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RESEARCH ARTICLE
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EVALUATION OF CHEST X-RAY FINDINGS IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A CROSS-SECTIONAL STUDY AT A TERTIARY CARE CENTER

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ABSTRACT

Introduction: Chronic Obstructive Pulmonary Disease (COPD) represents a major global health burden characterized by persistent airflow limitation. While spirometry remains the gold standard for diagnosis, chest radiography provides valuable complementary information for disease phenotyping and assessment. This study aimed to evaluate the spectrum of chest X-ray findings in COPD patients and correlate these with clinical and spirometric parameters.

Methods: A hospital-based cross-sectional observational study was conducted at Saraswathi Institute of Medical Sciences, Anwarpur, Uttar Pradesh, from March 2021 to August 2021. A total of 142 spirometrically confirmed COPD patients aged 40 years and above were enrolled using consecutive sampling. Detailed clinical history, spirometry, and standardized chest radiographs (posteroanterior and lateral views) were obtained. Radiographic findings were systematically evaluated and correlated with GOLD staging and spirometric parameters using appropriate statistical tests.

Results: The study population had mean age 62.4±9.8 years with 87.3% males. Hyperinflation was the most common radiographic finding (76.1%), followed by flattened diaphragm (67.6%), vascular pruning (54.9%), and bullae (36.6%). Only 9.9% had normal chest X-rays. Significant correlations existed between radiographic findings and COPD severity ($p<0.001$). Patients with hyperinflation had significantly lower FEV1% predicted (48.6% vs 68.4%, $p<0.001$) compared to those without. Progressive increase in radiographic abnormalities correlated with worsening GOLD stages.

Conclusion: Chest X-ray abnormalities are highly prevalent in COPD patients and correlate significantly with disease severity and spirometric impairment. Chest radiography remains a valuable complementary tool for COPD phenotyping and assessment alongside spirometry.

Keywords: Chronic Obstructive Pulmonary Disease, Chest Radiography, Emphysema, Spirometry, Hyperinflation

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) stands as one of the most significant global health challenges, representing a major cause of morbidity, mortality, and disability worldwide. This progressive respiratory condition is characterized by persistent airflow limitation that is usually

irreversible and associated with enhanced chronic inflammatory response in the airways and lungs to harmful particles or gases. The disease encompasses two primary components: chronic bronchitis characterized by small airways disease, and emphysema defined by permanent enlargement of airspaces distal to terminal bronchioles with destruction of alveolar walls (Washko, 2010). The burden of COPD continues to escalate, with projections indicating it will become the third leading cause of death globally.

The diagnosis and assessment of COPD traditionally relies on spirometry, which measures the severity of airflow limitation. However, spirometry alone provides limited information about the structural changes occurring within the lungs. This is where chest radiography becomes invaluable. Chest X-ray remains the most accessible, cost-effective, and widely available imaging modality for evaluating patients with suspected or confirmed COPD (Miniati et al., 2008). While computed tomography offers superior anatomical detail, the routine use of CT is restricted by factors including high radiation exposure, substantial cost, and limited availability, particularly in resource-constrained settings.

Chest radiography plays multiple important roles in COPD management. It serves as an initial diagnostic tool when COPD is suspected, helps exclude alternative diagnoses or comorbidities such as lung cancer, pneumonia, or heart failure, and assists in detecting complications like pneumothorax or bullous disease. Studies have shown that chest radiographs obtained during COPD evaluation detected potentially treatable causes of dyspnea in approximately 14% of cases and assisted in management decisions in 84% of patients (Wallace et al., 2009). This demonstrates that despite being less sensitive than CT, chest radiography provides clinically relevant information that influences patient care.

The radiographic manifestations of COPD vary depending on whether the predominant pathology is emphysema or chronic bronchitis. In emphysema, characteristic findings include lung hyperinflation with flattened hemidiaphragms, increased retrosternal space on lateral views, pruning of peripheral vessels, widened intercostal spaces, and a narrowed, vertically oriented cardiac silhouette (den Harder et al., 2017). Studies utilizing these criteria have reported sensitivity of 90% and specificity of 98% for detecting emphysema on chest radiography when validated against CT as the reference standard (Miniati et al., 2008). However, it is important to note that chest radiography generally lacks sensitivity for detecting early or mild emphysema.

In chronic bronchitis, the radiographic findings are typically more subtle and non-specific. They may include increased bronchovascular markings and thickening of bronchial walls when airways lie in appropriate planes for visualization. The "sabre-sheath trachea" sign, characterized by marked coronal narrowing of the intrathoracic trachea with sagittal widening, is occasionally observed and has been associated with COPD in multiple studies (Greene, 1978). Additional radiographic signs that merit attention include the presence of bullae, which appear as thin-walled, air-filled spaces, and evidence of pulmonary hypertension manifested by prominent central pulmonary arteries.

Research has established that chest radiography can be useful for phenotyping COPD patients. Emphysematous patients identified on chest X-rays have been shown to exhibit significantly lower body mass index, forced expiratory volume in one second (FEV1), diffusing capacity for carbon monoxide, and worse quality of life compared to non-emphysematous COPD patients (Miniati et al., 2008). This phenotypic distinction has therapeutic implications, as different COPD phenotypes may respond differently to treatment strategies. The ability to identify emphysema on routine chest radiography therefore adds clinical value beyond mere disease detection.

Despite advances in CT technology, chest radiography continues to hold relevance in COPD assessment for several reasons. First, it involves minimal radiation exposure compared to CT scans. Second, it is readily available in most healthcare settings, including primary care centers. Third, it is significantly less expensive than cross-sectional imaging. Fourth, it can be performed rapidly and does not require specialized positioning or breath-holding techniques that may be difficult for dyspneic patients. These practical advantages make chest X-ray an ideal first-line imaging investigation for COPD (Washko, 2010).

However, the limitations of chest radiography must also be acknowledged. The technique has limited sensitivity for detecting mild disease, cannot quantify disease severity as precisely as CT, and interpretation can be subjective with inter-observer variability. Furthermore, radiographic changes typically become apparent only after substantial structural damage has occurred, meaning that early COPD may show normal or near-normal chest X-rays (den Harder et al., 2017).

