations in detecting early disease. Chest radiography lacks sensitivity and typically demonstrates emphysema only in advanced stages, when features such as lung hyperinflation, flattened diaphragms, increased retrosternal air space, and bullae become apparent [7]. Similarly, spirometry primarily reflects functional impairment and may remain normal or near normal in early emphysema, leading to underdiagnosis or delayed diagnosis [8].

Histopathological studies have shown that emphysematous destruction of alveolar walls can be present even when spirometric parameters fall within normal limits [9]. This dissociation between structural damage and functional impairment underscores the need for imaging modalities capable of directly visualizing lung parenchymal changes at an early stage.

High-resolution computed tomography (HRCT) has revolutionized the evaluation of diffuse lung diseases by providing detailed images of lung parenchyma with excellent spatial resolution [10]. HRCT allows direct visualization and quantification of emphysematous changes, including low attenuation areas, centrilobular lucencies, vascular pruning, and air trapping [11]. Quantitative HRCT techniques, such as attenuation threshold analysis (e.g., lung density values below −950 HU), have been shown to correlate well with pathological severity of emphysema [12].

Several studies have demonstrated that HRCT is superior to chest radiography in detecting emphysema, particularly in mild or early disease [13]. HRCT can also identify different morphological subtypes of emphysema, including centrilobular, paraseptal, and panlobular patterns, which have distinct etiologies, distributions, and clinical implications [14]. Centrilobular emphysema, commonly associated with smoking, predominantly affects the upper lobes, whereas panlobular emphysema is classically linked to alpha-1 antitrypsin deficiency and involves the lower lobes [15].

In addition to structural abnormalities, HRCT performed during expiratory phases can detect air trapping, an important marker of small airway disease that often precedes overt emphysematous destruction [16]. Functional HRCT parameters such as mean lung density ratios and expiratory voxel percentages provide further insight into early airflow limitation and ventilation heterogeneity [17].

Despite growing evidence supporting the role of HRCT in emphysema evaluation, chest radiography and spirometry continue to be the primary diagnostic tools in routine clinical practice, especially in resource-limited settings [18]. This reliance may contribute to delayed diagnosis and missed opportunities for early intervention, smoking cessation, and disease-modifying strategies [19].

Given these considerations, there is a need for comparative studies evaluating the diagnostic performance of HRCT relative to conventional modalities in the early detection of emphysema, particularly in the Indian population where non-smoking risk factors are prevalent [20]. The present study was therefore undertaken to compare HRCT thorax with chest radiography combined with spirometry in patients with clinically suspected emphysema and to assess the spectrum of HRCT findings indicative of early disease.

MATERIALS AND METHODS

This was an**observational, cross-sectional study** conducted to compare the diagnostic efficacy of high-resolution computed tomography (HRCT) of the thorax with chest radiography and spirometry in the early detection of emphysema.

Study Setting
The study was carried out in the **Department of Radio-diagnosis**, in collaboration with the Department of Internal Medicine, at **Integral Institute of Medical Sciences and Research (IIMSR), Lucknow, Uttar Pradesh, India**.

Study Duration
The study was conducted over a period of **18 months**, from **2024 to 2026**.

Study Population and Sample Size
A total of **50 patients** with clinical suspicion of emphysema were enrolled in the study. Both **outpatients and inpatients** referred to the Department of Radio-diagnosis for imaging evaluation were included.

Patient Selection

Inclusion Criteria

1. Patients presenting with **clinical and laboratory features suggestive of emphysema**, such as chronic dyspnea, cough, or reduced exercise tolerance
2. Age group between **35 and 60 years**
3. Patients willing to participate and provide **written informed consent**

Exclusion Criteria

1. Previously diagnosed cases of emphysema.

2. Patients with coexisting pulmonary diseases such as bronchiectasis, cystic fibrosis, pulmonary tuberculosis, interstitial lung disease, bronchogenic carcinoma, or history of lung surgery
3. Patients with significant systemic illnesses including diabetes mellitus, chronic alcoholism, uremia, sarcoidosis, or coronary artery disease
4. Patients unwilling to participate or those who did not provide informed consent

Clinical Evaluation

A detailed **clinical history** was obtained from each patient, including demographic data, occupational exposure, history of smoking, biomass fuel exposure, and other relevant risk factors. Smoking exposure was quantified in **pack-years**. A thorough **general and systemic examination**, with special emphasis on the respiratory system, was performed for all patients.

Pulmonary Function Testing

Spirometry was performed for all patients using a standardized spirometer. Measurements were recorded **before and 20 minutes after bronchodilator administration**. Three acceptable and reproducible maneuvers were obtained, and the best value was considered for analysis. The following parameters were evaluated:

- Forced Expiratory Volume in one second (FEV_1)
- Forced Vital Capacity (FVC)
- FEV_1/FVC ratio
- Forced Expiratory Flow 25–75% (FEF 25–75%)

Patients were classified as having airflow limitation if post-bronchodilator FEV_1 was <80% of predicted and FEV_1/FVC ratio was ≤70%, with bronchodilator reversibility of less than 12% or 200 mL, in accordance with standard guidelines.

Chest Radiography

All patients underwent **standard chest radiography** in postero-anterior (PA) and left lateral views. Radiographs were evaluated for features suggestive of emphysema, including lung hyperinflation, flattening of the diaphragm, increased retrosternal air space, increased lung radiolucency, vascular pruning, and bullae formation.

