

“Study Of Cardiac Changes In Chronic Obstructive Pulmonary Disease Patients”

Dr Sayali Darunde¹, Dr Dharmendra Pandey^{2*}, Dr Nitin Karnik³, Dr Sangeeta Pednekar⁴

¹Junior Resident, Medicine Department, LTMMC

^{2*}Associate Professor, Medicine Department, LTMMC

³Head of Department, Medicine Department, LTMMC

⁴Professor, Medicine Department, LTMMC

*Corresponding Author: Dr Dharmendra Pandey,
 Associate Professor, Medicine Department LTMMC*

<p>Keywords COPD, cardiovascular disease, echocardiography, pulmonary hypertension, BODE index, SGRQ scores.</p>	<p>ABSTRACT</p> <p>Background: Chronic Obstructive Pulmonary Disease (COPD) is a major cause of morbidity and mortality globally, often complicated by cardiovascular diseases (CVDs) due to shared pathophysiological pathways. This study aims to explore the cardiac changes associated with varying severities of COPD, utilizing echocardiography and correlating these changes with clinical COPD assessments such as the BODE index, ABG values, and SGRQ scores.</p> <p>Methods: This prospective observational study included 60 patients diagnosed with COPD based on GOLD criteria, recruited from Lokmanya Tilak Medical College and Hospital. Participants underwent comprehensive clinical and echocardiographic evaluations to assess cardiovascular changes. The severity of COPD was staged using spirometric criteria, and the impact of COPD on cardiac function was analyzed through echocardiographic findings.</p> <p>Results: The majority of the study population was male (58.33%), with a significant number presenting with moderate to severe stages of COPD. Echocardiographic assessment revealed that 33.33% of the patients had pulmonary hypertension, with an increase in prevalence correlating with the severity of COPD. Significant associations were found between higher COPD severities and worse echocardiographic outcomes, including right and left ventricular dysfunctions. Higher BODE index scores and poorer SGRQ outcomes were also correlated with more severe cardiac abnormalities.</p> <p>Conclusion: The findings underscore the significant impact of COPD on cardiovascular health, highlighting the need for early cardiac assessment in COPD patients. Further studies are recommended to explore the mechanisms underlying these associations and to confirm the potential benefits of integrated cardiopulmonary management in improving outcomes for COPD patients.</p>
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INTRODUCTION: Chronic obstructive pulmonary disease (COPD) is a significant contributor to morbidity and mortality in individuals over 40 years of age and is projected to become the fourth leading cause of premature death by 2040 [1]. In 2023, COPD was redefined as “a heterogeneous lung condition characterized by chronic respiratory symptoms, including dyspnea, cough, sputum production, and/or exacerbations, which are due to abnormalities in the airways (such as bronchitis and bronchiolitis) and/or alveoli (as seen in emphysema) that cause persistent, often progressive, airflow obstruction”[2]. Additionally, a new definition for Acute Exacerbation of COPD (AECOPD) was introduced, describing it as “an event characterized by worsening dyspnea, cough, and sputum within 14 days, which may be accompanied by tachypnea and/or tachycardia, and is often associated with increased local and systemic inflammation caused by airway infections, pollution, or other irritants” [3]. Both definitions focus primarily on the clinical characteristics of these diseases rather than their epidemiology, risk factors, causes, or diagnostic criteria. COPD has a profound impact on patients' quality of life, particularly as exacerbations lead to increased direct healthcare costs, such as those for pharmacotherapy and hospitalization, as well as indirect costs, primarily from lost workdays due to worsening dyspnea and functional decline [4,5]. A history of smoking and advancing age in COPD patients increases the risk for various additional disorders, known as comorbidities, which complicate treatment and negatively affect outcomes [6]. Studies indicate that approximately 86–98% of COPD patients suffer from at least one comorbid condition [7], and it has been reported that comorbidities are responsible for about one-third of all deaths among COPD patients [8]. Furthermore, the risk of death is

higher in patients with multiple comorbidities [9]. Therefore, the management of comorbidities, alongside standard treatments such as smoking cessation, pharmacotherapy, pulmonary rehabilitation, and immunization, is a critical aspect of contemporary COPD care [10].

One of the most prevalent comorbidities in COPD patients is cardiovascular disease (CVD) [11], which is the leading cause of mortality worldwide, affecting approximately 85 million people in Europe [12]. The Global Initiative for Chronic Obstructive Lung Disease (GOLD) has emphasized the importance of coexisting COPD and CVD, noting that CVD accounts for over half of hospitalizations and deaths in COPD patients [13]. COPD and CVD share similar pathophysiological mechanisms and frequently coexist in the same individual. The medications used to treat CVD can have either beneficial or harmful effects on COPD patients, and vice versa.

The current study was conducted to study the correlation between cardiovascular changes and COPD severity, assess these changes using echocardiography, and compare them with ABG, SGRQ percentages, and BODE scores in COPD patients.

