



Echocardiographic Manifestations in Chronic Obstructive Pulmonary Disease Patients with a History of Chronic Smoking: A Cross-sectional Study

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[Visual Abstract](#)

ABSTRACT

Background: This study aimed to evaluate the clinical profile and its association with spirometry and two-dimensional (2D) echocardiographic findings in patients with chronic obstructive pulmonary disease (COPD).

Methodology: A cross-sectional study was carried out at LLRM Medical College, Meerut, which included 144 COPD patients over 40 years of age, selected after informed consent and ethical approval. Patients with other respiratory or cardiac diseases, immunocompromised status, or poor echocardiographic imaging were excluded. Each participant underwent clinical evaluation, which included a history of respiratory symptoms and comorbidities, along with comprehensive investigations such as blood tests, spirometry, chest X-ray, sputum analysis, electrocardiography (ECG), arterial blood gases, and 2D echocardiography. Data analysis was conducted using Statistical Package for the Social Sciences (SPSS) version 29. A p -value < 0.05 was considered statistically significant.

Results: The data reveal that most COPD patients fall into Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage 3 (severe), with a significant number also in stage 2 (moderate), indicating a high prevalence of advanced disease. COPD predominantly affects individuals over 50, with peak occurrence in the 60–69 age-group. Disease duration increases with severity, ranging from 2.38 years in stage 1 to 16.74 years in stage 4, showing a clear link between duration and progression. ECG abnormalities such as P-pulmonale, right ventricular hypertrophy (RVH), arrhythmias, and low QRS voltage were more frequent in severe stages, especially stage 3, highlighting the cardiovascular burden in advanced COPD. Echocardiographic findings, including pulmonary hypertension, right atrial enlargement, right ventricular dysfunction, and tricuspid regurgitation, showed significant association with disease severity ($p < 0.05$).

Conclusion: This study demonstrates a strong link between COPD severity and cardiovascular complications, especially right heart involvement. Significant associations between GOLD stages and 2D echocardiographic findings highlight the importance of routine cardiac screening in COPD patients. Pulmonary hypertension, right ventricular dysfunction, and tricuspid regurgitation were the most common complications, underscoring the need for close monitoring and targeted treatment. Early intervention and integrated cardiac evaluation in COPD management can help prevent right heart failure and improve patient outcomes.

Keywords: Chronic obstructive pulmonary disease, Smoking, Spirometry.

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) contributes significantly to global mortality and morbidity, responsible for over 3 million deaths annually. In 2020, 251 million individuals were affected worldwide, with a high burden in low- and middle-income countries like India.^{1,2} Prevalence in India varies regionally, ranging from 2 to 22% in men and 1.2 to 19% in women, with higher rates seen in Empowered Action Group (EAG) states and the Northeast. Risk factors include aging, smoking, biomass fuel use, poor ventilation, and past tuberculosis.^{3,4}

Pathologically, COPD is characterized by chronic inflammation, airway remodeling, and airflow obstruction.⁵ The Global

Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines classify disease severity based on spirometry.⁶ Importantly, COPD extends beyond pulmonary impairment and significantly affects cardiovascular health.

Cardiovascular problems—particularly coronary artery disease (30.2%), heart failure (15.7%), and dysarrhythmias (13%)—are major causes of morbidity and mortality among COPD patients. A 10% reduction in FEV₁ increases heart-related death by 28% and morbid coronary events by 20%. COPD is also linked to atherosclerosis, as shown by raised carotid intimal medial thickening (CMT).⁷

A study in Madurai found a 22.1% COPD prevalence, higher in men (39.2%) than

women (12.2%), associated with smoking and environmental risks. Smoking worsens cardiac outcomes, leading to pulmonary hypertension and right heart failure.⁸

Two-dimensional (2D) echocardiography and electrocardiography (ECG) are effective in detecting cardiac abnormalities, such as right ventricular hypertrophy and tricuspid regurgitation. These findings correlate with disease severity, highlighting the need for early cardiovascular screening and intervention in COPD patients.

MATERIALS AND METHODS

A cross-sectional study was carried out at LLRM Medical College, Meerut, among patients admitted to the Medicine Ward, following informed written consent from participants and approval from the institutional ethical committee. The total sample size for the study was 144, calculated using the formula $4pq/D^2$, where p represents the prevalence of COPD (taken as 10%), $q = 100 - p = 90$, and d is the allowable error (5%). All patients meeting the inclusion criteria were interviewed, and relevant investigations were conducted. Clinical and laboratory data were extracted from patient records and analyzed using appropriate statistical software. Smoking exposure was quantified in pack-years and categorized based on the duration and intensity of smoking to assess its association with spirometric severity and echocardiographic abnormalities.

