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ECHOCARDIOGRAPHIC ASSESSMENT OF CARDIAC FUNCTION IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND ITS ASSOCIATION WITH DISEASE SEVERITY

General Medicine

Dr. Sandeep Devrao Wadhave* Junior Resident, Department of General Medicine, Seth G.S.Medical Collage and KEM Hospital Parel Mumbai Maharashtra-400012 *Corresponding Author

Dr. Nitin S Sarate Assistant Professor, Department of Medicine, Seth G.S.Medical College and KEM Hospital, Parel, Mumbai, Maharashtra 400012

ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) induces significant cardiopulmonary interactions that lead to structural and functional alterations in both right and left ventricular performance, along with pulmonary vascular remodelling. Cardiac impairment constitutes a primary determinant of reduced survival in COPD patients. Doppler echocardiography provides an effective bedside modality for comprehensive evaluation of these cardiovascular changes. **Aims:** The primary aim of this investigation was to define the pattern of echocardiographic abnormalities present in patients with COPD and to evaluate their correlation with progressively worsening stages of the disease. **Materials and Methods:** We performed a prospective observational study of 40 consecutively enrolled COPD patients stratified according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) spirometry criteria. Comprehensive echocardiographic examination was conducted to assess ventricular function, pulmonary pressures, and structural cardiac changes. **Results:** Echocardiographic parameters remained within normal limits in 50% of participants. Hemodynamically significant tricuspid regurgitation was demonstrated in 67.5% of cases (n=27). Pulmonary hypertension, defined as systolic pulmonary artery pressure >30 mmHg, was identified in 42.5% of the total cohort (n=17), with stratification revealing mild (58.8%), moderate (23.5%), and severe (17.6%) presentations. A marked gradation in PH prevalence corresponded with advancing COPD severity: stage I (16.7%), stage II (54.5%), stage III (60.0%), and stage IV (83.3%). Right atrial pressure estimation indicated normal values in 82.5% of participants. Cor pulmonale was evident in 41.2% of patients with established Pulmonary hypertension. Left ventricular assessment demonstrated diastolic impairment (47.5%), concentric hypertrophy (22.5%), and systolic dysfunction (7.5%). **Conclusion:** The development and progression of pulmonary hypertension exhibits direct correlation with advancing COPD severity, while severe pulmonary hypertension demonstrates consistent association with right ventricular failure. Echocardiographic surveillance permits early identification of cardiac complications, providing critical opportunities for therapeutic intervention in COPD management.

KEYWORDS

Obstructive Lung Disease, Right Ventricular Dysfunction, Doppler Echocardiography, Pulmonary Pressure Elevation, Cardiac Impairment.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD), characterized by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) as a preventable and treatable condition with significant extrapulmonary manifestations, is a prevalent clinical diagnosis globally. It ranks among the leading causes of mortality and disability. [1,2].

A substantial portion of COPD's disease burden stems from its systemic effects, with cardiac complications being the most frequent. Cardiovascular disease is responsible for approximately half of all hospitalizations and nearly one-third of all deaths in COPD patients with an FEV1 > 50% predicted [3]. Even in advanced disease, cardiac events account for 20-25% of mortality [4]. COPD pathogenesis leads to pulmonary vascular remodelling, right ventricular strain, and left ventricular impairment, resulting in pulmonary hypertension, cor pulmonale, and ventricular dysfunction.

Echocardiography offers a rapid, non-invasive, and accurate method for assessing right ventricular function, filling pressures, valvular function, and left ventricular performance [5]. Numerous studies have validated that echocardiographically derived pulmonary arterial pressure estimates correlate strongly with invasive measurements obtained via right heart catheterization [6,7].

1. To evaluate echocardiographic cardiac changes in patients with COPD.
2. To investigate the correlation between these echocardiographic parameters and COPD severity as stratified by GOLD guidelines.

Objectives

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Study Design- Prospective observational study.
Study Setting- Tertiary Care Centre, Medicine Department at Seth G.S. Medical College & KEM Hospital, Mumbai, Maharashtra, INDIA.
Study Duration- 6 Months.
Study Group- Patients with a definitive history of COPD attending to the Tertiary Care Centre, Medicine Department at Seth G.S. Medical College & KEM Hospital, Mumbai, Maharashtra, INDIA.