In India, where the burden of COPD is substantial and healthcare resources are limited, chest radiography assumes even greater importance. Studies conducted in Indian populations have documented the prevalence and risk factors for COPD, highlighting the need for accessible diagnostic tools (Jindal et al., 2012). The high prevalence of smoking, exposure to biomass fuel smoke, and occupational exposures in India contribute to a significant COPD burden. Understanding the chest radiographic patterns of COPD in this population context becomes crucial for improving diagnosis and management strategies.

The relationship between radiographic findings and clinical parameters including spirometric indices, disease severity, and patient symptoms has been explored in various studies. However, comprehensive evaluation of chest X-ray patterns in COPD patients, particularly in the Indian context, remains an area requiring further investigation. This gap in knowledge motivated the current study, which aimed to systematically evaluate chest X-ray findings in COPD patients and correlate these findings with clinical and spirometric parameters.

The aim of the study is to evaluate the spectrum of chest X-ray findings in patients with Chronic Obstructive Pulmonary Disease and to correlate these radiographic findings with clinical and spirometric parameters.

METHODOLOGY

Study Design

A hospital-based observational cross-sectional study.

Study Site

The study was conducted at Saraswathi Institute of Medical Sciences, located in Anwarpur, Uttar Pradesh, India. This tertiary care teaching hospital serves a large population from rural and semi-urban areas of western Uttar Pradesh.

Study Duration

The study was conducted over a period of six months, from March 2021 to August 2021.

Sampling and Sample Size

The study employed consecutive sampling technique, wherein all eligible patients presenting to the outpatient department and emergency department who met the inclusion criteria were enrolled until the desired sample size was achieved. Consecutive sampling was preferred over random sampling as it reduced selection bias while ensuring practical feasibility of recruitment. The sample size was calculated based on the expected prevalence of specific chest X-ray findings in COPD patients reported in previous literature and considering the finite population correction. A total of 142 patients were included in the study. This sample size provided adequate statistical power for detecting significant associations between radiographic findings and clinical parameters with 95% confidence level and 80% power.

Inclusion and Exclusion Criteria

The inclusion criteria for the study were: patients aged 40 years or above, those with clinically and spirometrically confirmed diagnosis of COPD according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines defined as post-bronchodilator FEV1/FVC ratio less than 0.70, patients in stable clinical condition who could undergo chest radiography and pulmonary function testing, and those who provided written informed consent to participate in the study. The exclusion

criteria included: patients with other primary pulmonary diseases such as bronchiectasis, interstitial lung disease, active pulmonary tuberculosis, lung cancer, or asthma as primary diagnosis, patients with significant cardiac comorbidities including heart failure or valvular heart disease that could confound radiographic interpretation, pregnant women due to radiation exposure concerns, patients with acute exacerbation of COPD requiring immediate intensive care as they could not undergo systematic evaluation, those with poor quality chest radiographs that were non-diagnostic, patients unable to perform satisfactory spirometry despite coaching, and individuals who declined to provide informed consent or were unable to complete the study protocol.

Data Collection Tools and Techniques

Data collection was performed using a structured proforma designed specifically for this study, which captured demographic information, detailed clinical history including smoking history quantified in pack-years, occupational exposure history, symptom duration and severity, comorbidities, and current medications. Clinical examination findings including body mass index, respiratory rate, oxygen saturation, and presence of signs such as barrel chest, use of accessory muscles, and cyanosis were systematically recorded. Spirometry was performed using a calibrated spirometer in the pulmonary function laboratory, following American Thoracic Society and European Respiratory Society standardized protocols (Graham et al., 2019). Pre and post-bronchodilator values for FEV1, forced vital capacity (FVC), FEV1/FVC ratio, and predicted percentages were recorded. COPD severity was classified according to GOLD staging criteria. Chest radiography was conducted using a digital X-ray system with standard posteroanterior and lateral views taken at full inspiration with the patient in standing position whenever possible. Radiographic parameters evaluated included lung hyperinflation assessed by counting ribs visible above the diaphragm and measuring lung height, diaphragm flattening and position, cardiac silhouette size and shape, retrosternal space on lateral view, pulmonary vascular pattern changes including pruning or prominence, presence of bullae or blebs, bronchial wall thickening, presence of any consolidation, pleural abnormalities, and tracheal abnormalities such as sabre-sheath trachea. All chest X-rays were reported by experienced radiologists who were blinded to the spirometry results to minimize interpretation bias. Inter-observer agreement was assessed for key radiographic findings.

Data Management and Statistical Analysis

All collected data were entered into a computerized database using Microsoft Excel and subsequently transferred to Statistical Package for Social Sciences (SPSS) version 23.0 for statistical analysis. Data cleaning and validation checks were performed to identify and rectify any errors or inconsistencies. Descriptive statistics were calculated for all variables, with continuous variables presented as mean and standard deviation or median and interquartile range depending on distribution normality assessed using Kolmogorov-Smirnov test. Categorical variables were expressed as frequencies and percentages. Bivariate analysis was conducted using appropriate statistical tests: chi-square test or Fisher's exact test for categorical variables, independent t-test for normally distributed continuous variables, and Mann-Whitney U test for non-normally distributed continuous variables. Correlation between radiographic findings and spirometric parameters was assessed using Pearson or Spearman correlation coefficients as appropriate. Multivariate logistic regression analysis was performed to identify independent predictors of specific radiographic findings after adjusting for potential confounders. A p-value of less than 0.05 was considered statistically significant for all analyses. Results were presented in tables and appropriate graphical representations including bar charts, scatter plots, and receiver operating characteristic curves where applicable.

Ethical Considerations

The study protocol was submitted to and approved by the Institutional Ethics Committee of Saraswathi Institute of Medical Sciences before initiation of patient recruitment. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and Good Clinical Practice guidelines. Written informed consent was obtained from all participants after providing detailed information about the study objectives, procedures, potential risks and benefits, and their right to withdraw from the study at any time without affecting their clinical care.