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Statistical Analysis

Data were compiled using Microsoft Excel and analyzed with Statistical Package for the Social Sciences (SPSS) version 29. Continuous variables were summarized using mean and standard deviation, and categorical variables as frequency and percentage. Associations between categorical variables were tested using the Chi-squared test/Fisher's exact test. Relationships between continuous variables were analyzed using Pearson correlation (*r*). A *p*-value < 0.05 was considered statistically significant.

The inclusion criteria comprised adult female and male COPD patients aged over 40 years. The exclusion criteria comprised patients having known respiratory diseases other than COPD, those with a history of cardiac diseases such as ischemic heart disease, rheumatic or valvular heart disorders, congenital heart conditions, or peripheral vascular disease. Additionally, immunocompromised individuals and patients with poor echogenicity, in whom diagnostic echocardiographic evaluation could not be performed, were excluded.

Each enrolled patient underwent a comprehensive evaluation, including a detailed clinical history of presenting complaints such as breathlessness, chest pain, cough with sputum, fever, weight loss, and appetite loss. Symptoms of comorbid conditions such as cardiac, hepatic, or renal failure (e.g., pedal edema, abdominal distension, and reduced urine output) were documented. Past medical history, particularly of tuberculosis, antitubercular treatment, diabetes, or other significant illnesses, as well as contact with patients with tuberculosis, was recorded. All participants underwent investigations such as complete blood count, kidney and liver function tests, serum electrolytes, virology screening, spirometry, chest X-ray (PA view), sputum analysis for CBNAAT and culture sensitivity, ELISA for HIV, arterial blood gas analysis, ECG, and a 2D echocardiogram. This comprehensive approach aimed to assess the systemic and cardiac impact of COPD in detail.

RESULTS

The distribution of COPD patients according to GOLD staging is shown in Table 1. The majority of patients fall under stage 3 (severe), followed by stage 2 (moderate). Stage 4 (very severe) and stage 1 (mild) comprise 13.19 and 9.02% of the population, respectively. Overall, the data show a higher prevalence of severe forms of COPD among the study population.

The age-wise distribution of patients is presented in Table 2. The highest number

of patients falls in the 60–69 age-group (56 cases), followed closely by the 50–59 age-group (52 cases). The 40–49 and 70–79 age-groups account for 14 and 18 patients, respectively. Very few cases are seen in the 80–89 age-group (4 patients), and none are reported in the 30–39 range. This indicates that COPD predominantly affects individuals over 50 years of age.

The mean duration of COPD across different GOLD stages is shown in Table 3. Patients in stage 1 (mild) have had the disease for an average of 2.38 years. The duration increases progressively with disease severity: 5.58 years in stage 2, 9.93 years in stage 3, and 16.74 years in stage 4. This trend suggests a strong correlation between disease progression and duration of illness. Longer disease duration is associated with more severe GOLD stages.

The distribution of ECG abnormalities across GOLD stages is summarized in Table 4. P-pulmonale and right ventricular hypertrophy (RVH) are most prevalent in stage 3 (severe), with 46 and 43 cases, respectively. Stage 2 (moderate) shows a high incidence of arrhythmias (18) and low QRS voltage (21). In stage 4 (very severe), RVH remains notable (17 cases), but arrhythmias and low QRS voltage are less frequent. ECG abnormalities become more prominent with increasing COPD severity, especially in GOLD stages 2 and 3 (*p*-value < 0.05).

Table 1: Distribution of COPD patients according to GOLD staging (*n* = 144)

GOLD stage	Number of patients	Percentage
Stage 1 (mild)	13	9.02%
Stage 2 (moderate)	52	36.11%
Stage 3 (severe)	60	41.66%
Stage 4 (very severe)	19	13.19%
Total	144	100%

GOLD, Global Initiative for Chronic Obstructive Lung Disease

Table 2: Age-wise distribution of COPD patients (*n* = 144)

Age-group (years)	Number of patients
40–49	14
50–59	52
60–69	56
70–79	18
80–89	4
Total	144

GOLD, Global Initiative for Chronic Obstructive Lung Disease

Echocardiographic findings across different GOLD stages are presented in Table 5. It shows a progressive increase in right-sided cardiac abnormalities (RAE, RVD, RVH, TR, pulmonary hypertension, and cor pulmonale) from mild to very severe COPD. Left ventricular changes (LVDD, LVH) rise in severe stages. Overall, advanced GOLD stages were strongly associated with right heart dysfunction and pulmonary hypertension (*p*-value < 0.05).