MATERIAL AND METHODS: This prospective observational study was conducted at Lokmanya Tilak Medical College and Hospital, involving a total of 60 patients diagnosed with Chronic Obstructive Pulmonary Disease (COPD) based on the GOLD criteria. Patients eligible for inclusion were aged 18 years and above with a history of at least 10 pack-years of smoking or exposure to biomass fuel, and confirmed COPD via spirometry. Exclusion criteria included patients with other chronic pulmonary diseases such as asthma, tuberculosis, and lung carcinoma, as well as those with significant cardiac conditions not related to COPD. Over the 18-month study period, participants underwent a thorough clinical examination and were assessed using a comprehensive set of diagnostic tools. Spirometry was performed to confirm and categorize the severity of COPD, while cardiac function was evaluated using electrocardiograms (ECGs) and echocardiography. Additional assessments included Arterial Blood Gases (ABG) to evaluate gas exchange, and the Six-Minute Walk Test (6MWT) to measure functional exercise capacity. Data on demographics, clinical history, spirometric results, and echocardiographic findings were systematically collected and analyzed using SPSS version 22. Statistical methods applied included frequency distribution and cross-tabulation with chi-square tests for categorical variables, and ANOVA for continuous variables where applicable.

RESULTS

Demographic information: The age distribution of the study participants reveals a significant variation across different age groups. The majority of the subjects fall within the age range of more than 65 years, accounting for 31.67% of the total population. This is followed by participants aged 46 to 55 years (26.67%), and those aged 56 to 65 years (20.00%). The age groups of 36 to 45 years and less than 35 years represent 15.00% and 6.67% of the population, respectively, indicating a higher prevalence of the condition among older adults. In terms of gender distribution, males constituted a larger portion of the study population, representing 58.33% of the total, whereas females made up 41.67%. This suggests a higher prevalence of the condition among males in the study group, which could be linked to various demographic and lifestyle factors.

Table 1: Demographic information

Demographic information		Number of subjects	Percentage
Age distribution	Less than 35 years	4	6.67
	36 to 45 years	9	15.00
	46 to 55 years	16	26.67
	56 to 65 years	12	20.00
	More than 65 years	19	31.67
Genderwise distribution	Males	35	58.33
	Females	25	41.67

COPD Grading: The COPD grading of the subjects shows a predominance of moderate severity among the study population, with 43.33% of subjects falling under Grade-2 (Moderate). This is followed by 28.33% in Grade-3 (Severe), 18.33% in Grade-1 (Mild), and 10.00% in Grade-4 (Very Severe).

Clinical Presentation: The analysis of risk factors indicates that smoking is the most prevalent risk factor, affecting 40.00% of the study population. A history of pulmonary tuberculosis (PTB) and occupational

exposure are also significant contributors, affecting 38.33% and 30.00% of the population, respectively. The clinical signs observed in the study population reveal that tachycardia is the most frequent sign, present in 60.00% of the subjects. Pallor is also common, observed in 35.00% of the participants. Other signs include tachypnea (23.33%), pedal oedema (18.33%), raised JVP (6.67%), clubbing (5.00%), and both icterus and cyanosis (3.33% each).

The symptoms reported by the study participants demonstrate that breathlessness is the most common symptom, affecting 85.00% of the subjects. This is followed by cough with sputum (78.33%) and weakness and fatigue (60.00%).

Other notable symptoms include chest pain (38.33%), fever (26.67%), swelling of feet (21.67%), decreased urine output (20.00%), and haemoptysis (11.67%). In this study, total 51.67% subjects were enrolled from IPD (indoor patients), while 48.33% were enrolled from OPD (out-patient department).

Incidence of pulmonary hypertension: The incidence of pulmonary hypertension among the study population was 33.33%, with 20 subjects diagnosed with this condition. The remaining 66.67% of the population, accounting for 40 subjects, did not exhibit pulmonary hypertension.