TABLES

Table 1: Demographic and Clinical Characteristics of Study Participants (N=142)

Characteristic	Frequency (n)	Percentage (%)	Mean ± SD
Age Groups			
40-50 years	18	12.7	-
51-60 years	45	31.7	-
61-70 years	52	36.6	-
>70 years	27	19.0	-
Mean Age (years)	-	-	62.4 ± 9.8
Gender			
Male	124	87.3	-
Female	18	12.7	-
Smoking Status			
Current Smoker	68	47.9	-
Ex-smoker	54	38.0	-
Non-smoker	20	14.1	-
Mean Pack Years (smokers)	-	-	28.6 ± 14.2
BMI Categories			
Underweight (<18.5)	32	22.5	-
Normal (18.5-24.9)	78	54.9	-
Overweight (≥25)	32	22.5	-
Mean BMI (kg/m²)	-	-	21.8 ± 3.6
Duration of Symptoms			
<5 years	48	33.8	-
5-10 years	62	43.7	-
>10 years	32	22.5	-

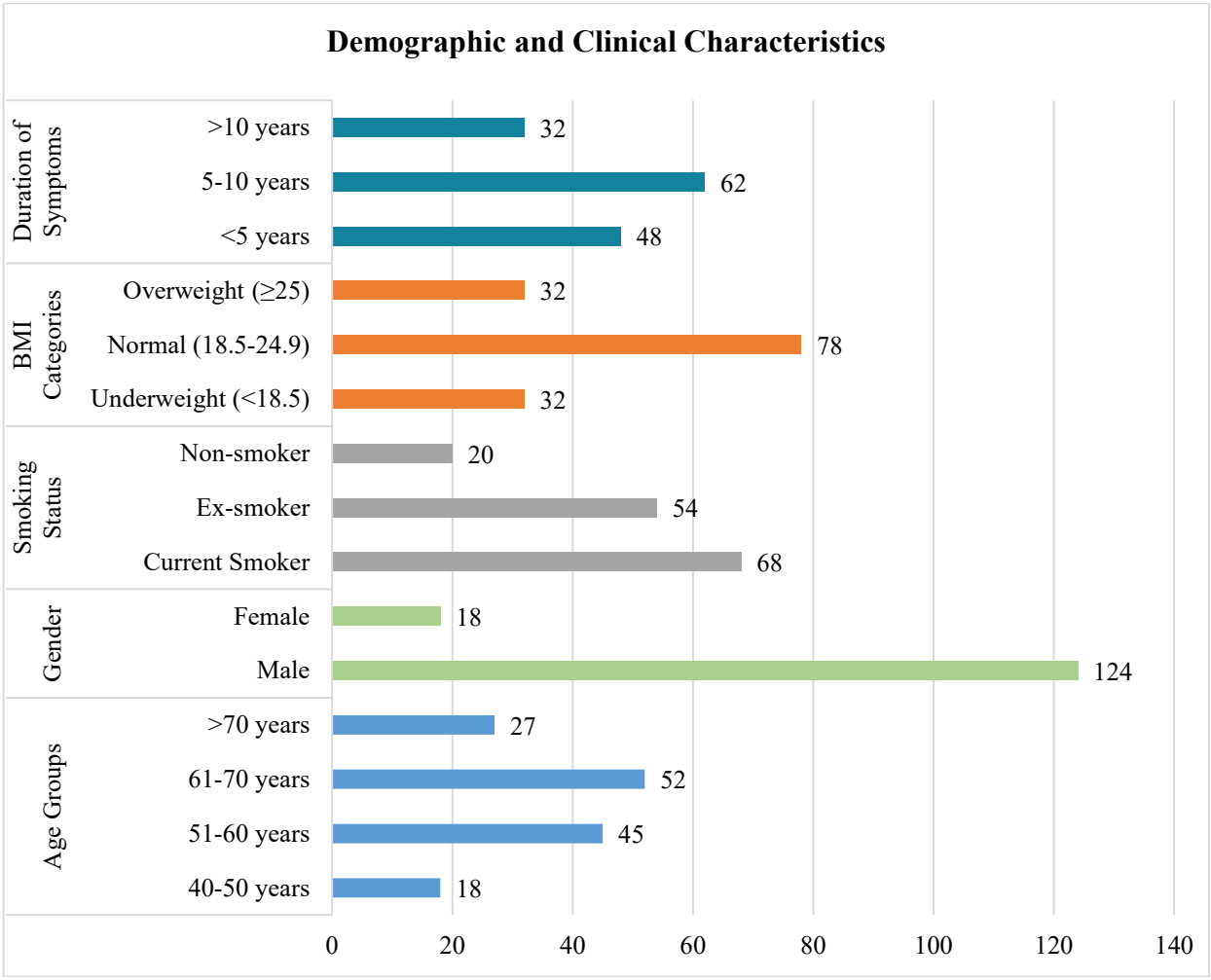


Fig: 1(i)