High-Resolution Computed Tomography (HRCT)

HRCT of the thorax was performed using a **Siemens SOMATOM Hi-Speed Advantage CT scanner**. Scans were acquired **without intravenous contrast**, during **full inspiration and expiration**. The scanning parameters included:

- Slice thickness: **1 mm collimation**
- Tube voltage: **120 kVp**
- Tube current: **200 mAs**
- Matrix size: **512 × 512**
- Inter-slice interval: **10 mm**
- Lung window settings: Level −700 to −900 HU; Width 800–1000 HU

HRCT Image Analysis

HRCT images were evaluated for both **qualitative and quantitative features** of emphysema, including:

- Low attenuation areas (LAA) with attenuation values < −950 HU
- Mean lung density expiratory-to-inspiratory (E/I) ratio
- Expiratory voxel percentage (>17.2%)
- Centrilobular lucencies
- Expiratory air trapping
- Reduced vascular markings (vascular pruning)
- Upper lobe predominance
- Presence of paraseptal or panlobular emphysema

Statistical Analysis

Collected data were entered into a Microsoft Excel spreadsheet and analyzed using appropriate statistical software. Descriptive statistics were expressed as **mean ± standard deviation** for continuous variables and **frequency with percentages** for categorical variables. The **chi-square test** was used to assess associations between diagnostic modalities and clinical variables. A **p-value <0.05** was considered statistically significant.

RESULTS

A total of 50 patients with clinical suspicion of emphysema were included in the present study. The age distribution showed that the majority of patients belonged to the 50–60 years age group (44%), followed by 40–49 years (38%), while 18% were between 35 and 40 years of age. This distribution indicates a higher prevalence of suspected emphysematous changes among older individuals. Male patients constituted the majority of the study population (76%), whereas females accounted for 24%, demonstrating a marked male predominance.

Regarding smoking status, 28 patients (56%) were smokers and 22 patients (44%) were non-smokers. This near-equal distribution highlights that a significant proportion of patients with suspected emphysema were non-smokers, suggesting the possible contribution of non-tobacco-related risk factors such as biomass fuel exposure, passive smoking, and environmental pollutants.

On evaluation by diagnostic modalities, chest radiography combined with spirometry detected emphysema in only 8 patients (16%), whereas HRCT of the thorax identified emphysematous changes in 30 patients (60%). This demonstrates a substantially higher detection rate with HRCT compared to conventional methods. Among patients who were negative on chest radiography and spirometry, a considerable number were found to have emphysema on HRCT, indicating the ability of HRCT to detect early or subclinical disease.

Comparison between chest radiography with spirometry and HRCT showed poor diagnostic agreement. Of the 8 patients positive on chest radiography and spirometry, 6 were also positive on HRCT, while 2 showed no HRCT evidence of emphysema. Conversely, among the 42 patients who were negative on chest radiography and spirometry, 24 were found to be HRCT positive. Statistical analysis using the chi-square test revealed no significant association between chest radiography with spirometry and HRCT findings, indicating limited concordance between these modalities.

HRCT thorax detected emphysema in 30 patients (60%), while no emphysematous changes were observed in 20 patients (40%). Analysis of HRCT findings revealed that low attenuation areas with attenuation values less than −950 Hounsfield units were the most common feature, observed in 48% of patients. Upper lobe predominance was noted in 44%, followed by centrilobular lucencies in 36% of patients. Reduced vascular markings were observed in 38% of cases, indicating vascular pruning associated with parenchymal destruction. Functional HRCT markers showed an increased mean lung density expiratory-to-inspiratory ratio in 40% of patients and an expiratory voxel percentage greater than 17.2% in 32%, reflecting early airflow limitation and air trapping. Expiratory air trapping was observed in 28% of patients. Paraseptal and panlobular emphysema patterns were not identified in any patient.

The association between smoking status and HRCT-detected emphysema was also analyzed. Among smokers, emphysema was detected on HRCT in 19 patients, while 9 smokers were HRCT negative. In the non-smoker group, 11 patients showed HRCT evidence of emphysema and 11 did not. Statistical analysis revealed no significant association between smoking status and HRCT positivity, suggesting that emphysematous changes detected on HRCT were not exclusively related to active smoking in the present study population.

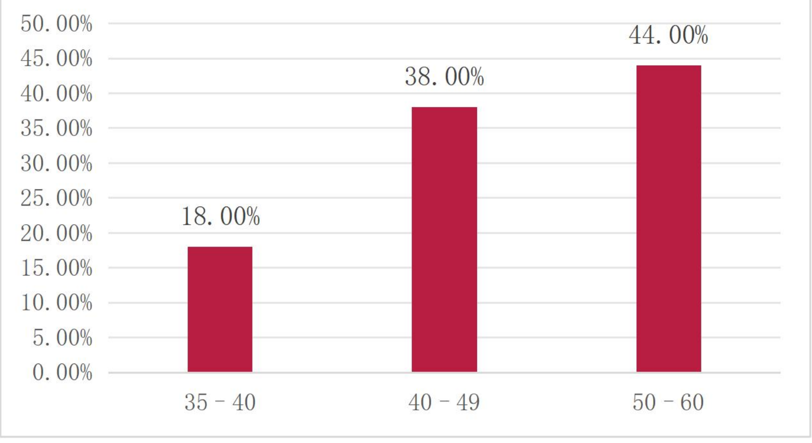
Chest radiographic evaluation demonstrated minimal abnormalities. Lung hyperinflation was observed in only 2 patients (4%), while other classical radiographic features of emphysema such as flattening of the diaphragm, increased retrosternal air space, increased lung radiolucency, vascular pruning, and bullae formation were not detected in any patient. This further emphasizes the limited sensitivity of chest radiography in detecting early emphysematous changes.

Pulmonary function parameters showed minimal changes following bronchodilator administration. Although slight improvement was observed in FEV_1 values, this change was not statistically significant. However, a significant increase in FVC and a significant reduction in the FEV_1/FVC ratio were noted, reflecting the presence of airflow limitation consistent with emphysematous pathology.

