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Original Research Article

Study of Cardiac Dysfunction by Echocardiography in Patients of Chronic Obstructive Pulmonary Disease Classified on the Basis of GOLD Guideline 2024

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Abstract

Introduction: Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder associated with important cardiovascular complications such as pulmonary hypertension, right ventricular dysfunction, and cor pulmonale. Echocardiography is a non-invasive method for detecting these abnormalities. The present study was conducted to evaluate cardiac dysfunction in COPD patients and correlate echocardiographic findings with disease severity according to GOLD 2024 classification.

Materials and Methods: This hospital-based cross-sectional observational study was conducted in 100 COPD patients aged more than 40 years over a period of 18 months. Diagnosis and severity grading were based on GOLD 2024 criteria using spirometry. Detailed clinical history, examination, and transthoracic echocardiography were performed in all patients. Echocardiographic findings were correlated with COPD severity.

Results: The mean age of the patients was 52.8 ± 8.6 years and males constituted 62% of the study population. Smoking was present in 68% of patients. Tricuspid regurgitation was the most common echocardiographic abnormality and was observed in 56% of patients, followed by pulmonary arterial hypertension in 53%, left ventricular hypertrophy in 33%, right atrial enlargement in 16%, and right ventricular dilatation in 14%. Pulmonary arterial hypertension increased from 1.9% in mild COPD to 52.8% in very severe COPD. Similar increases were noted in tricuspid regurgitation, right atrial enlargement, and right ventricular dilatation with increasing COPD severity.

Conclusion: Cardiac dysfunction was common in COPD patients and increased with worsening disease severity. Echocardiography was found to be an effective non-invasive tool for early detection of cardiovascular abnormalities.

Keywords: Chronic Obstructive Pulmonary Disease, Echocardiography, Pulmonary Arterial Hypertension, GOLD 2024, Cardiac Dysfunction

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable, and treatable disease characterized by persistent respiratory symptoms and progressive airflow limitation caused by chronic inflammatory changes in the airways and lungs due to exposure to harmful particles and gases [1]. The major pathological components of COPD include chronic bronchitis and emphysema, both of which contribute to irreversible airflow obstruction [2]. Tobacco smoking remains the most important risk factor worldwide, while biomass fuel exposure, occupational dust, environmental pollution, and recurrent respiratory infections play a major role in developing countries such as India [1,2].

COPD is a major public health concern and is currently the third leading cause of death worldwide according to the World Health

Organization [3]. The global burden of COPD has increased significantly over recent decades because of increased smoking, urbanization, environmental pollution, and ageing of the population [4]. In India, the prevalence of COPD has been reported to range between 6.5% and 7.7%, largely due to smoking, indoor air pollution, poor air quality, post-tuberculosis lung damage, and biomass fuel exposure [5].

The diagnosis of COPD is confirmed by spirometry, with a post-bronchodilator FEV_1/FVC ratio of less than 0.70 indicating persistent airflow limitation [1]. According to GOLD 2024 guidelines, COPD severity is classified into four spirometric stages: GOLD 1 (FEV_1 ≥80% predicted), GOLD 2 (FEV_1 50–79%), GOLD 3 (FEV_1 30–49%), and GOLD 4 (FEV_1 <30%) [1]. The updated GOLD 2024 guidelines also incorporate symptom burden using mMRC and CAT scores along with exacerbation history for better assessment of disease severity [1].

Although COPD is primarily a respiratory disease, it is increasingly recognized as a systemic disorder with significant cardiovascular involvement [6]. Cardiovascular complications account for nearly half of hospitalizations and about one-third of deaths in COPD patients [6,7]. Pulmonary hypertension, cor pulmonale, right ventricular hypertrophy, right ventricular dysfunction, left ventricular dysfunction, arrhythmias, ischemic heart disease, and heart failure are among the common cardiovascular manifestations associated with COPD [8,9].

The development of cardiac dysfunction in COPD is mainly related to chronic hypoxemia, pulmonary vasoconstriction, pulmonary vascular remodeling, systemic inflammation, oxidative stress, and increased sympathetic activity [10]. These factors increase pulmonary artery pressure and eventually result in right ventricular overload, hypertrophy, and failure [11]. Progressive right heart dysfunction may also affect left ventricular filling because of ventricular interdependence [11].