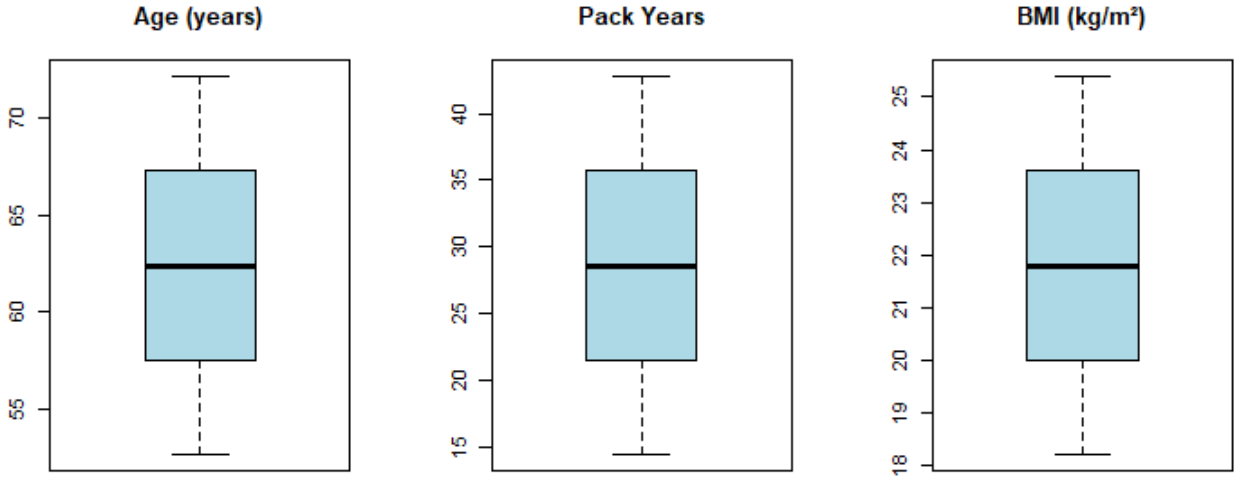
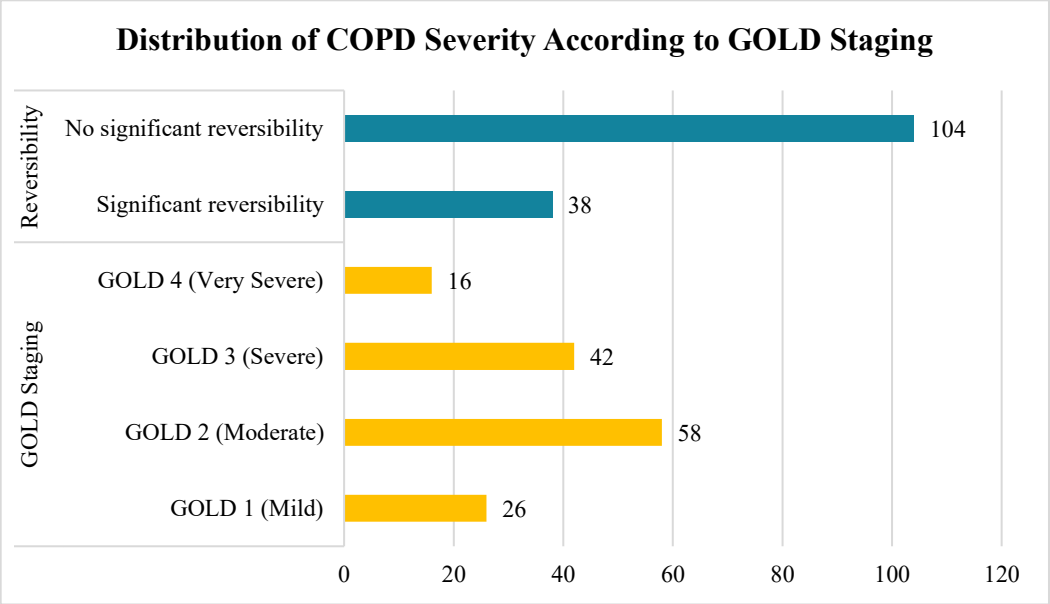


Fig: 1(ii)

Table 2: Distribution of COPD Severity According to GOLD Staging and Spirometric Parameters (N=142)

Parameter	Frequency (n)	Percentage (%)	Mean ± SD
GOLD Staging			
GOLD 1 (Mild)	26	18.3	-
GOLD 2 (Moderate)	58	40.8	-

GOLD 3 (Severe)	42	29.6	-
GOLD 4 (Very Severe)	16	11.3	-
Spirometric Values			
Pre-BD FEV1 (L)	-	-	1.42 ± 0.52
Pre-BD FVC (L)	-	-	2.18 ± 0.68
Pre-BD FEV1/FVC ratio	-	-	0.58 ± 0.12
Post-BD FEV1 (L)	-	-	1.56 ± 0.54
FEV1 % predicted	-	-	52.8 ± 18.4
FVC % predicted	-	-	61.2 ± 16.8
Reversibility			
Significant reversibility	38	26.8	-
No significant reversibility	104	73.2	-



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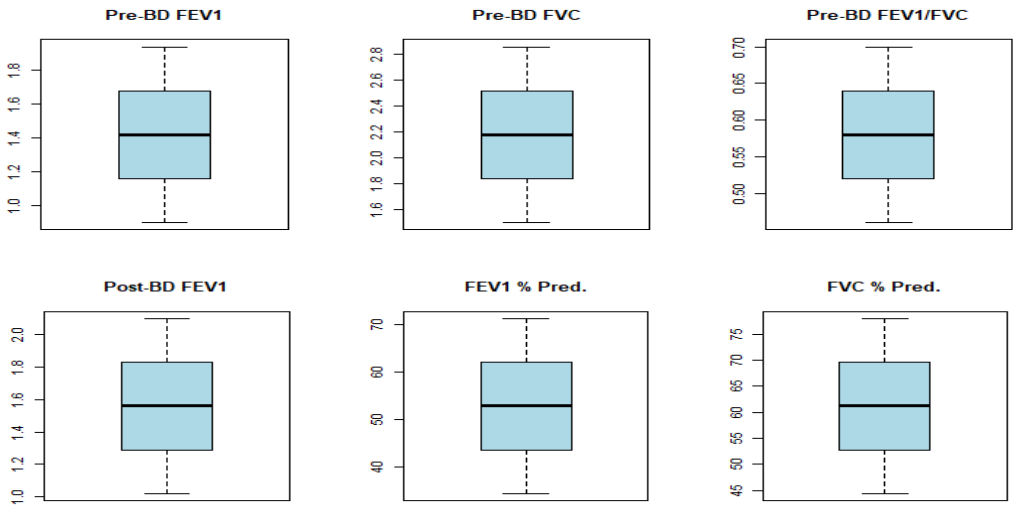


Spirometric Values

Fig: 2 (ii)

Table 3: Frequency of Chest X-ray Findings in COPD Patients (N=142)