Figure 1: COPD Grading

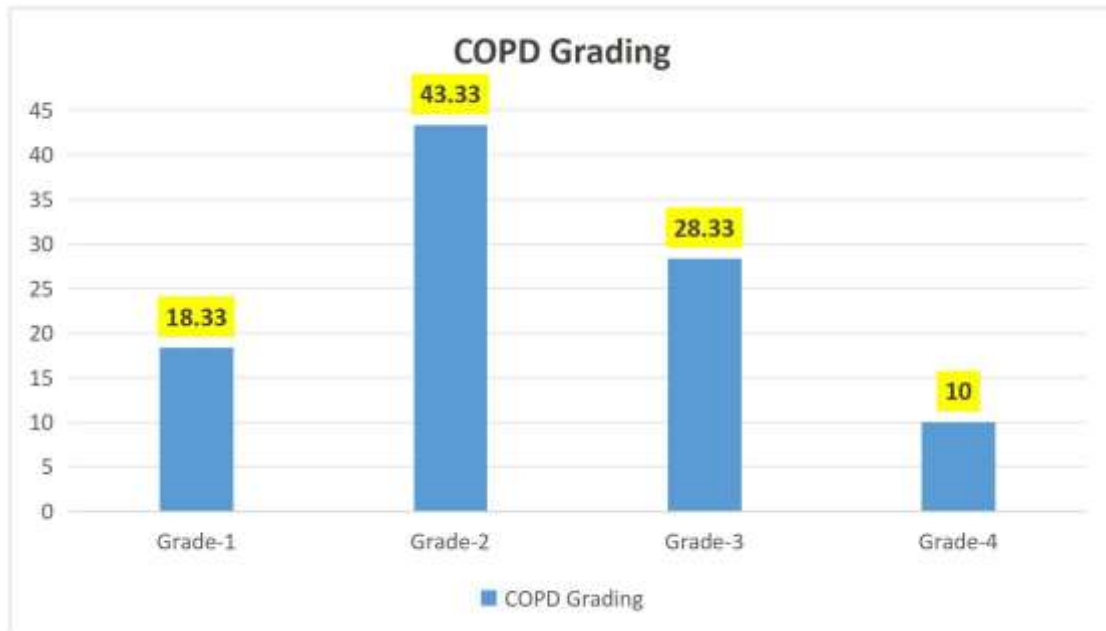


Table 2: Clinical Presentation

Clinical Presentation		Number of subjects	Percentage
Risk factors	Smoking	24	40.00
	Occupational Exposure	18	30.00
	History of PTB (Pulmonary Tuberculosis)	23	38.33
Signs	Pallor	21	35.00
	Icterus	2	3.33
	Cyanosis	2	3.33
	Clubbing	3	5.00
	Pedal Oedema	11	18.33
	Raised JVP	4	6.67
	Tachycardia	36	60.00
Symptoms	Tachypnea	14	23.33
	Cough with sputum	47	78.33
	Fever	16	26.67

	Breathlessness	51	85.00
	Swelling of feet	13	21.67
	Decreased urine output	12	20.00
	Haemoptysis	7	11.67
	Weakness and Fatigue	36	60.00
	Chest pain	23	38.33
IPD/OPD	IPD	31	51.67
	OPD	29	48.33

2D ECHO findings: The 2D echocardiographic findings in the study population provide critical insights into the cardiovascular complications associated with COPD. Right atrial dilatation was observed in 14 patients, accounting for 23.33% of the study group, while right ventricular dilatation was noted in 7 patients (11.67%). Pulmonary artery dilatation was present in 13 patients (21.67%), with the mean systolic pulmonary artery pressure recorded at 32.66 ± 17.15 mmHg. The left ventricular ejection fraction, an indicator of systolic function, had a mean value of $58.60 \pm 4.10\%$. Detectable tricuspid regurgitation was observed in 15 patients, representing 25.00% of the cohort. Pulmonary hypertension was diagnosed in 20 patients, constituting 33.33% of the study population.

In terms of specific echocardiographic findings, 40 patients (66.67%) exhibited a normal echocardiographic study. Pulmonary hypertension, characterized by; mild (30-50 mmHg) in 10 patients (16.67%), moderate (50-70 mmHg) in 4 patients (6.67%), and severe (>70 mmHg) in 6 patients (10.00%). Cor pulmonale, a condition of right heart failure secondary to lung disease, was found in 7 patients (11.67%). Right ventricular systolic dysfunction (RVSD) was noted in 3 patients (5.00%), while left ventricular hypertrophy (LVH) and left ventricular diastolic dysfunction (LVDD) were present in 9 (15.00%) and 19 patients (31.67%), respectively. Left ventricular systolic dysfunction (LVSD) was observed in 3 patients (5.00%). These findings underscore the high prevalence of both right and left ventricular abnormalities in COPD patients, highlighting the importance of comprehensive cardiovascular assessment in this population.