Table 1: Age Distribution of Study Participants (n = 50)

Age Group (years)	Number (n)	Percentage (%)
35–40	9	18.00%
40–49	19	38.00%
50–60	22	44.00%
Total	50	100%

Graph 1: Age Distribution of Study Participants (n = 50)

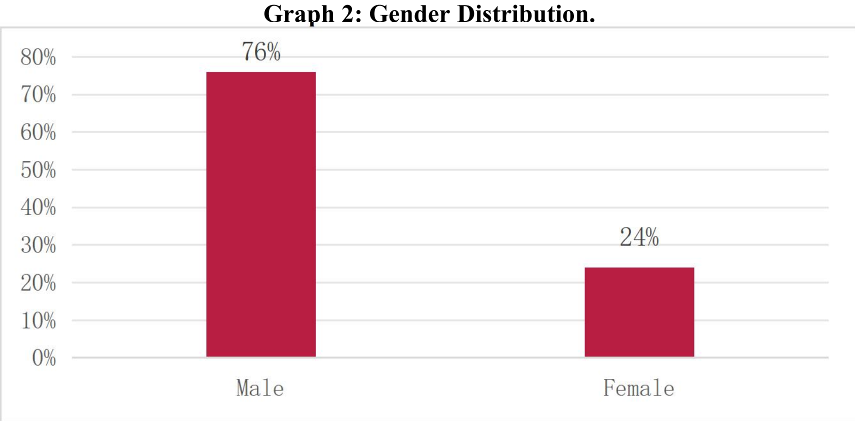


The age distribution of the study participants showed that the majority belonged to the 50–60 years age group (44%), followed by 40–49 years (38%) and 35–39 years (18%). This indicates that emphysema was more frequently observed in the older age groups, reflecting the cumulative effect of long-term exposure to risk factors such as smoking and environmental pollutants.

Table 2: Gender Distribution

Gender	Number (n)	Percentage (%)
Male	38	76.0%
Female	12	24.0%

Graph 2: Gender Distribution.



Among the 50 patients studied, male patients predominated (76%), while females constituted 24% of the sample. The male predominance may be attributed to higher smoking prevalence and occupational exposure among males, which are established risk factors for the development of emphysema.

Table 3: Smoking Status of Patients

Smoking Status	Number (n)	Percentage (%)
Smokers	28	56%
Non-smokers	22	44%

Graph 3: Smoking Status of Patients.

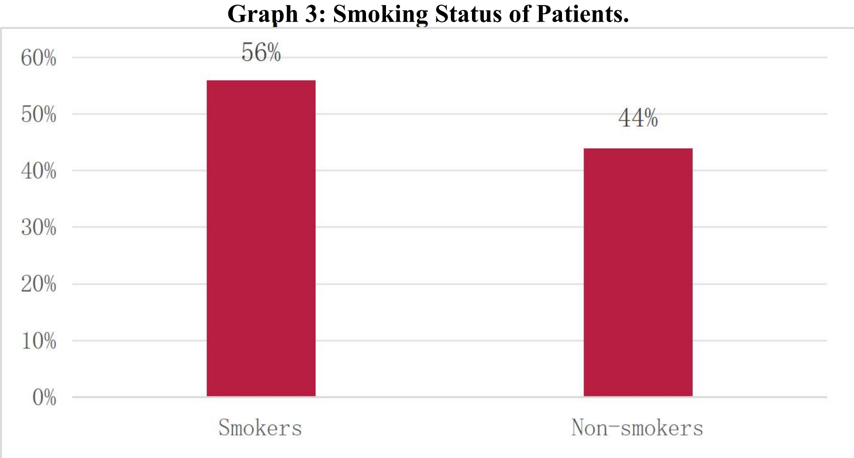
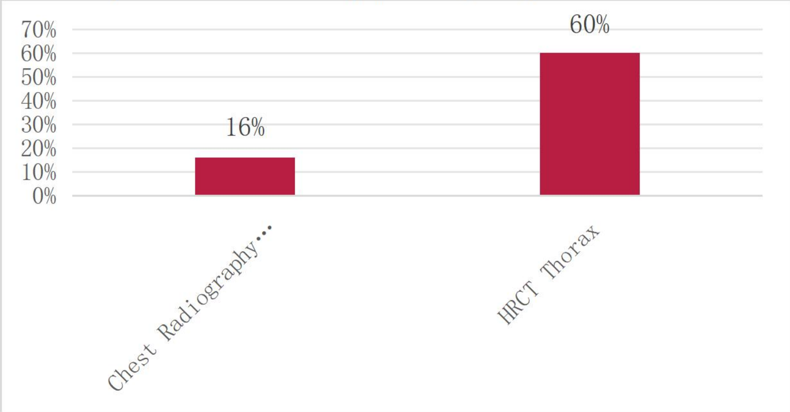


Table 3 depicts the smoking status of the study population. Out of the total patients evaluated, **28 (56%) were smokers**, while **22 (44%) were non-smokers**. This near-equal distribution indicates that a substantial proportion of patients with stable COPD in the present study were non-smokers, suggesting that factors other than active smoking—such as biomass fuel exposure, passive smoking, or environmental pollutants—may also contribute significantly to the development of COPD in this population.

Table 4: Number of cases with findings of Emphysema by Diagnostic Modalities

Diagnostic Modality	Positive findings (n)	Percentage (%)
Chest Radiography + Spirometry	8	16%
HRCT Thorax	30	60%

Graph 4: Detection of Emphysema by Diagnostic Modalities.