Radiographic Finding	Present n (%)	Absent n (%)
Hyperinflation	108 (76.1)	34 (23.9)
Flattened diaphragm	96 (67.6)	46 (32.4)
>7 ribs visible anteriorly	102 (71.8)	40 (28.2)
Increased retrosternal space	84 (59.2)	58 (40.8)
Vascular Changes	94 (66.2)	48 (33.8)
Vascular pruning	78 (54.9)	64 (45.1)
Prominent central vessels	46 (32.4)	96 (67.6)
Cardiac Changes	68 (47.9)	74 (52.1)
Narrow vertical heart	62 (43.7)	80 (56.3)
Cardiomegaly	24 (16.9)	118 (83.1)
Bullae/Blebs	52 (36.6)	90 (63.4)
Increased Bronchovascular Markings	58 (40.8)	84 (59.2)
Bronchial Wall Thickening	42 (29.6)	100 (70.4)
Sabre-sheath Trachea	12 (8.5)	130 (91.5)
Consolidation	8 (5.6)	134 (94.4)
Pleural Thickening	18 (12.7)	124 (87.3)
Normal Chest X-ray	14 (9.9)	128 (90.1)

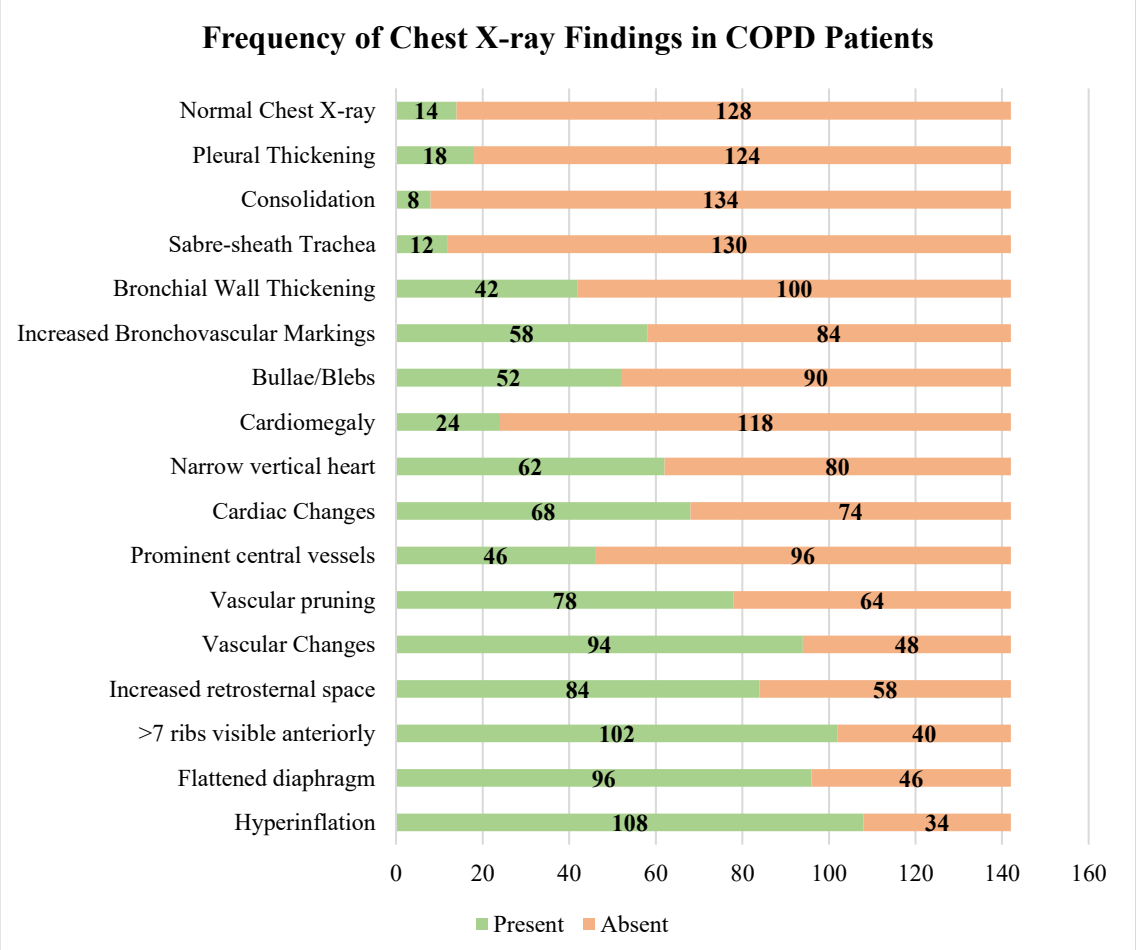


Fig: 3

Table 4: Correlation Between Chest X-ray Findings and COPD Severity (GOLD Staging)

Radiographic Finding	GOLD 1 (n=26)	GOLD 2 (n=58)	GOLD 3 (n=42)	GOLD 4 (n=16)	p-value	Chi-square
Hyperinflation	12 (46.2%)	42 (72.4%)	38 (90.5%)	16 (100%)	<0.001	24.86
Flattened Diaphragm	10 (38.5%)	36 (62.1%)	36 (85.7%)	14 (87.5%)	<0.001	22.14
Vascular Pruning	8 (30.8%)	28 (48.3%)	30 (71.4%)	12 (75.0%)	0.002	15.42
Narrow Vertical Heart	6 (23.1%)	22 (37.9%)	24 (57.1%)	10 (62.5%)	0.006	12.58
Bullae/Blebs	4 (15.4%)	16 (27.6%)	22 (52.4%)	10 (62.5%)	<0.001	18.92
Increased Bronchovascular Markings	14 (53.8%)	26 (44.8%)	14 (33.3%)	4 (25.0%)	0.124	5.76
Normal Chest X-ray	8 (30.8%)	6 (10.3%)	0 (0%)	0 (0%)	<0.001	26.34