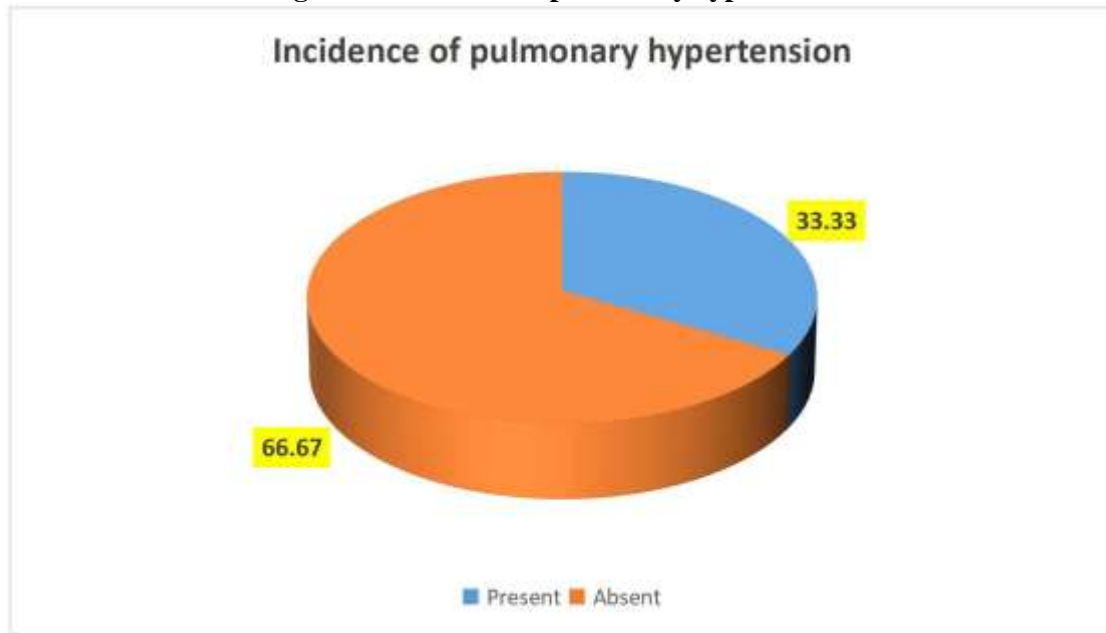
Table 3: 2D ECHO findings

2D ECHO findings	Number	Percentage
Right atrial dilatation	14	23.33
Right ventricular dilatation	7	11.67
Pulmonary artery dilatation	13	21.67
Systolic pulmonary artery pressure (mmHg) (Mean \pm SD):	32.66 ± 17.15	
Left ventricular ejection fraction (%) (Mean \pm SD):	58.60 ± 4.10	
Detectable tricuspid Regurgitation	15	25.00
Pulmonary hypertension	20	33.33

Findings	No. of Patients	% Patients
Normal study	40	66.67
Pulmonary hypertension	- Mild (30-50 mmHg)	10
	- Moderate (50-	4
		6.67

	70 mmHg)		
	- Severe (>70 mmHg)	6	10.00
Cor pulmonale		7	11.67
RVSD		3	5.00
LVH		9	15.00
LVDD		19	31.67
LVSD		3	5.00

Figure 2: Incidence of pulmonary hypertension



Comparison between severity of COPD and incidence of pulmonary hypertension: The comparison between the severity of COPD and the incidence of pulmonary hypertension reveals a significant correlation. Pulmonary hypertension was more prevalent in patients with more severe COPD. Specifically, it was present in 83.33% of patients with very severe COPD (Grade-4) and in 47.06% of patients with severe COPD (Grade-3). The incidence was lower in moderate (19.23%) and mild (18.18%) cases of COPD. The Chi-square statistic was 11.6545, with a p-value of 0.008666, indicating a statistically significant association between the severity of COPD and the incidence of pulmonary hypertension.

Table 4: Comparison between severity of COPD and incidence of pulmonary hypertension

COPD Grading	Pulmonary hypertension				Total
	Absent		Present		
	Number	Percentage	Number	Percentage	
Grade-1	9	81.82	2	18.18	11
Grade-2	21	80.77	5	19.23	26
Grade-3	9	52.94	8	47.06	17
Grade-4	1	16.67	5	83.33	6
Total	40	66.67	20	33.33	60
Significan ce	The chi-square statistic is 11.6545. The <i>p</i> -value is .008666. The result is significant at <i>p</i> < .05.				

Comparison of Echocardiographic Findings According to Severity of COPD: The comparison of echocardiographic findings according to the severity of COPD demonstrates that normal echocardiograms were more common in patients with mild COPD, with 13 out of 18 mild cases showing normal results. Pulmonary hypertension was observed in 17 patients, with the distribution increasing with COPD severity, particularly in very severe cases. Left ventricular diastolic dysfunction (LVDD) was prevalent across all severity levels, affecting a total of 19 patients. Cor pulmonale and right heart failure (RHF) were more common in severe and very severe cases.

Comparison of BODE Index Score with Cardiovascular Diseases: The analysis indicates that the prevalence of pulmonary hypertension increases from 2 cases in the low-risk group to 7 in the high-risk group and reaches 3 in the very high-risk group. Notably, severe pulmonary hypertension (sPAP > 70 mmHg) is most prevalent in the very high-risk group, affecting 4 out of 9 patients (44.4%). Cor pulmonale follows a similar trend, present in only 1 patient (10%) in the low-risk group, increasing to 3 patients (13%) in the high-risk group, and slightly decreasing to 1 patient (11%) in the very high-risk group.