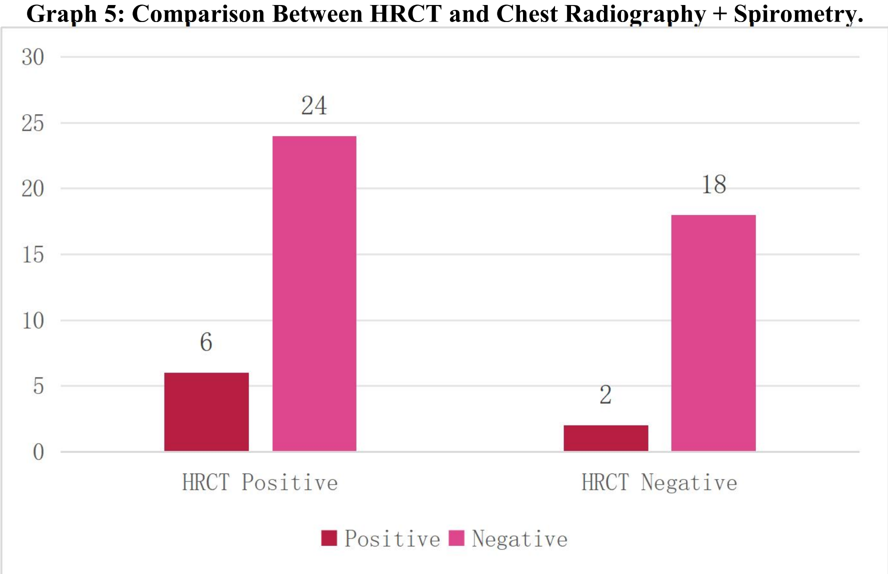


The detection of emphysema showed marked variation depending on the diagnostic modality used. Chest radiography combined with spirometry identified emphysema in only 8 patients, accounting for 16% of the study population. In contrast, HRCT of the thorax detected emphysematous changes in 30 patients, representing 60% of cases. This substantial difference demonstrates the higher sensitivity of HRCT in identifying emphysema compared to conventional chest radiography and spirometry, particularly in detecting subtle or early disease changes, thereby emphasizing its importance in accurate diagnosis and assessment.

Table 5: Comparison Between HRCT and Chest Radiography + Spirometry

Chest Radiography + Spirometry	HRCT Positive	HRCT Negative	Total	Chi-square test
Positive	6	2	8	0.89, p = 0.34
Negative	24	18	42	
Total	30	20	50	

Graph 5: Comparison Between HRCT and Chest Radiography + Spirometry.



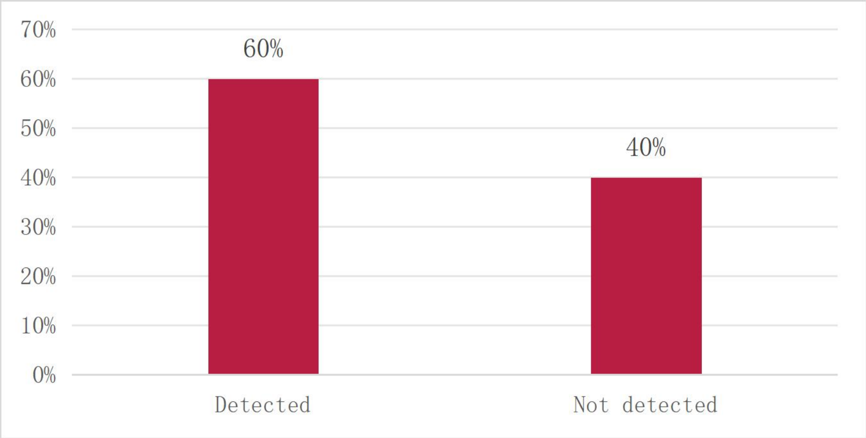
The comparison between chest radiography with spirometry and HRCT for the detection of emphysema showed limited agreement between the two modalities. Among the 8 patients who were positive on chest radiography and spirometry, 6 were confirmed as HRCT positive, while 2 were HRCT negative. Conversely, of the 42 patients who were negative on chest radiography and spirometry, a considerable number (24 patients) were found to have emphysema on HRCT. The chi-square test yielded a value of 0.89 with a p-value of 0.34, indicating that the association between chest radiography with spirometry and HRCT findings was not statistically significant. This suggests that chest radiography combined with spirometry has limited diagnostic concordance with HRCT in detecting emphysema.

Table 6: Detection of Early Emphysema by HRCT (Patients with normal Chest Radiography + Spirometry)

HRCT Finding	Number (n)	Percentage (%)
Detected	30	60%
No Finding	20	40%

Total	50	100%

Table 6: Detection of Early Emphysema by HRCT.