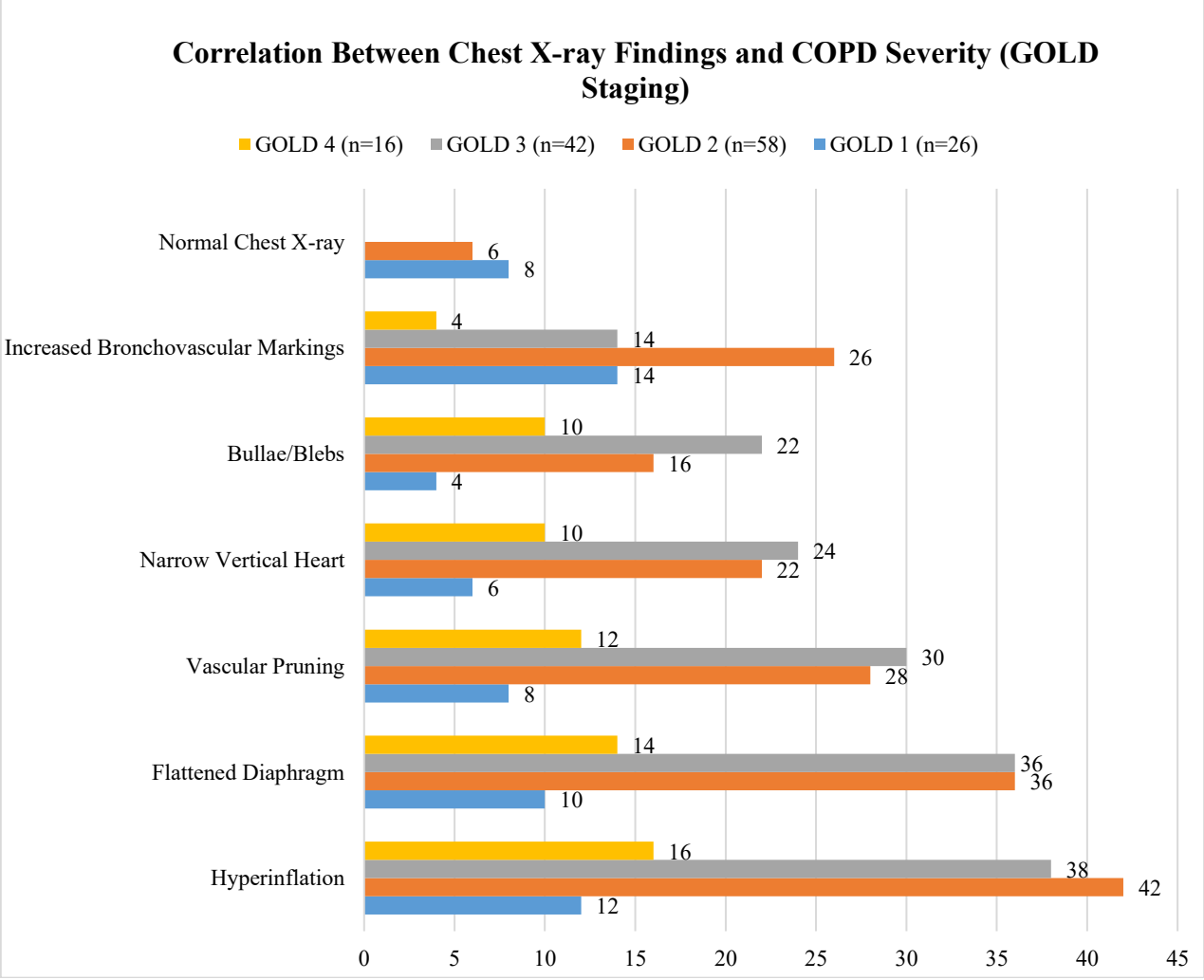
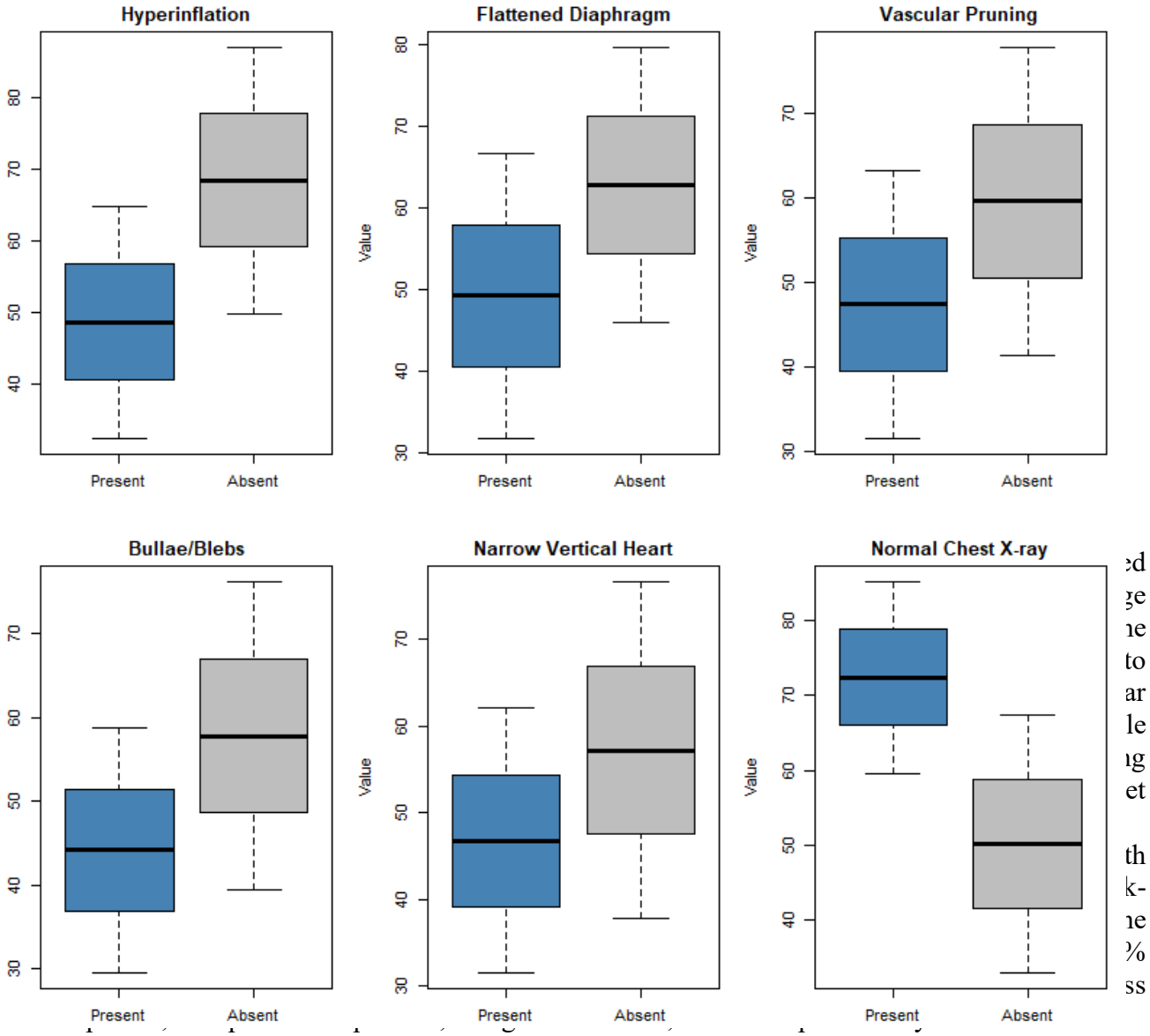