Echocardiography is a valuable, non-invasive, and cost-effective tool for evaluating cardiac abnormalities in COPD patients [12]. It provides important information regarding right and left ventricular function, pulmonary artery pressure, tricuspid regurgitation, right atrial pressure, and cardiac chamber size [12]. Parameters such as tricuspid annular plane systolic excursion (TAPSE), right ventricular fractional area change (RV FAC), myocardial performance index (Tei index), and pulmonary artery systolic pressure (PASP) are useful in assessing right heart dysfunction in COPD [13–15].

Early echocardiographic detection of cardiac dysfunction may help in timely management, reduce hospitalizations, and improve outcomes in COPD patients [12]. Therefore, the present study was undertaken to evaluate cardiac dysfunction by echocardiography in COPD patients and to correlate echocardiographic abnormalities with disease severity classified according to GOLD Guideline 2024.

Methodology:

Study Design

The present study was a cross-sectional observational study conducted to evaluate cardiac dysfunction by echocardiography in patients with Chronic Obstructive Pulmonary Disease (COPD). Patients were classified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) Guideline 2024 based on spirometry findings.

Study Setting

The study was conducted in the Departments of Respiratory Medicine and General Medicine at K.D. Medical College Hospital and Research Centre, Mathura. The hospital catered to both urban and rural populations, ensuring inclusion of a diverse group of COPD patients.

Study Duration

The study was conducted over a period of 18 months.

Study Population

The study population consisted of patients diagnosed with COPD who attended the outpatient department or were admitted to the inpatient department of K.D. Medical College Hospital and Research Centre, Mathura. Patients were enrolled consecutively after satisfying the inclusion and exclusion criteria.

Ethical Approval and Consent

Approval for the study was obtained from the Institutional Ethics Committee of K.D. Medical College, Mathura. Written informed consent was obtained from all study participants before enrolment. Confidentiality of patient information was maintained throughout the study period.

Inclusion Criteria

- Patients who provided written informed consent.
- Patients aged more than 40 years.
- Patients diagnosed with COPD by spirometry according to GOLD 2024 guidelines.

Exclusion Criteria

- Patients who did not provide consent.
- Patients with pulmonary diseases other than COPD.
- Patients with documented cardiac disease.
- Patients with active or past tubercular infection.
- Patients with pulmonary hypertension due to causes other than COPD.

Sample Size Calculation

A total of 100 patients were included in the study.

Methodology

Eligible patients were selected after detailed screening. After obtaining written informed consent, a detailed clinical history was recorded in a structured proforma. Information regarding demographic profile, presenting complaints, history of present illness, past medical history, family history, and personal habits was obtained. A complete general physical and systemic examination was performed in all patients. Respiratory, cardiovascular, abdominal, and central nervous system examinations were carried out.

Diagnosis and Classification of COPD

The diagnosis of COPD was established by spirometry according to GOLD 2024 guidelines. Spirometry was performed using a calibrated spirometer. Pre-bronchodilator values for FEV_1, FVC, and FEV_1/FVC ratio were recorded. After administration of 200–400 micrograms of inhaled salbutamol, post-bronchodilator spirometry was performed after 10–15 minutes. Airway obstruction was defined as post-bronchodilator FEV_1/FVC ratio less than 70%. COPD severity was classified as mild (FEV_1 ≥80% predicted), moderate (FEV_1 50–79% predicted), severe (FEV_1 30–49% predicted), and very severe (FEV_1 <30% predicted).

Echocardiographic Evaluation

All COPD patients underwent two-dimensional echocardiographic assessment performed by an experienced cardiologist. Right heart parameters evaluated included right ventricular size during systole and diastole, right atrial size, right ventricular systolic function using tricuspid annular plane systolic excursion (TAPSE), right ventricular diastolic function, right ventricular wall thickness, systolic pulmonary artery pressure, right atrial pressure estimated from inferior vena cava size and collapsibility, and pulmonary artery diastolic pressure. Left heart assessment included left ventricular size and function, left atrial size, ejection fraction, and diastolic function. Echocardiographic findings were correlated with COPD severity based on FEV_1 values.