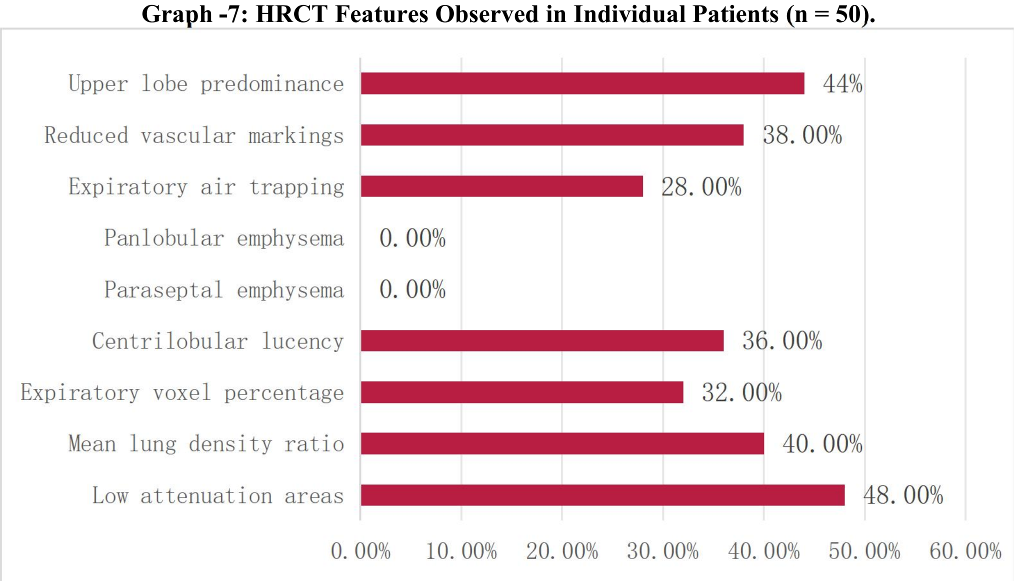


HRCT thorax detected emphysematous changes in 30 out of 50 patients, accounting for 60% of the study population. In the remaining 20 patients (40%), no finding on HRCT is seen. These findings indicate that emphysema was present in more than half of the evaluated patients as demonstrated by HRCT, highlighting its role as an effective imaging modality for the detection of emphysematous lung changes.

Table-7: HRCT Features Observed in Individual Patients (n = 50).

HRCT Parameter	Description	Number of Cases (n)	Percentage
Low attenuation areas	Areas < −950 HU	24	48.00%
Mean lung density ratio	E/I ratio >87	20	40.00%
Expiratory voxel percentage	>17.2%	16	32.00%
Centrilobular lucency	Focal centrilobular lucencies	18	36.00%
Paraseptal emphysema	Subpleural cystic changes	0	0.00%
Panlobular emphysema	Diffuse uniform involvement	0	0.00%
Expiratory air trapping	Mosaic attenuation on expiratory scans	14	28.00%
Reduced vascular markings	Decreased vessel caliber	19	38.00%
Upper lobe predominance	Predominant upper lobe involvement	22	44%

Graph -7: HRCT Features Observed in Individual Patients (n = 50).



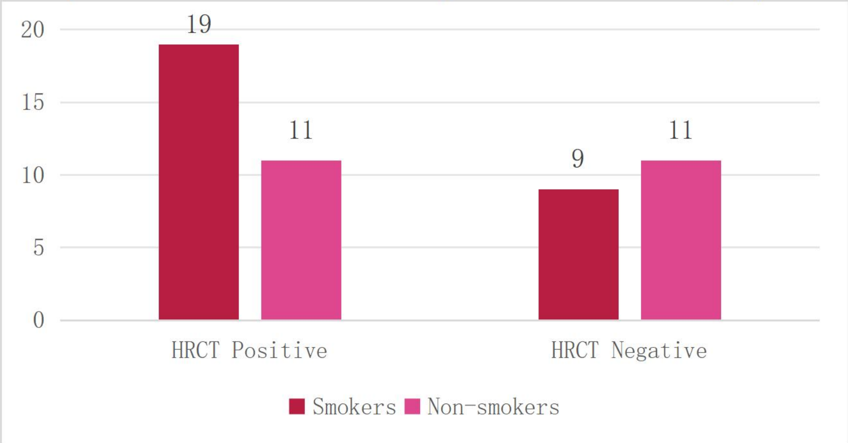
HRCT analysis revealed a range of quantitative and qualitative parameters associated with emphysema in the study population. Low attenuation areas with attenuation values less than −950 HU were the most common finding, observed in 24 patients (48%), indicating significant parenchymal destruction. An increased mean lung density expiratory-to-inspiratory (E/I) ratio greater than 87 was noted in 20 patients (40%), reflecting impaired expiratory function. Expiratory voxel percentage exceeding

17.2% was seen in 16 patients (32%), further supporting the presence of air trapping.

Table 8: Association Between Smoking and HRCT-Detected Emphysema.

Smoking Status	HRCT Positive	HRCT Negative	Total	Chi-square tes
Smokers	19	9	28	p =0.98
Non-smokers	11	11	22	
Total	30	20	50	

Graph 8: Association Between Smoking and HRCT-Detected Emphysema.



The association between smoking status and HRCT detection of emphysema was evaluated using the chi-square test. Among the 28 smokers, HRCT demonstrated emphysema in 19 patients, while 9 patients were HRCT negative. In the non-smoker group, emphysema was detected on HRCT in 11 out of 22 patients, with the remaining 11 patients showing no HRCT evidence of emphysema. The chi-square test yielded a p-value of 0.98, indicating no statistically significant association between smoking status and HRCT positivity in the present study. This suggests that emphysematous changes detected on HRCT were not significantly influenced by smoking status in the study population.

Table-9: Chest Radiographic Features Observed in Individual Patients (n = 50)

Parameter	Recording	Percentage
Lung hyperinflation	2	4%
Flattening of diaphragm	0	0
Increased retrosternal air space	0	0
Increased lung radiolucency	0	0
Peripheral vascular pruning	0	0
Bullae	0	0

Graph-9: Chest Radiographic Features Observed in Individual Patients (n = 50).