Fig: 4

Table 5: Association Between Chest X-ray Findings and Spirometric Parameters

Radiographic Finding		Mean FEV1 % predicted (±SD)	p-value	Mean FEV1/FVC ratio (±SD)	p-value
Hyperinflation	Present (n=108)	48.6 ± 16.2	<0.001	0.55 ± 0.11	0.002
	Absent (n=34)	68.4 ± 18.6		0.68 ± 0.08	

Flattened Diaphragm	Present (n=96)	49.2 ± 17.4	0.001	0.56 ± 0.12	0.008
	Absent (n=46)	62.8 ± 16.8		0.64 ± 0.10	
Vascular Pruning	Present (n=78)	47.4 ± 15.8	<0.001	0.54 ± 0.11	<0.001
	Absent (n=64)	59.6 ± 18.2		0.63 ± 0.12	
Bullae/Blebs	Present (n=52)	44.2 ± 14.6	<0.001	0.52 ± 0.10	0.001
	Absent (n=90)	57.8 ± 18.4		0.61 ± 0.12	
Narrow Vertical Heart	Present (n=62)	46.8 ± 15.2	0.002	0.54 ± 0.11	0.004
	Absent (n=80)	57.2 ± 19.4		0.61 ± 0.12	
Normal Chest X-ray	Present (n=14)	72.4 ± 12.8	<0.001	0.69 ± 0.06	<0.001
	Absent (n=128)	50.2 ± 17.2		0.57 ± 0.12	



Indian context where indoor air pollution from cooking fuels affects predominantly women (Parasuramalu et al., 2014).

The body mass index analysis revealed that 22.5% of patients were underweight, a finding that has significant prognostic implications. Low BMI in COPD patients is associated with worse outcomes, increased exacerbation rates, and higher mortality. This observation corroborates the findings of Makita et al. (2007), who demonstrated that emphysematous COPD patients exhibited significantly

lower BMI compared to non-emphysematous patients. The nutritional status decline in COPD results from increased energy expenditure due to work of breathing, systemic inflammation, and reduced caloric intake.

The distribution of COPD severity according to GOLD staging showed that 40.8% of patients had moderate disease (GOLD 2), followed by 29.6% with severe disease (GOLD 3), 18.3% with mild disease (GOLD 1), and 11.3% with very severe disease (GOLD 4). This distribution pattern suggests that most patients presented with established moderate to severe disease, indicating delayed diagnosis or presentation to tertiary care. The mean FEV1 percentage predicted of 52.8% and mean FEV1/FVC ratio of 0.58 reflect significant airflow limitation in the study population. These findings are comparable to those reported by Gupta et al. (2009) in their study examining high-resolution CT features in COPD patients, where similar spirometric impairment was documented.

The presence of significant bronchodilator reversibility in 26.8% of patients suggests an overlap phenomenon between COPD and asthma or indicates patients with potentially better treatment response. This finding aligns with contemporary understanding of COPD heterogeneity and the existence of multiple phenotypes. The GOLD guidelines acknowledge that some reversibility may be present in COPD patients, and this finding supports the importance of bronchodilator trials in all COPD patients (Global Initiative for Chronic Obstructive Lung Disease, 2020).

The most frequent radiographic finding in our study was hyperinflation, present in 76.1% of patients, followed by flattened diaphragm (67.6%), more than seven ribs visible anteriorly (71.8%), and vascular changes (66.2%). These findings are consistent with the characteristic radiographic features of emphysema described in previous literature. Washko (2010) reported that chest radiography demonstrates hyperinflation, flattened diaphragms, and vascular pruning as cardinal features of emphysema, though with limited sensitivity for mild disease. The high prevalence of hyperinflation in our study reflects the predominance of moderate to severe COPD in our cohort.

Vascular pruning, observed in 54.9% of patients, represents the destruction of peripheral pulmonary vasculature accompanying emphysematous changes. This finding has been validated against histopathological examination in multiple studies. Miniati et al. (2008) utilized four validated radiographic criteria for emphysema detection and achieved 90% sensitivity and 98% specificity when compared to CT as reference standard. Our findings support the continued utility of chest radiography for identifying emphysematous changes in COPD patients.

The presence of bullae or blebs in 36.6% of patients indicates severe emphysematous destruction and carries important clinical implications. Bullae can become secondarily infected, rupture causing pneumothorax, or occupy significant lung volume contributing to dyspnea. The identification of bullous disease on chest X-ray may prompt consideration for interventional procedures such as bullectomy or lung volume reduction surgery in selected patients (O'Brien et al., 2000).

Increased bronchovascular markings were noted in 40.8% of patients, while bronchial wall thickening was identified in 29.6%. These findings typically represent the chronic bronchitis component of COPD, though they are less specific than emphysematous changes. The relatively lower frequency of these findings compared to hyperinflation suggests that emphysema was the predominant phenotype in our study population, which is consistent with the high proportion of male smokers. Fujimoto et al. (2006) demonstrated that COPD patients could be classified into distinct phenotypes based on CT findings, with emphysema-predominant and airway-disease predominant patterns showing different clinical characteristics.