The distribution of clinical symptoms across GOLD stages is shown in Table 6. Breathlessness was the most common symptom across all GOLD stages. Raised JVP and pedal edema were more prevalent in severe and very severe stages, suggesting worsening right heart strain in advanced COPD. Symptoms progressively worsen from mild to moderate to severe stages, with a slight drop in symptoms at the very severe stage, possibly due to patient adaptation or reduced reporting.

DISCUSSION

This study classified patients based on the GOLD criteria. The highest prevalence was noted in GOLD stage 3 (severe COPD), with 60 patients, followed by stage 2 (moderate, 52 patients), stage 4 (very severe, 19 patients), and stage 1 (mild, 13 patients). These findings are consistent with global trends, where moderate to severe cases dominate clinical presentations, often due to delayed diagnosis and intervention. Comparable findings have been reported in earlier studies.¹

When symptoms were stratified across GOLD stages, breathlessness and cough were universally present, with increasing frequency and severity noted from GOLD 1 to GOLD 4. Raised JVP and pedal edema—markers of right heart strain—were most prevalent in GOLD stages 3 and 4. For instance, breathlessness was reported in all 19 GOLD 4 patients and 50 of 60 GOLD 3 patients. These findings are consistent with established clinical guidelines and prior studies,¹ underscoring that symptom burden escalates with disease severity.

Table 3: Mean duration of COPD across GOLD stages

GOLD stage	Mean duration (years)
Stage 1 (mild)	2.38
Stage 2 (moderate)	5.58
Stage 3 (severe)	9.93
Stage 4 (very severe)	16.74

GOLD, Global Initiative for Chronic Obstructive Lung Disease

Table 4: Distribution of ECG abnormalities across GOLD stages

GOLD stage	P-pulmonale	RVH	Arrhythmia	Low QRS voltage
Stage 1	12	4	3	2
Stage 2	23	11	18	21
Stage 3	46	43	21	17
Stage 4	15	17	5	2

ECG, electrocardiogram; RVH, right ventricular hypertrophy

Table 5: Echocardiographic findings across GOLD stages

Finding	Mild	Moderate	Severe	Very severe
Cor pulmonale	7	21	33	16
LVDD	2	1	4	5
LVH	6	9	44	16
Pulmonary hypertension	4	11	43	17
RAE	4	23	46	15
RVD	6	25	43	15
RVH	4	15	41	16
TR	9	20	49	14

RAE, right atrial enlargement; RVD, right ventricular dilatation; TR, tricuspid regurgitation

Table 6: Distribution of clinical symptoms across GOLD stages

GOLD stage	Breathlessness	Raised JVP	Pedal edema	Cough
Stage 1	13	7	7	9
Stage 2	50	21	21	33
Stage 3	57	33	33	45
Stage 4	19	16	16	13

JVP, jugular venous pressure

The age distribution of participants ranged from 46 to 85 years, with a mean age of 60.79 ± 8.52 years and a median of 61. These figures align with global literature indicating higher COPD prevalence in older populations, as chronic exposure to smoking and environmental pollutants accumulates over time. Previous studies have also highlighted a strong association between age and COPD severity¹⁰ and onset, reinforcing the need for early screening in individuals over 50 years. In terms of gender distribution, a significant male predominance was observed—122 males compared to 22 females. Similar gender-based trends have been observed in earlier studies,^{10,11} which attribute higher male prevalence to greater exposure to smoking and occupational hazards. However, increasing COPD incidence among women in recent years due to biomass fuel exposure and rising smoking trends underlines the necessity of gender-sensitive public health strategies.

A significant correlation was found between clinical symptoms and 2D echocardiographic findings. Raised JVP and pedal edema showed perfect positive correlations ($r = 1.0$) with cor pulmonale, reflecting their reliability as clinical markers for right heart dysfunction. Additionally, mild

positive correlations were noted between breathlessness and echocardiographic signs like right atrial enlargement (RAE) and right ventricular hypertrophy (RVH), reinforcing their diagnostic value.