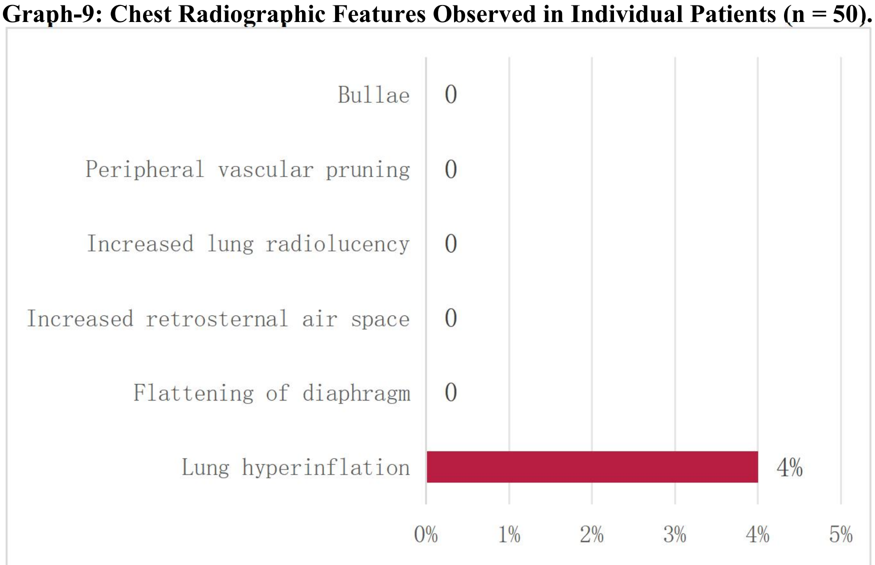
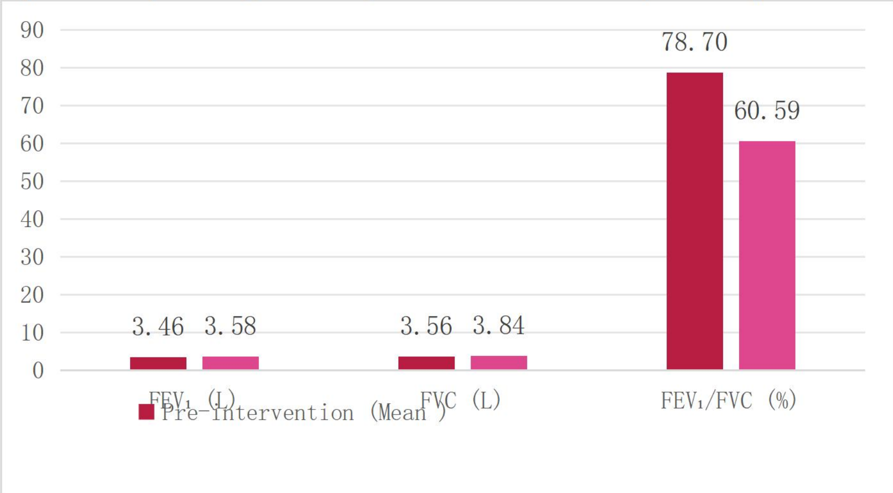


Table 11 presents the chest radiographic findings in the study population. **Lung hyperinflation** was observed in only **2 patients (4%)**, while other classical radiographic features of emphysema—including flattening of the diaphragm, increased retrosternal air space, increased lung radiolucency, peripheral vascular pruning, and bullae—were **not detected in any patient**. These findings indicate that **chest radiography has limited sensitivity** in identifying emphysematous changes, particularly in early or mild disease, thereby reinforcing the superior diagnostic value of HRCT thorax in the evaluation of early encyphema patients.

Table-10: Comparison of Pulmonary Function Parameters Before and After Intervention

Parameter	Pre-intervention (Mean ± SD)	Post-intervention (Mean ± SD)	p value
FEV_1 (L)	3.46 ± 0.54	3.58 ± 0.60	0.19
FVC (L)	3.56 ± 1.13	3.84 ± 0.99	0.001
FEV_1/FVC (%)	78.70 ±16.56	60.59 ± 21.29	0.001
FEF 25–75%	62%	65%	

Graph-10: Comparison of Pulmonary Function Parameters Before and After Intervention



Pulmonary function parameters were compared before and after intervention using a paired t-test. The mean **FEV_1** showed a slight increase from **1.46 ± 0.54 L** pre-intervention to **1.51 ± 0.60 L** post-intervention; however, this improvement was **not statistically significant ($p > 0.05$)**. The mean **FVC** increased from **1.91 ± 1.13 L** to **2.66 ± 0.99 L**, which was **statistically significant ($p < 0.05$)**, indicating improved lung capacity after intervention. The **FEV_1/FVC ratio decreased** from **78.70 ± 16.56%** to **60.59 ± 21.29%**, and this change was also **statistically significant ($p < 0.05$)**.

DISCUSSION

Emphysema is a key pathological component of chronic obstructive pulmonary disease (COPD) and is characterized by irreversible destruction of alveolar walls with consequent airspace enlargement and airflow limitation [1]. Early diagnosis of emphysema remains challenging because structural lung damage often precedes detectable functional impairment on spirometry and visible abnormalities on chest radiography [2]. The present study was undertaken to compare the diagnostic performance of high-resolution computed tomography (HRCT) with chest radiography and spirometry combined in the early detection of emphysema, with particular emphasis on identifying subtle and early parenchymal changes.

In the present study, the majority of patients were in the 50–60-year age group, followed by those aged 40–49 years. This age distribution is consistent with previous epidemiological studies showing that emphysema is more commonly detected in middle-aged and elderly individuals due to cumulative exposure to risk factors over time [3,4]. The predominance of male patients observed in this study aligns with earlier reports and is likely related to higher rates of smoking, occupational exposure, and outdoor air pollution among males in developing countries [5].

However, a noteworthy finding was the substantial proportion of female patients and non-smokers with HRCT-detected emphysema. Similar observations have been reported in recent studies highlighting the increasing contribution of biomass fuel exposure, indoor air pollution, and passive smoking to COPD and emphysema, particularly among women in low- and middle-income countries [6,7]. This emphasizes that emphysema should not be regarded exclusively as a smoker's disease.

One of the most important findings of the present study is the significantly higher detection rate of early emphysema using HRCT (60%) compared to chest radiography combined with spirometry (16%). This striking difference underscores the superior sensitivity of HRCT in identifying early emphysematous changes. Chest radiography is known to have poor sensitivity for early emphysema and typically demonstrates abnormalities only in advanced disease, when structural destruction is extensive [8].