The narrow vertical cardiac silhouette, observed in 43.7% of patients, results from hyperinflation with downward displacement of the heart and represents an indirect sign of emphysema. Conversely, cardiomegaly was noted in 16.9% of patients, which may indicate cor pulmonale development or concurrent cardiac disease. The rare finding of sabre-sheath trachea in 8.5% of patients represents marked coronal narrowing of the intrathoracic trachea with sagittal widening, a sign that has been associated with severe COPD in previous studies (Greene, 1978).

Importantly, 9.9% of patients with spirometrically confirmed COPD had normal chest X-rays. This finding underscores the limited sensitivity of chest radiography for detecting early or mild COPD

and emphasizes that normal chest X-ray does not exclude COPD diagnosis. Den Harder et al. (2017) demonstrated that mild COPD could not be reliably diagnosed on chest radiography without substantial overdiagnosis, with positive predictive value of only 37-55% for overall appearance specific for COPD. This reinforces that spirometry remains the gold standard for COPD diagnosis, with chest radiography serving complementary roles in phenotyping and excluding alternative diagnoses.

Our study demonstrated statistically significant associations between several chest X-ray findings and COPD severity as classified by GOLD staging. Hyperinflation showed progressive increase from 46.2% in GOLD 1 to 100% in GOLD 4 patients ($p<0.001$), indicating that radiographic evidence of hyperinflation correlates with increasing airflow limitation severity. Similarly, flattened diaphragm, vascular pruning, and presence of bullae showed significant increasing trends with worsening GOLD stage. These findings validate the clinical utility of chest radiography for disease severity assessment and support previous research demonstrating correlation between radiographic features and functional impairment.

The observation that no patients with GOLD 3 or 4 disease had normal chest X-rays, while 30.8% of GOLD 1 patients showed normal radiographs, confirms the lower sensitivity of chest radiography for mild disease. This pattern is consistent with the pathophysiological understanding that radiographic changes become apparent only after substantial structural lung damage has occurred. Makita et al. (2007) similarly found that severity of emphysema on CT correlated significantly with FEV1 decline and symptom burden.

Interestingly, increased bronchovascular markings showed a non-significant inverse trend with disease severity ($p=0.124$), being more common in milder disease stages. This may reflect the natural history of COPD where chronic bronchitis predominates initially, with progressive emphysematous destruction occurring in advanced disease. This finding aligns with the concept of different COPD phenotypes and their evolution over time.

The present study established strong correlations between specific chest X-ray findings and spirometric parameters. Patients with hyperinflation on chest X-ray had significantly lower mean FEV1 percentage predicted (48.6% vs 68.4%, $p<0.001$) and lower FEV1/FVC ratio (0.55 vs 0.68, $p=0.002$) compared to those without hyperinflation. This quantitative relationship between radiographic hyperinflation and spirometric impairment validates the pathophysiological significance of this radiographic finding. Similar associations were observed for flattened diaphragm, vascular pruning, bullae, and narrow vertical heart, all showing significantly worse spirometric values when present.

These findings corroborate the study by Miniati et al. (2008), who demonstrated that emphysematous patients identified on chest radiography had significantly lower FEV1 and diffusing capacity compared to non-emphysematous COPD patients. The correlation between radiographic features and functional impairment provides evidence that chest X-ray findings have clinical relevance beyond mere anatomical description. Importantly, patients with normal chest X-rays despite spirometric COPD diagnosis had significantly better lung function (mean FEV1 72.4% predicted) compared to those with abnormal radiographs (50.2% predicted, $p<0.001$), confirming that radiographic abnormalities generally appear in more advanced disease.

The relationship between bullae presence and spirometric impairment (mean FEV1 44.2% vs 57.8%, $p<0.001$) deserves particular attention as bullous disease represents severe emphysematous destruction and may be amenable to surgical intervention in selected cases. The identification of such patients through chest radiography can prompt appropriate referrals for advanced imaging and evaluation for lung volume reduction procedures (O'Brien et al., 2000).

The findings from our study support the role of chest radiography in COPD phenotyping, as proposed by Miniati et al. (2008). The presence or absence of emphysematous changes on chest X-ray helps distinguish emphysema-predominant from chronic bronchitis-predominant phenotypes, which may have implications for prognosis and treatment selection. Fujimoto et al. (2006) demonstrated that COPD phenotypes classified by imaging characteristics showed different clinical

profiles and disease progression patterns. Our data extend these observations by providing prevalence estimates for various radiographic findings in an Indian COPD population.

The study also highlights the continued relevance of chest radiography despite advances in CT technology. While CT offers superior sensitivity and specificity for detecting emphysema and airway abnormalities, chest X-ray remains more accessible, less expensive, involves lower radiation exposure, and provides clinically useful information for the majority of COPD patients (Washko, 2010). In resource-limited settings like many parts of India, chest radiography represents a practical imaging tool for COPD assessment.

CONCLUSION

This study demonstrated that chest X-ray abnormalities are highly prevalent in COPD patients, with hyperinflation being the most common finding. Significant correlations exist between radiographic features and both COPD severity and spirometric parameters. Patients with emphysematous changes on chest X-ray showed worse lung function and more advanced disease compared to those without such findings. While chest radiography has limited sensitivity for mild COPD, it provides valuable information for disease phenotyping, severity assessment, and exclusion of comorbidities. The findings support the continued utility of chest radiography as a complementary diagnostic tool alongside spirometry in comprehensive COPD evaluation, particularly in resource-limited settings.

RECOMMENDATIONS

Chest radiography should be incorporated as a routine component of COPD assessment at diagnosis and during follow-up to identify complications. Standardized reporting protocols for COPD chest X-rays should be implemented to improve consistency and inter-observer agreement. Further research should evaluate the prognostic value of specific radiographic patterns and their correlation with clinical outcomes. Healthcare providers should be trained to recognize subtle radiographic signs of COPD to facilitate early diagnosis and intervention.

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