Analyzing the duration of COPD revealed a strong link with disease severity. The average disease duration in GOLD 4 patients was 16.74 years, compared to just 2.38 years in GOLD 1. A correlation coefficient of 0.92 indicated a very strong positive association, suggesting that the longer the disease persists, the more likely patients are to develop severe airflow obstruction. This observation is supported by findings from previous studies,¹⁰ where disease duration and exposure were key predictors of progression.

ECG findings also showed clear stratification with disease severity and duration. ECG signs like P-pulmonale and RVH were more common in GOLD stages 3 and 4, with P-pulmonale observed in 46 GOLD 3 patients and 15 GOLD 4 patients. These changes are hallmarks of chronic right heart strain due to pulmonary hypertension. RVH prevalence also rose with disease duration, reaching over 90% in patients with disease duration beyond 12 years. These

results reinforce ECG's utility^{12,13} as a simple yet effective screening tool, especially in resource-constrained settings.

A strong correlation was also seen between ECG findings and 2D echocardiography. For example, RAE was 100% consistent with ECG P-pulmonale, and pulmonary hypertension was strongly associated with ECG RVH. Tricuspid regurgitation (TR), another marker of right heart pressure overload, was noted in 65.28% of patients, further reinforcing the interdependence, as reported in earlier studies,^{13,14} of echocardiographic and ECG indicators.

By GOLD stage, echocardiographic abnormalities became progressively common. RVH increased from 21.6% in GOLD 1 to 84.21% in GOLD 4. Similarly, pulmonary hypertension rose from 30.77% in GOLD 1 to nearly 90% in GOLD 4. Other cardiac manifestations, such as RVD, cor pulmonale, TR, and RAE, followed similar patterns. These findings are in agreement with previous studies¹³ that persistent hypoxia and pulmonary vascular remodeling in advanced COPD lead to progressive right heart involvement (Chi-square p -value < 0.05).

Interestingly, left-sided cardiac abnormalities like LVH and LVDD, though not primary manifestations of COPD, were more frequent in advanced stages, suggesting coexisting systemic hypertension or aging-related changes. LVDD was highest in GOLD 4 (26.32%), with similar observations reported in previous studies,¹⁵ where LV diastolic dysfunction was linked to poor exercise capacity and comorbid cardiovascular disease in COPD patients.

The correlation coefficient between FEV1 and pulmonary hypertension was -0.48 , indicating a moderate negative association—lower FEV1 values were linked with a higher likelihood of pulmonary hypertension, as associated in previous studies.¹⁵ This supports well-established pathophysiology that airflow obstruction and hypoxia elevate pulmonary artery pressure. Similarly, the correlation of cor pulmonale with raised JVP and pedal edema (Pearson correlation $r = 1.0$) validates these signs as important noninvasive diagnostic tools.

In conclusion, the study underscores the intertwined nature of pulmonary and cardiac complications in COPD. With increasing GOLD stage and longer disease duration, both the prevalence and severity of right heart dysfunction escalate significantly. Clinical signs like raised JVP and pedal edema, alongside ECG and echocardiographic findings, provide valuable insight into disease progression and should be routinely evaluated in COPD management. Early detection

of cardiac involvement through simple clinical and diagnostic tools can guide timely interventions and improve patient outcomes.

CONCLUSION

In conclusion, this cross-sectional study of 144 COPD patients found that echocardiographic abnormalities were highly prevalent and increased significantly with disease severity. Cor pulmonale was present in 53.5% and showed a significant association with advanced GOLD stages (Chi-square $p = 0.03$). Tricuspid regurgitation increased significantly with GOLD severity ($p < 0.001$), while right atrial enlargement (66.7%, $p = 0.0008$) and right ventricular dysfunction (65.3%, $p = 0.008$) were significantly more common in severe and very severe COPD.

The statistically significant associations observed between GOLD staging and various 2D echocardiographic parameters underscore the necessity of incorporating echocardiographic screening into routine COPD evaluation. Pulmonary hypertension, right ventricular dysfunction, and tricuspid regurgitation emerged as the most prominent cardiovascular complications, necessitating close monitoring and targeted management. The correlation analysis further elucidated the interlinked nature of these abnormalities, providing valuable insights into disease progression. Most

importantly, the findings reinforce the need for early intervention strategies to impede or alleviate right heart failure in COPD patients. By integrating comprehensive cardiac assessments into COPD management protocols, healthcare providers can enhance patient care and improve long-term outcomes.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The study received prior approval from the Institutional Ethics Committee of LLRM Medical College, Meerut, and informed consent was obtained from all participants.

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