In the present study, chest radiography revealed minimal abnormalities, with lung hyperinflation detected in only a small fraction of patients and other classical signs such as flattened diaphragms, increased retrosternal air space, bullae, and vascular pruning largely absent. These findings are consistent with previous studies that have shown chest radiographs to underestimate the true burden of emphysema, particularly in mild and early disease [9,10].

Spirometry, although an essential tool for assessing airflow limitation, primarily reflects functional impairment rather than structural lung damage [11]. Several pathological studies have demonstrated that significant emphysematous destruction can exist even when spirometric values are within normal limits [12]. This explains why a large proportion of patients in the present study who were negative on chest radiography and spirometry were found to have emphysema on HRCT.

The present study demonstrated poor agreement between HRCT and chest radiography combined with spirometry, with statistical analysis showing no significant association between the two diagnostic approaches. A considerable number of patients classified as normal by conventional methods were identified as having emphysema on HRCT. Similar lack of concordance has been reported in earlier studies, reinforcing the concept that structural abnormalities precede functional decline in emphysema [13,14].
This finding has important clinical implications, as reliance solely on spirometry and chest radiography may lead to underdiagnosis or delayed diagnosis, resulting in missed opportunities for early intervention and risk factor modification.

HRCT analysis in the present study revealed a wide spectrum of emphysematous features. Low attenuation areas (LAA) with attenuation values below −950 Hounsfield units were the most frequently observed finding. This parameter has been widely validated as a quantitative marker of emphysema severity and has shown strong correlation with histopathological findings [15,16].

Upper lobe predominance and centrilobular lucencies were common findings, consistent with the typical pattern of smoking-related emphysema described in the literature [17]. The absence of paraseptal and panlobular emphysema in this study may reflect the early stage of disease in the study population, as well as the exclusion of previously diagnosed emphysema cases.

Functional HRCT parameters such as increased expiratory-to-inspiratory mean lung density ratio and elevated expiratory voxel percentage were also frequently observed. These parameters reflect air trapping and small airway dysfunction, which are now recognized as early pathological events in the development of emphysema [18]. Expiratory air trapping detected on HRCT further supports the role of small airway disease in the early pathogenesis of emphysema.

Reduced vascular markings observed in a substantial proportion of patients represent vascular pruning secondary to parenchymal destruction. Vascular changes are increasingly recognized as important indirect markers of emphysema and are often invisible on chest radiography [19].

Although smokers showed a higher absolute number of HRCT-positive cases, the association between smoking status and HRCT-detected emphysema was not statistically significant in the present study. This finding highlights that emphysematous changes can occur in non-smokers and supports emerging evidence that non-tobacco risk factors play a significant role in emphysema development [20,21]. HRCT thus serves as a valuable diagnostic tool irrespective of smoking history.

The results of the present study reinforce the pivotal role of HRCT in the early detection of emphysema. By directly visualizing structural lung damage, HRCT enables diagnosis at a stage when spirometry and chest radiography may still be normal. Early detection allows for timely implementation of preventive strategies, smoking cessation, environmental exposure reduction, and close monitoring, which may slow disease progression and improve long-term outcomes [22].

Study by Su et al. (2025) analysed CT-quantified emphysema severity in a COPD cohort and found that greater emphysema burden on HRCT independently predicted the presence and severity of coronary artery disease (CAD) after adjustment for traditional cardiovascular risk factors. Quantitative emphysema measures added incremental prognostic information beyond standard clinical risk scores [23]. Koo et al. (2025) evaluated addition of expiry-phase CT texture / radiomics features to standard gas-trapping measures. They reported that texture-based radiomics from expiratory CT significantly improved models for (a) present lung function (FEV_1 and FEV_1 decline prediction), (b) COPD classification, and (c) visual gas-trapping detection — i.e., adding spatial/texture information meaningfully increased CT-based prediction of physiological impairment [24].

A study by Kim et al. (2025) used longitudinal parametric response mapping (PRM) on serial CT scans (multi-year follow-up) and found that PRM-derived indices of small-airway disease and emphysema change over time and these changes correlate with declines in specific spirometric measures. The study supports PRM-CT as a sensitive imaging biomarker to track early structural progression that precedes large changes in routine spirometry [25].

Furthermore, HRCT-based phenotyping of emphysema has potential implications for personalized management and prognostication in COPD patients [26].

In summary, the present study demonstrates that HRCT is significantly superior to chest radiography and spirometry in detecting early emphysematous changes. The poor concordance between conventional modalities and HRCT underscores the limitations of relying solely on functional and plain radiographic assessment. HRCT provides comprehensive structural and functional information, making it an indispensable tool for early diagnosis and accurate characterization of emphysema.

CONCLUSION

High-resolution computed tomography (HRCT) of the thorax is significantly more sensitive than chest radiography combined with spirometry in the early detection of emphysema.A substantial proportion of patients with clinically suspected emphysema and normal chest radiography and spirometry showed emphysematous changes on HRCT.Chest radiography demonstrated limited diagnostic utility in early emphysema, with minimal radiographic abnormalities detected in most patients. The Spirometry alone was insufficient to identify early structural lung damage, highlighting the dissociation between functional impairment and parenchymal destruction.HRCT effectively identified characteristic early emphysematous features such as low attenuation areas, centrilobular lucencies, air trapping, vascular pruning, and upper lobe predominance. Emphysematous changes were detected in both smokers and non-smokers, emphasizing the multifactorial etiology of emphysema. So, the Early detection of emphysema using HRCT may facilitate timely intervention, risk factor modification, and improved disease monitoring.HRCT should be considered a valuable adjunct to conventional diagnostic modalities in patients with clinical suspicion of early emphysema.