Table 5: Comparison of Echocardiographic Findings According to Severity of COPD

Echocardiographic Findings	Mild (18)	Moderate (11)	Severe (5)	Very Severe (6)	Total
Normal	13	5	2	0	20
Pulmonary Hypertension (sPAP > 30 mmHg)	3	6	3	5	17
- Mild (30-50 mmHg)	2	5	1	2	10
- Moderate (50-70 mmHg)	1	1	1	1	4
- Severe (>70 mmHg)	0	0	1	5	6
Cor Pulmonale	2	0	3	2	7
Right Heart Failure (RHF)	1	0	1	1	3
Left Ventricular Diastolic Dysfunction (LVDD)	6	4	3	6	19
Left Ventricular Hypertrophy (LVH)	3	2	2	3	10
Left Ventricular Systolic Dysfunction (LVSD)	1	0	1	1	3

Table 6: Comparison of BODE Index Score with Cardiovascular Diseases

BODE Index Score	Number of subjects	Percentage
0-2 (Low Risk)	10	16.67
3-4 (Moderate Risk)	18	30.00
5-6 (High Risk)	23	38.33
7-10 (Very High Risk)	9	15.00
Total	60.00	100.00

BODE Index Score	0-2 (Low Risk)	3-4 (Moderate Risk)	5-6 (High Risk)	7-10 (Very High Risk)	Total
Number of Patients	10	18	23	9	60
Normal Study	7	6	5	2	20
Pulmonary Hypertension (sPAP > 30 mmHg)	2	5	7	3	17
Mild (30-50 mmHg)	1	3	4	2	10

Moderate (50-70 mmHg)	1	1	2	0	4
Severe (>70 mmHg)	0	1	1	4	6
Cor Pulmonale	1	2	3	1	7
RVSD	0	1	1	1	3
LVH	1	2	3	3	9
LVDD	3	6	7	3	19
LVSD	0	1	1	1	3

Saint George Respiratory Questionnaire (SGRQ): Left ventricular hypertrophy (LVH) and diastolic dysfunction (LVDD) demonstrate progressive increases with higher BODE scores. LVH is found in 1 case (10%) in the low-risk group, expanding to 3 cases (13%) each in the high and very high-risk groups. LVDD is even more common, appearing in 3 cases (30%) in the low-risk group and peaking at 7 cases (30%) in the high-risk group before slightly decreasing to 3 cases (33%) in the very high-risk group. Left ventricular systolic dysfunction (LVSD) appears in 1 case in each of the moderate, high, and very high-risk groups, showing its presence across more severe COPD stages but remaining relatively uncommon.

Table 7: Comparison of SGRQ Scores with Cardiovascular Diseases

Domain	Mean ± SD	Median	Minimum	Maximum
Symptom	50.2 ± 22.0	51	2	89
Activity	62.1 ± 22.5	65	4	95
Impact	42.3 ± 21.5	44	3	93
Total Score	49.5 ± 19.0	50	6	87.5

Echocardiographic Findings	SGRQ Score Range				
	0-25 (Low Impact)	26-50 (Moderate Impact)	51-75 (High Impact)	76-100 (Very High Impact)	Total
Pulmonary Hypertension (sPAP > 30 mmHg)	3	4	6	7	20
Cor Pulmonale	0	1	3	3	7
RVSD	0	1	1	1	3
Left Ventricular Diastolic Dysfunction (LVDD)	2	6	7	4	19
Left Ventricular Hypertrophy (LVH)	1	2	3	3	9
Left Ventricular Systolic Dysfunction (LVSD)	0	1	1	1	3

Comparison of ABG Values with Cardiovascular Diseases: Saint George Respiratory Questionnaire (SGRQ) scores correlate strongly with cardiovascular findings. The symptom domain score averages at 50.2 ± 22.0, with the highest incidence of pulmonary hypertension noted in patients scoring between 76 and 100. The activity domain has a mean score of 62.1 ± 22.5, with cor pulmonale prevalence increasing in the higher score ranges, especially in the high and very high impact groups. The impact domain mean score is 42.3 ± 21.5, showing a broad impact of COPD on patients' lives with prevalent LVDD, especially in the moderate to high impact groups (scores 26-75). This intricate statistical portrayal underlines the necessity for vigilant cardiovascular monitoring and comprehensive management strategies tailored to COPD severity to mitigate the associated risks effectively.