Inclusion Criteria

The study included patients who met the following condition:

- Confirmed Diagnosis of COPD: Patients with a diagnosis of Chronic Obstructive Pulmonary Disease (COPD) confirmed through:
  - o Clinical history
  - o Radiology of the chest (e.g., X-ray)
  - o Pulmonary Function Test (PFT) (post-bronchodilator $FEV_1/FVC < 70\%$)

Exclusion Criteria

Patients were excluded from the study based on the following criteria:

- Other Chronic Lung Diseases: History of any chronic lung disease other than COPD.
- Hypertension: Patients with a diagnosis of hypertension.
- Primary Cardiac Disease: Patients with any known primary cardiac disease.
- Systemic Diseases Causing PH: Patients with any systemic disease known to cause pulmonary hypertension (e.g., connective tissue disorders, chronic liver disease, etc.).
- Poor Echocardiographic Window: Patients with poor acoustic windows that would make echocardiographic assessment technically difficult or inaccurate.
- Inability to Perform Spirometry: Patients who were unable to perform spirometry for any reason.

Method of Study

Forty patients with COPD, confirmed through clinical history, chest radiology, and pulmonary function testing, were recruited from the Medicine Department at Seth G.S. Medical College & KEM Hospital, Mumbai. Exclusion criteria encompassed a history of other chronic lung diseases, hypertension, primary cardiac disease, any systemic illness known to cause pulmonary hypertension, poor echocardiographic windows, and an inability to perform spirometry.

All participants underwent routine investigations, including complete blood count, lipid profile, blood glucose, renal function tests, and electrocardiography as indicated. Spirometry was performed on all patients for diagnosis and GOLD classification (post-bronchodilator FEV1/FVC < 0.7). Severity stages were defined as: Mild ($FEV1 \geq 80\%$ predicted), Moderate ($50\% \leq FEV1 < 80\%$ predicted), Severe ($30\% \leq FEV1 < 50\%$ predicted), and Very Severe ($FEV1 < 30\%$ predicted).

A comprehensive resting transthoracic Doppler echocardiogram was conducted by experienced cardiologists using a GE VIVID 7 system with a 2-4.3 MHz transducer. The examination assessed pericardium, valvular structure/function, and chamber dimensions. Tricuspid regurgitant jet velocity was measured using continuous-wave Doppler. Systolic pulmonary arterial pressure (sPAP) was calculated using the modified Bernoulli equation: $sPAP = 4v^2$ (where v is the peak TR velocity) + right atrial pressure (RAP). RAP was estimated based on inferior vena cava collapsibility: 5 mmHg (complete collapse), 10 mmHg (partial collapse), or 15 mmHg (no collapse) [8].

Pulmonary hypertension was defined as sPAP ≥ 30 mmHg [9] and classified as Mild (30-50 mmHg), Moderate (50-70 mmHg), and Severe (>70 mmHg), based on conversions to mean pulmonary arterial pressure [10]. Right ventricular dilation (cor pulmonale) was defined as an RV dimension exceeding 2.6 cm. Left ventricular systolic function was assessed via ejection fraction (EF) and fractional shortening (FS). Diastolic dysfunction (LVDD) was defined by an age-adjusted E/A ratio < 1.

RESULTS

Table 1: Patient Distribution by COPD Severity

Severity of COPD	No. of Patients	% Patients
Mild (FEV1 ≥ 80%)	18	45%
Moderate (50%≤FEV1<80%)	11	27.5%
Severe (30%≤FEV1<50%)	5	12.5%
Very Severe (FEV1<30%)	6	15%

This table describes the study population. The majority of patients (45%) were classified as having mild COPD, followed by moderate (27.5%). The severe and very severe groups were smaller (12.5% and 15%, respectively). This distribution is common in studies recruiting stable outpatients but is crucial to note because it means conclusions about the most advanced stages of COPD are drawn from a smaller subset of patients. The high percentage of mild patients suggests the study was effective in capturing the disease across its spectrum, from early to end-stage.

Table 2: Echocardiographic Findings (N=40)

Finding	No. of Patients	% Patients
Normal Study	20	50%
Pulmonary Hypertension (Total)	17	42.5%
- Mild PH (30-50 mmHg)	10	25%
- Moderate PH (50-70 mmHg)	4	10%
- Severe PH (>70 mmHg)	3	7.5%
Cor Pulmonale	7	17.5%
RV Systolic Dysfunction	3	7.5%
LV Hypertrophy	9	22.5%
LV Diastolic Dysfunction	19	47.5%
LV Systolic Dysfunction	3	7.5%

This table provides a comprehensive overview of cardiac abnormalities found.

- High Prevalence of Cardiac Disease: Strikingly, only half of the COPD patients had a completely normal echocardiogram. This underscores that cardiac involvement is not a rare complication but a frequent feature of COPD.
- Pulmonary Hypertension is Common: Pulmonary Hypertension (PH) was the most significant abnormality, present in 42.5% of all patients. Most cases were mild (25%), but a substantial minority (17.5% of all PH cases) were moderate or severe.
- Left Ventricular Diastolic Dysfunction is Highly Prevalent: The most common individual finding was LV Diastolic Dysfunction (LVDD) at 47.5%. This suggests that COPD affects the heart's ability to relax and fill properly more often than it affects the heart's pumping strength (systolic function, which was only 7.5%). This is a critical insight, as LVDD is often asymptomatic initially but carries significant prognostic implications.
- Right Heart Strain: The presence of cor pulmonale (17.5%) and RV systolic dysfunction (7.5%) confirms that the pressure overload from PH leads to tangible structural and functional damage to the right side of the heart.
- Left Ventricular Changes: LV Hypertrophy (22.5%) indicates that the heart muscle is thickening, likely as a response to various stressors like systemic inflammation or hypoxemia common in COPD.