Investigations

The following investigations were performed in all patients:

- Chest X-ray to assess hyperinflation and exclude other pulmonary pathology.
- Electrocardiogram (ECG) to identify rhythm abnormalities and evidence of cor pulmonale.
- Pulmonary function test (PFT) to confirm COPD and classify severity.
- Two-dimensional echocardiography to assess cardiac structure and function.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using SPSS version 25. Continuous variables such as age, body mass index, duration of COPD, FEV_1/FVC ratio, and pulmonary artery systolic pressure were expressed as mean ± standard deviation or median with interquartile range, depending on data distribution. Categorical variables such as sex, residence, occupation, smoking status, comorbidities, MMRC grade, COPD severity, and echocardiographic findings were presented as frequencies and percentages. Associations between categorical variables were analyzed using the Chi-square test. Pearson's correlation coefficient was used to assess the relationship between COPD severity and cardiac parameters. A p-value less than 0.05 was considered statistically significant.

Results:

The present cross-sectional observational study was conducted over a period of 18 months at K.D. Medical College Hospital and Research Centre, Mathura, to evaluate cardiac dysfunction in patients with Chronic Obstructive Pulmonary Disease (COPD) using two-dimensional echocardiography. A total of 100 patients aged more than 40 years were included in the study after applying the inclusion and exclusion criteria. COPD severity was classified according to GOLD 2024 guidelines based on spirometry findings.

The majority of patients belonged to the 50–59 years age group (34%), followed by 60–69 years (26%) and 40–49 years (22%). The mean age of the study population was 52.8 ± 8.6 years, with a median age of 54 years (IQR: 47–60 years). Males constituted 62% of the study population, while females accounted for 38%, showing a male predominance.

Regarding body mass index, 42% of patients had normal BMI, while 34% were overweight and 16% were obese. Only 8% were underweight. The mean BMI was 25.6 ± 4.2 kg/m², with a median of 25.1 kg/m² (IQR: 22.4–28.6). Rural residents formed 64% of the study population, whereas 36% were from urban areas. Farmers constituted the largest

occupational group (45%), followed by housewives (16%), laborers (14%), ex-servicemen (10%), clerks (8%), and shopkeepers (7%).

Hypertension was the most common comorbidity, present in 41% of patients, followed by diabetes mellitus in 25%. Hypothyroidism and cerebrovascular accident were observed in 5% and 4% of patients, respectively, while 25% of patients had no associated comorbidity. Smoking was highly prevalent, with 68% of patients being smokers and 32% non-smokers.

The mean duration of COPD was 4.16 ± 4.16 years, with a median duration of 4 years (IQR: 0.05–5.88 years). Forty-five percent of patients were on treatment, whereas 55% were not receiving any treatment at the time of evaluation.

Assessment of dyspnea severity using the Modified Medical Research Council (MMRC) grading system showed that Grade 4 dyspnea was the most common, observed in 45% of patients, followed by Grade 3 in 33%, Grade 2 in 17%, and Grade 1 in only 5% of patients.

Among clinical signs of right heart failure, pedal edema was present in 47% of patients, while raised jugular venous pressure and hepatomegaly were each observed in 6%. On respiratory examination, rhonchi alone were noted in 48% of patients, rhonchi with crepitations in 46%, and isolated crepitations in 6%.

Cardiovascular examination was normal in 94% of patients, while 6% had an irregularly irregular pulse suggestive of atrial fibrillation. Chest radiography showed low and flat diaphragms in 48% of patients, hyperinflated lungs in 45%, tubular heart in 45%, prominent hilar vessels in 15%, bullae in 8%, and cardiomegaly in 9%.

Electrocardiographic abnormalities included P pulmonale in 20% of patients, right axis deviation in 3%, right bundle branch block in 9%, and Lead I sign in 9%. Other ECG findings included left axis deviation in 27%, sinus tachycardia in 26%, atrial fibrillation in 6%, left ventricular hypertrophy in 5%, T-wave abnormalities in 3%, sinus bradycardia in 2%, and poor R-wave progression in 2%.

Echocardiographic evaluation revealed that tricuspid regurgitation was the most common abnormality, present in 56% of patients, followed by pulmonary arterial hypertension in 53%. Right atrial enlargement was observed in 16%, right ventricular dilatation in 14%, right ventricular hypertrophy in 4%, and right ventricular systolic dysfunction in 3%. No patient had pulmonary valve regurgitation. The mean systolic pulmonary artery pressure/right ventricular systolic pressure was 41.83 ± 8.42 mmHg, with a median of 41 mmHg (IQR: 35–46 mmHg).