Table 8: Comparison of ABG Values with Cardiovascular Diseases

Echocardiographic Findings	ABG Value Range			
	PaO2 > 80 mmHg (Normal)	PaO2 60-80 mmHg (Mild Hypoxemia)	PaO2 40-59 mmHg (Moderate Hypoxemia)	PaO2 < 40 mmHg (Severe Hypoxemia)
Pulmonary Hypertension (sPAP > 30 mmHg)	3	5	6	7
Cor Pulmonale	1	2	3	3
Right Heart Failure (RHF)	0	1	1	2
Left Ventricular Diastolic Dysfunction (LVDD)	2	6	7	4
Left Ventricular Hypertrophy (LVH)	1	2	3	3
Left Ventricular Systolic Dysfunction (LVSD)	0	1	1	1

DISCUSSION

COPD, a preventable and treatable lung disease, is becoming increasingly prevalent and is now the fourth leading cause of death worldwide. Over the past two decades, COPD-related deaths have nearly doubled despite improvements in cardiovascular mortality. The WHO predicts COPD will become the third most fatal disease by 2030, with 25% of adults over 40 exhibiting airflow obstruction. Cardiovascular complications significantly increase COPD-related mortality and morbidity. This study explores the under-researched link between COPD and cardiovascular conditions, including pulmonary hypertension, cor pulmonale, and left ventricular dysfunction, particularly in the Indian population. While echocardiography is a valuable non-invasive tool for assessing cardiac function, it remains underutilized in COPD management. This study highlights its importance in detecting COPD-related heart changes, emphasizing the need for routine cardiovascular screening and early intervention to improve patient outcomes and quality of life.

The age distribution of participants highlights the increased vulnerability of older adults to COPD. The majority were over 65, aligning with epidemiological trends linking COPD severity to age-related factors such as smoking, pollution exposure, and declining pulmonary function. A significant proportion (46-65 years) further reinforces the need for early intervention. Kaushal et al. [14] and Gupta et al.[15] also observed a similar age distribution, emphasizing older adults' susceptibility to COPD complications. The study also showed a higher prevalence of COPD in males (58.33%), consistent with global trends due to higher smoking rates and occupational exposures. However, a substantial proportion of female participants (41.67%) reflects the increasing recognition of COPD in women, likely due to rising smoking rates and heightened vulnerability to tobacco and pollutants. These findings align with those of Gupta et al.[16] and Kaushal et al.[14], who noted shifting COPD patterns among women. Aurangabadkar et al. [17] also found that 70% of COPD patients were male, with the highest prevalence in the 60-69 age group.

COPD grading showed that most patients had moderate to severe disease (43.33% and 28.33%, respectively), suggesting advanced disease stages associated with severe symptoms, higher healthcare utilization, and cardiovascular complications. Mild and very severe COPD cases (18.33% and 10.00%) reinforce the need for continuous monitoring across all disease stages. These findings align with Gupta et al.[16] and Kaushal et al.[14], who also reported a higher prevalence of moderate to severe COPD. Smoking was the most significant risk factor, affecting 40% of patients, consistent with prior studies confirming its leading role in COPD development. A significant proportion had a history of pulmonary tuberculosis (38.33%) and occupational exposure (30.00%), emphasizing COPD's multifactorial etiology. Similar findings were reported by Gupta et al.[16] and Kaushal et al. [14], who emphasized smoking and environmental exposures in COPD progression. Breathlessness (85%) was the most common symptom, followed by cough with sputum (78.33%) and fatigue (60.00%), consistent with COPD's hallmark airflow limitation. Less frequent symptoms such as chest pain, fever, and pedal edema indicate infections and right heart failure, common in advanced COPD. These findings align with Gupta et al.[16] and Kaushal et al.[14], who reported dyspnea as the predominant symptom. Aurangabadkar et al.[17] found breathlessness in 93% of patients and cough in 87%, further

supporting these trends. Clinical signs such as tachycardia (60.00%), pallor (35.00%), and tachypnea (23.33%) reflect COPD's systemic effects, including hypoxia-induced cardiovascular complications. The presence of pedal edema, raised JVP, and clubbing suggests cor pulmonale. These findings align with Gupta et al.[16] and Kaushal et al.[14] who observed similar systemic effects in COPD patients.

2D echocardiography revealed a significant cardiovascular burden in COPD patients, with right atrial dilatation (23.33%), right ventricular dilatation (11.67%), and pulmonary artery dilatation (21.67%), indicating pulmonary hypertension and cor pulmonale. Mean systolic pulmonary artery pressure was 32.66 ± 17.15 mmHg, with pulmonary hypertension present in 33.33% of cases. Left ventricular dysfunction was less frequent, with preserved ejection fraction (mean $58.60 \pm 4.10\%$), though left ventricular hypertrophy (15.00%), diastolic dysfunction (31.67%), and systolic dysfunction (5.00%) were observed. These findings highlight the complex interplay between COPD and cardiovascular health, underscoring the need for regular cardiovascular assessments. Gupta et al.[16] and Kaushal et al.[14] similarly reported a high prevalence of pulmonary hypertension and right heart dysfunction in COPD, emphasizing echocardiography's role in early detection. Pulmonary hypertension was diagnosed in 33.33% of patients, a lower prevalence than Gupta et al.[16] (42.5%) but consistent with other studies¹⁶⁻²⁰ (Jain et al.[18] - 37.25%, Aurangabadkar et al.[17] - 40%, Rao et al.[19] - 56.45%).