Table 3: Prevalence of PH by COPD Severity

Severity of COPD	Patients with PH (%)
Mild (n=18)	16.67% (3)
Moderate (n=11)	54.55% (6)
Severe (n=5)	60.00% (3)
Very Severe (n=6)	83.33% (5)

This table is central to the study's objective and demonstrates a powerful correlation.

- Clear Dose-Response Relationship: There is a strong, positive correlation between the severity of COPD and the prevalence of Pulmonary Hypertension. The rate of PH escalates dramatically as lung function declines.
- A critical finding was the disproportionate surge in PH prevalence among patients with moderate COPD (54.55%) compared to those with mild disease (16.67%), identifying the GOLD Stage 2 threshold as a crucial period for echocardiographic screening and intervention.
- Almost Universal in Advanced Disease: In very severe COPD, PH is the rule rather than the exception, affecting 83.33% of patients. This confirms that managing advanced COPD must include surveillance and management of cardiac complications, especially PH.

Table 5: Prevalence of Cor Pulmonale by PH Severity

Severity of PH	Frequency of Cor Pulmonale
Mild (n=10)	10% (1)
Moderate (n=4)	75% (3)
Severe (n=3)	100% (3)

This table establishes a direct consequence of untreated or progressive PH.

- Direct Cause-and-Effect: The data shows a striking correlation between the severity of PH and the development of cor pulmonale (right heart failure due to lung disease).
- Threshold Effect: While mild PH only rarely (10%) leads to cor pulmonale, the risk becomes very high once PH reaches a moderate severity (75%).
- Inevitable Outcome: In this cohort, all patients (100%) with severe PH had developed cor pulmonale. This is a critical clinical takeaway: severe PH in COPD is a grave prognostic sign that has almost invariably caused significant damage to the right ventricle. The strong correlation between PH severity and cor pulmonale underscores the imperative for early detection and treatment to prevent this progression.

SUMMARY

The data indicates a general trend where cardiac dysfunction increases with advancing COPD severity. This is not isolated to PH and cor pulmonale but also includes left ventricular issues like diastolic dysfunction and hypertrophy. This points to the concept of COPD as a systemic inflammatory disorder that affects the entire cardio-pulmonary system, not just the lungs. The heart and lungs are intimately connected, and dysfunction in one organ system directly and indirectly impairs the other.

DISCUSSION

This study confirms a high prevalence of cardiac abnormalities in COPD patients, directly linked to disease severity. The finding that 42.5% of patients had echocardiographic evidence of PH aligns with existing literature, which reports a wide range (20-90%) depending on the method of assessment and patient selection [11-16]. The demonstrable linear increase in PH prevalence with worsening GOLD stage (from 16.67% in mild to 83.33% in very severe COPD) underscores the progressive nature of pulmonary vascular disease in COPD. This is driven by factors including chronic hypoxia-induced vasoconstriction, vascular remodeling, destruction of the capillary bed, and increased blood viscosity.

The incidence of cor pulmonale (17.5%) in our study is consistent with previous estimates [17]. and its strong correlation with the severity of PH (affecting all patients with severe PH) highlights the direct consequence of elevated afterload on the right ventricle. This progression from PH to right heart failure is a critical determinant of prognosis in COPD [18].

Notably, left ventricular dysfunction was also common. LV diastolic dysfunction was the most frequent finding (47.5%), which can be attributed to mechanisms such as chronic hypoxemia impairing

myocardial relaxation, ventricular interdependence due to RV overload, and altered intrathoracic pressures [19]. The presence of LV hypertrophy (22.5%) and systolic dysfunction (7.5%) further illustrates that COPD has a biventricular impact, possibly exacerbated by shared risk factors like smoking and systemic inflammation.

CONCLUSION

This investigation demonstrates that pulmonary hypertension, cor pulmonale, and left ventricular dysfunction are frequent complications of COPD, with their prevalence escalating with disease severity. Echocardiography is a vital, non-invasive tool for screening and early identification of these cardiac sequelae. Incorporating routine echocardiographic assessment into the management of COPD patients can significantly enhance prognostic evaluation, allowing for closer monitoring and more aggressive treatment strategies in high-risk individuals, ultimately aiming to improve outcomes.

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