Among left-sided cardiac findings, left ventricular hypertrophy was the most common abnormality, present in 33% of patients. Aortic regurgitation was seen in 6%, mitral regurgitation in 5%, left ventricular systolic dysfunction in 5%, mitral annular calcification in 2%, and left ventricular diastolic dysfunction in 1%.

According to GOLD classification, 42% of patients had very severe COPD, 30% had severe COPD, 23% had moderate COPD, and only 5% had mild disease. The mean FEV_1/FVC ratio was 0.60 ± 0.10, with a median value of 0.61 (IQR: 0.52–0.68).

There was a clear association between MMRC grade and COPD severity. All patients with Grade 1 dyspnea had mild COPD, while Grade 4 dyspnea was predominantly associated with very severe COPD. Among Grade 4 patients, 60% belonged to the very severe COPD category.

The prevalence of right heart abnormalities increased progressively with COPD severity. Pulmonary arterial hypertension increased from 1.9% in mild COPD to 52.8% in very severe COPD. Similarly, tricuspid regurgitation increased from 3.6% in mild COPD to 48.2% in very severe COPD. Right ventricular dilatation, right atrial enlargement, and right ventricular systolic dysfunction were also more common in severe and very severe COPD.

Correlation analysis demonstrated that COPD severity had a significant positive correlation with pulmonary arterial hypertension ($r = 0.32$, $p = 0.002$), tricuspid regurgitation ($r = 0.29$, $p = 0.005$), right ventricular dilatation ($r = 0.26$, $p = 0.010$), and right atrial enlargement ($r = 0.28$, $p = 0.006$). However, left ventricular systolic dysfunction ($r = 0.14$, $p = 0.16$) and left ventricular diastolic dysfunction ($r = 0.09$, $p = 0.34$) did not show significant correlation with COPD severity.

Overall findings indicated that cardiac dysfunction, particularly right-sided cardiac abnormalities such as pulmonary arterial hypertension, tricuspid regurgitation, right ventricular dilatation, and right atrial enlargement, became increasingly prevalent with worsening COPD severity. Overall findings suggested that echocardiography is a useful tool for early detection of cardiac involvement in COPD patients, especially in severe and very severe disease.

Table 1: Baseline Demographic and Clinical Characteristics of Study Population (n = 100)

Variable	Value
Mean Age ± SD (years)	52.8 ± 8.6
Male Sex	62 (62%)
Mean BMI ± SD (kg/m²)	25.6 ± 4.2
Rural Residence	64 (64%)
Smokers	68 (68%)
Mean Duration of COPD ± SD (years)	4.16 ± 4.16
On Treatment	45 (45%)
Hypertension	41 (41%)
Diabetes Mellitus	25 (25%)
MMRC Grade 3 or 4	78 (78%)

Table 2: Echocardiographic Findings in Study Population (n = 100)

Echocardiographic Finding	No. of Patients	Percentage
Tricuspid Regurgitation	56	56%
Pulmonary Arterial Hypertension	53	53%
Left Ventricular Hypertrophy	33	33%
Right Atrial Enlargement	16	16%
Right Ventricular Dilatation	14	14%
Aortic Regurgitation	6	6%
Mitral Regurgitation	5	5%
LV Systolic Dysfunction	5	5%
Right Ventricular Hypertrophy	4	4%
RV Systolic Dysfunction	3	3%
Mitral Annular Calcification	2	2%
LV Diastolic Dysfunction	1	1%

Table 3. Association of COPD Severity with Major Cardiac Abnormalities

COPD Severity	PAH n (%)	TR n (%)	RV Dilatation n (%)	RA Enlargement n (%)
Mild (n = 12)	1 (1.9%)	2 (3.6%)	0 (0.0%)	0 (0.0%)
Moderate (n = 25)	6 (11.3%)	8 (14.3%)	2 (14.3%)	3 (18.8%)
Severe (n = 30)	18 (34.0%)	19 (33.9%)	5 (35.7%)	6 (37.5%)
Very Severe (n = 33)	28 (52.8%)	27 (48.2%)	7 (50.0%)	7 (43.8%)

Discussion:

In the present study, pulmonary arterial hypertension (PAH) was the most common echocardiographic abnormality and was observed in 53% of patients, followed by tricuspid regurgitation (TR) in 56%, right atrial enlargement in 16%, right ventricular dilatation in 14%, right ventricular hypertrophy in 4%, and right ventricular systolic dysfunction in 3% of patients. These findings indicate that pulmonary vascular involvement and right heart changes are common in COPD patients and become more prominent with increasing disease severity. Similar findings were reported by Vaghela et al. [16], who observed PAH in 62%, right ventricular dysfunction in 52%, and left ventricular diastolic dysfunction in 44% of COPD patients. Mohiuddin et al. [17] also reported PAH in 43.9%, right atrial and right ventricular dilatation in 36.7%, RV hypertrophy in 35.7%, and RV systolic dysfunction in 9.2% of cases. Likewise, Patil et al. [18] found PAH in 56%, cor pulmonale in 54%, RV dilatation in 48%, and RA dilatation in 38% of patients. These studies consistently demonstrate that right-sided cardiac abnormalities are common in COPD and are closely related to the severity of airflow limitation.

The mean SPAP/RVSP in the present study was 41.83 ± 8.42 mmHg, indicating that most patients had moderate pulmonary hypertension. Gupta et al. [19] reported pulmonary hypertension in 63% of COPD patients overall, increasing to 83.33% in very severe disease. Similarly, Muataz et al. [20] observed elevated pulmonary artery systolic pressure in 36% of patients and found that it was significantly associated with declining lung function and oxygen saturation. Agrawal et al. [21] also reported pulmonary hypertension in 63% of patients with measurable tricuspid regurgitation. These findings suggest that pulmonary hypertension is one of the most important cardiovascular complications of COPD.

Left-sided cardiac abnormalities were less frequent in the present study. Left ventricular hypertrophy was observed in 33% of patients, whereas LV systolic dysfunction and LV diastolic dysfunction were found in only 5% and 1% of patients, respectively. In contrast, Vaghela et al. [16] reported LV diastolic dysfunction in 44% of patients, Mohiuddin et al. [17] observed it in 30.6%, Jatav et al. [22] in 46%, and Gupta et al. [19] in 47.5% of cases. The lower prevalence of LV dysfunction in the present study may be due to exclusion of patients with pre-existing overt cardiac disease and the predominance of pulmonary vascular rather than systemic cardiac involvement.

The present study also showed that the severity of COPD had a strong association with the prevalence of echocardiographic abnormalities. PAH increased progressively from mild COPD to very severe COPD, with the highest prevalence seen among patients with advanced disease. Similarly, TR, RV dilatation, and RA enlargement were more common in severe and very severe COPD. Mohiuddin et al. [17] demonstrated that echocardiographic abnormalities were present in 45.7% of GOLD stage 3 patients and 92.9% of GOLD stage 4 patients. Patil et al. [18] reported that PAH, RV dilatation, and cor pulmonale were predominantly seen in severe and very severe COPD. Jatav et al. [22] also observed that PAH, RV hypertrophy, and cor pulmonale increased significantly with COPD severity.

Correlation analysis in the present study revealed a significant positive association between COPD severity and right heart parameters. PAH, TR, RV dilatation, and RA enlargement showed significant correlations with increasing disease severity, whereas left ventricular dysfunction showed only weak and non-significant correlations. Gupta et al. [19], YM et al. [23], and Chaudhari et al. [24] similarly reported that pulmonary hypertension and right heart abnormalities were strongly associated with worsening COPD severity, while left ventricular involvement was relatively uncommon.

Overall findings suggested that pulmonary hypertension and right heart abnormalities were the most common cardiac manifestations in COPD patients and increased significantly with disease severity.

Overall findings highlighted that routine echocardiographic evaluation should be considered in COPD patients, particularly in severe and very severe disease, for early detection of cardiac dysfunction and timely management.

Limitation

The study was conducted at a single centre with a relatively small sample size, which may limit generalizability of the findings. Its cross-sectional design did not allow assessment of causal relationships or long-term outcomes. Advanced investigations such as cardiac MRI or right heart catheterization were not performed for confirmation of echocardiographic findings. In addition, echocardiographic assessment may have been affected by poor acoustic windows in COPD patients due to hyperinflated lungs.

Conclusion

Cardiac dysfunction was common in COPD patients and increased with worsening disease severity according to GOLD 2024 classification. Pulmonary arterial hypertension and tricuspid regurgitation were the most frequent abnormalities. Echocardiography proved to be a simple and effective non-invasive tool for early detection of cardiac involvement. Routine echocardiographic evaluation should be considered in patients with moderate to severe COPD.

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