Pulmonary hypertension was most common in very severe COPD (83.33%) and severe COPD (47.06%), demonstrating a strong correlation between COPD severity and pulmonary artery pressure increases. The chi-square statistic (11.6545) and p-value (0.008666) confirm this significant association, reinforcing the need for aggressive COPD management to prevent pulmonary hypertension. Gupta et al.¹⁶ and Kaushal et al.[14] reported similar findings, noting a direct correlation between COPD severity and pulmonary hypertension. Studies by Rao et al.[19], Scharf et al., and Doi et al. also found that pulmonary hypertension severity aligns with airflow obstruction degree. Aurangabadkar et al.[17] reported statistically significant differences in pulmonary hypertension severity across GOLD stages ($\chi^2 = 36.195$, $p < 0.001$), with the highest proportion of pulmonary hypertension in GOLD Stage 4. Deshwal et al.[15] found that mild pulmonary hypertension was most common in GOLD Stages I and II, while moderate to severe pulmonary hypertension predominated in Stages III and IV.

Echocardiographic findings demonstrated a clear gradient of increasing cardiovascular complications with COPD severity. Normal echocardiography was most common in mild COPD, while pulmonary hypertension, cor pulmonale, and left ventricular diastolic dysfunction were more prevalent in severe and very severe cases. These findings emphasize the need for comprehensive cardiac evaluation as part of COPD management, as early detection and treatment of cardiac complications can improve patient outcomes. Similar trends were observed in studies by Gupta et al.[16] and Kaushal et al.[14], reinforcing that cardiac dysfunction prevalence increases with COPD severity.

The study confirms that COPD patients face a significant cardiovascular risk, which worsens with increasing BODE Index scores. Patients with very high BODE scores exhibited the highest prevalence of severe pulmonary hypertension, marking advanced disease progression. Interestingly, cor pulmonale incidence was lower in very high-risk COPD patients, potentially due to multi-organ complications in advanced disease stages. Higher BODE scores also correlated with worsening right and left ventricular dysfunction. The Saint George Respiratory Questionnaire (SGRQ) further established that patients with higher COPD impact scores also had more severe cardiovascular conditions. Those with severe COPD functional impairment exhibited higher cor pulmonale and left ventricular diastolic dysfunction incidence in activity and impact domains. Arterial blood gas (ABG) analysis confirmed that lower oxygen levels increased pulmonary hypertension, cor pulmonale, and ventricular hypertrophy risks. These findings strongly support the need for integrated pulmonary and cardiovascular management strategies to reduce COPD-related complications and improve patient outcomes.

CONCLUSIONS: The study underscores a significant cardiovascular burden in Chronic Obstructive Pulmonary Disease (COPD) patients, particularly those with advanced disease stages, manifesting as pulmonary hypertension, cor pulmonale, and left ventricular dysfunction. It establishes a strong correlation between the severity of COPD, as indicated by BODE Index and SGRQ scores, and the prevalence of cardiovascular complications, highlighting the necessity for targeted cardiovascular monitoring and management. Additionally, the research reveals that lower arterial blood gas (ABG) values, especially PaO₂ levels, significantly correlate with a higher incidence of cardiovascular diseases, emphasizing the

importance of maintaining adequate oxygenation in COPD patients. The findings advocate for a comprehensive management approach that includes routine cardiovascular assessments and proactive interventions to mitigate cardiovascular risks, with early detection through echocardiographic evaluations and ABG monitoring being crucial for improving prognosis and reducing morbidity and mortality from cardiovascular diseases in COPD patients.

Limitation of the Study: In this study, investigations were conducted only once for each subject, and no follow-up tests were performed to assess disease progression. Repeating the investigations could have provided valuable insights into the progression of the disease over time.

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CONFLICT OF INTEREST: NONE TO DECLARE