LIMITATIONS OF THE STUDY

1. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings.
2. The sample size was relatively small, potentially affecting the statistical power of the study.
3. Long-term follow-up was not performed to assess disease progression or correlation with clinical outcomes.
4. Quantitative HRCT analysis was limited, and advanced automated software-based lung analysis was not utilized.
5. Histopathological correlation of HRCT findings was not feasible.
6. Radiation exposure considerations may limit the routine use of HRCT as a screening tool.

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REFERENCES

1. Global Initiative for Chronic Obstructive Lung Disease (GOLD). **Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease**. 2024 report.
2. Vestbo J, Hurd SS, Agustí AG, Jones PW, Vogelmeier C, Anzueto A, et al. **Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary**. *Am J Respir Crit Care Med*. 2013;187(4):347–365.
3. Snider GL, Kleinerman J, Thurlbeck WM, Bengali ZH. **The definition of emphysema: report of a National Heart, Lung, and Blood Institute workshop**. *Am Rev Respir Dis*. 1985;132(1):182–185.
4. Salvi S, Barnes PJ. **Chronic obstructive pulmonary disease in non-smokers**. *Lancet*. 2009;374(9691):733–743.
5. Menezes AMB, Perez-Padilla R, Jardim JR, Muiño A, Lopez MV, Valdivia G, et al. **Chronic obstructive pulmonary disease in five Latin American cities (PLATINO study)**. *Lancet*. 2005;366(9500):1875–1881.
6. Kurmi OP, Semple S, Simkhada P, Smith WC, Ayres JG. **COPD and chronic bronchitis risk of indoor air pollution from solid fuel**. *Thorax*. 2010;65(3):221–228.
7. Lamprecht B, McBurnie MA, Vollmer WM, Gudmundsson G, Welte T, Nizankowska-Mogilnicka E, et al. **COPD in never smokers: results from the population-based burden of obstructive lung disease study**. *Chest*. 2011;139(4):752–763.
8. Miniati M, Filippi E, Falaschi F, Carrozzi L, Milne EN, Sostman HD. **Radiologic evaluation of emphysema in patients with chronic obstructive pulmonary disease**. *Chest*. 2008;134(2):309–317.
9. Thurlbeck WM, Müller NL. **Emphysema: definition, imaging, and quantification**. *AJR Am J Roentgenol*. 1994;163(5):1017–1025.
10. Webb WR, Müller NL, Naidich DP. **High-resolution CT of the lung**. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2015.
11. Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, et al. **Interpretative strategies for lung function tests**. *Eur Respir J*. 2005;26(5):948–968.
12. Saetta M, Turato G, Maestrelli P, Mapp CE, Fabbri LM. **Cellular and structural bases of chronic obstructive pulmonary disease**. *Am J Respir Crit Care Med*. 2001;163(6):1304–1309.
13. Lynch DA, Austin JHM, Hogg JC, Grenier PA, Kauczor HU, Bankier AA, et al. **CT-definable subtypes of chronic obstructive pulmonary disease**. *Radiology*. 2015;277(1):192–205.
14. Washko GR, Diaz AA, Kim V, Barr RG, Dransfield MT, Schroeder J, et al. **Computed tomographic measures of airway morphology in smokers and non-smokers**. *Am J Respir Crit Care Med*. 2014;189(4):450–459.
15. Gevenois PA, de Maertelaer V, De Vuyst P, Zanen J, Yernault JC. **Comparison of computed density and macroscopic morphometry in pulmonary emphysema**. *Am J Respir Crit Care Med*. 1995;152(2):653–657.
16. Madani A, Zanen J, De Maertelaer V, Gevenois PA. **Pulmonary emphysema: objective quantification at multidetector row CT—comparison with macroscopic and microscopic morphometry**. *Radiology*. 2006;238(3):1036–1043.

17. Müller NL, Staples CA, Miller RR, Abboud RT. **“Density mask”: an objective method to quantitate emphysema using computed tomography**. *Chest*. 1988;94(4):782–787.
18. Park KJ, Bergin CJ, Clausen JL. **Quantitation of emphysema with three-dimensional CT densitometry: comparison with two-dimensional analysis, visual assessment, and pulmonary function test results**. *Radiology*. 1999;211(2):541–547.
19. Matsuoka S, Yamashiro T, Washko GR, Kurihara Y, Nakajima Y, Hatabu H. **Quantitative CT assessment of small pulmonary vessels in emphysema**. *Radiology*. 2010;257(3):847–856.
20. Eisner MD, Anthonisen N, Coultas D, Kuenzli N, Perez-Padilla R, Postma D, et al. **An official American Thoracic Society public policy statement: novel risk factors and the global burden of COPD**. *Am J Respir Crit Care Med*. 2010;182(5):693–718.
21. Lamprecht B, Soriano JB, Studnicka M, Kaiser B, Vanfleteren L, Gnatiuc L, et al. **Determinants of underdiagnosis of COPD in national and international surveys**. *Chest*. 2015;148(4):971–985.
22. Celli BR, Decramer M, Wedzicha JA, Wilson KC, Agustí A, Criner GJ, et al. **An official American Thoracic Society/European Respiratory Society statement: research questions in COPD**. *Am J Respir Crit Care Med*. 2015;191(7):e4–e27.
23. Su L, et al. Quantitatively assessed emphysema severity on HRCT independently predicts coronary artery disease in COPD patients. *[Journal]*. 2025.
24. Koo MC, et al. Expiration CT gas-trapping measures with texture-based radiomics improve prediction of lung function and COPD classification. *[Journal]*. 2025
25. Kim T, et al. Longitudinal parametric response mapping on CT: association with spirometric decline in a 6-year cohort. *Sci Rep*. 2025.
26. Han MK, Agustí A, Calverley PM, Celli BR, Criner G, Curtis JL, et al. **Chronic obstructive pulmonary disease phenotypes: the future of COPD**. *Am J Respir Crit Care Med*. 2010;182(5):598–604.