REFERENCES

1. Foreman, K.J.; Marquez, N.; Dolgert, A.; Fukutaki, K.; Fullman, N.; McGaughey, M.; Pletcher, M.A.; Smith, A.E.; Tang, K.; Yuan, C.W.; et al. Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: Reference and alternative scenarios for 2016-40 for 195 countries and territories. *Lancet* 2018, 392, 2052–2090.
2. Celli, B.; Fabbri, L.; Criner, G.; Martinez, F.J.; Mannino, D.; Vogelmeier, C.; Montes de Oca, M.; Papi, A.; Sin, D.D.; Han, M.K.; et al. Definition and Nomenclature of Chronic Obstructive Pulmonary Disease: Time for Its Revision. *Am. J. Respir. Crit Care Med.* 2022, 206, 1317–1325.
3. Celli, B.R.; Fabbri, L.M.; Aaron, S.D.; Agusti, A.; Brook, R.; Criner, G.J.; Franssen, F.M.E.; Humbert, M.; Hurst, J.R.; O'Donnell, D.; et al. An Updated Definition and Severity Classification of Chronic Obstructive Pulmonary Disease Exacerbations: The Rome Proposal. *Am. J. Respir. Crit. Care Med.* 2021, 204, 1251–1258.
4. Sin, D.D.; Stafinski, T.; Ng, Y.C.; Bell, N.R.; Jacobs, P. The impact of chronic obstructive pulmonary disease on work loss in the United States. *Am. J. Respir. Crit. Care Med.* 2002, 165, 704–707.
5. Guarascio, A.J.; Ray, S.M.; Finch, C.K.; Self, T.H. The clinical and economic burden of chronic obstructive pulmonary disease in the USA. *Clin. Outcomes Res.* 2013, 5, 235–245.
6. Chatila, W.M.; Thomashow, B.M.; Minai, O.A.; Criner, G.J.; Make, B.J. Comorbidities in chronic obstructive pulmonary disease. *Proc. Am. Thorac. Soc.* 2008, 5, 549–555.
7. Putcha, N.; Drummond, M.B.; Wise, R.A.; Hansel, N.N. Comorbidities and Chronic Obstructive Pulmonary Disease: Prevalence, Influence on Outcomes, and Management. *Semin. Respir. Crit. Care Med.* 2015, 36, 575–591.
8. Rennard, S.I. Looking at the patient—Approaching the problem of COPD. *N. Engl. J. Med.* 2004, 350, 965–966.
9. Mannino, D.M.; Thorn, D.; Swensen, A.; Holguin, F. Prevalence and outcomes of diabetes, hypertension and cardiovascular disease in COPD. *Eur. Respir. J.* 2008, 32, 962–969.
10. Recio Iglesias, J.; Diez-Manglano, J.; Lopez Garcia, F.; Diaz Peromingo, J.A.; Almagro, P.; Varela Aguilar, J.M. Management of the COPD Patient with Comorbidities: An Experts Recommendation Document. *Int. J. Chronic Obstr. Pulm. Dis.* 2020, 15, 1015–1037.
11. Magnussen, H.; Disse, B.; Rodriguez-Roisin, R.; Kirsten, A.; Watz, H.; Tetzlaff, K.; Towse, L.; Finnigan, H.; Dahl, R.; Decramer, M.; et al. Withdrawal of inhaled glucocorticoids and exacerbations of COPD. *N. Engl. J. Med.* 2014, 371, 1285–1294.
12. European Heart Network. European Cardiovascular Disease Statistics 2017 Edition. 2017. Available online: <http://www.ehnheart.org/cvd-statistics.htm> (accessed on 1 February 2023).
13. Brassington, K.; Selemidis, S.; Bozinovski, S.; Vlahos, R. New frontiers in the treatment of comorbid cardiovascular disease in chronic obstructive pulmonary disease. *Clin. Sci.* 2019, 133, 885–904.
14. Kaushal M, Shah PS, Shah AD, Francis SA, Patel NV, Kothari KK. Chronic obstructive pulmonary disease and cardiac comorbidities: A cross-sectional study. *Lung India* 2016;33:404-9.
15. Deshwal A, Khah R, Kumar K, Singh DK, Kumar S, Srivastava S. Pulmonary Hypertension in COPD Patients and its Correlation with Exercise Capacity and Quality of Life of Patients. *J Indian Acad Clin Med.* 2021 Jan-Jun;22(1-2)
16. Gupta NK, Agrawal RK, Srivastav AB, Ved ML. Echocardiographic evaluation of heart in chronic

- obstructive pulmonary disease patient and its co-relation with the severity of disease. Lung India. 2011 Apr;28(2):105-9.
17. Aurangabadkar GM, Lanjewar AV, Jadhav US, Ali SN, Wagh PB. Evaluation of Pulmonary Hypertension in Chronic Obstructive Pulmonary Disease. Cureus. 2022 Feb 2;14(2):e21828
 18. Jain BK, Pasari N, Bajpai A, Songara A. Evaluation of Right Ventricular Dysfunction and Pulmonary Artery Hypertension Secondary to COPD Severity by Electrocardiogram and Echocardiography. J Evol Med Dent Sci. 2015 May 25;4(42):7275-7281
 19. Rao VV, Eswaramma, Soujanya. Study of cardiovascular changes in COPD by ECG & 2D echo and correlation with duration and severity of COPD. Sch J App Med Sci. 2016;4(12D):4430-4438.
 20. Mangshetty, Basavaraj G., and Kunireddy Apuroopa. "Study of clinical profile of chronic obstructive pulmonary disease and evaluation of pulmonary hypertension with ECG and 2D echo findings." Journal of Evolution of Medical and Dental Sciences, vol. 5, no. 100, 15 Dec. 2016, pp. 7331+