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Original Research Article

PREVALENCE AND DETERMINANTS OF METABOLIC SYNDROME AMONG PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE: A CROSS-SECTIONAL STUDY AND ITS ASSOCIATION WITH COPD SEVERITY

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is increasingly recognized as a systemic inflammatory disorder associated with multiple comorbidities, including metabolic syndrome (MS). The coexistence of MS may significantly influence disease progression and cardiovascular outcomes in COPD patients. **Aim:** To determine the prevalence and determinants of metabolic syndrome among patients with COPD and to evaluate its association with COPD severity.

Materials and Methods: This cross-sectional study included 193 clinically diagnosed COPD patients. Demographic characteristics, smoking and biomass exposure history, anthropometric parameters, comorbidities, and biochemical investigations were recorded. Pulmonary function tests were used to classify COPD severity. Metabolic syndrome was defined according to standard diagnostic criteria. Statistical analysis included chi-square test and appropriate comparative measures, with $p < 0.05$ considered statistically significant.

Results: The prevalence of metabolic syndrome was 51.81%. Metabolic syndrome was more common in older age groups, overweight and obese individuals, and those with biomass exposure ($p = 0.003$). Central obesity (86%), impaired fasting glucose (69%), elevated blood pressure (60%), and low HDL cholesterol (70%) were the predominant components. Although moderate COPD showed a higher proportion of metabolic syndrome cases, no statistically significant association was observed between COPD severity and metabolic syndrome ($p = 0.3856$).

Conclusion: Metabolic syndrome is highly prevalent among COPD patients and is strongly associated with modifiable risk factors such as obesity and biomass exposure. The lack of significant association with airflow limitation severity suggests that systemic metabolic dysfunction may develop independently of spirometric impairment. Early screening and comprehensive management of metabolic risk factors are essential to reduce long-term cardiovascular complications in COPD patients.

Keywords: Metabolic Syndrome; Chronic Obstructive Pulmonary Disease; Central Obesity.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive, preventable, and treatable disorder characterized by persistent respiratory symptoms and irreversible airflow limitation resulting from airway and/or alveolar abnormalities. It remains a leading global cause of morbidity and mortality, with more than 3 million deaths annually. Cigarette smoking is the predominant risk factor, but biomass exposure, occupational pollutants, recurrent infections, and genetic predisposition also play key roles. COPD is increasingly recognized as a systemic illness rather than a condition limited to the lungs. Growing evidence indicates that chronic systemic inflammation, oxidative stress, physical inactivity, and hypoxia contribute to several extrapulmonary manifestations that significantly influence disease progression and patient outcomes. Among these, metabolic syndrome (MetS) has emerged as one of the most important and prevalent comorbidities.[1]

Metabolic syndrome is a cluster of metabolic derangements including abdominal obesity, insulin resistance or hyperglycemia, elevated blood pressure, dyslipidemia (high triglycerides and low HDL cholesterol), and increased cardiovascular risk. Its prevalence is rising globally, driven by sedentary lifestyles, urbanization, unhealthy diets, and an aging population. In COPD, the chronic inflammatory state, elevated cytokines, oxidative stress, impaired skeletal muscle function, and corticosteroid therapy further amplify metabolic abnormalities. The convergence of these factors predisposes COPD patients to develop MetS at a higher rate compared to the general population. Research suggests that the coexistence of MetS in COPD leads to more frequent exacerbations, increased symptom burden, reduced functional capacity, poorer quality of life, and higher cardiovascular morbidity and mortality.[2]

The pathophysiological links between COPD and MetS are complex and multifactorial. Systemic inflammation marked by TNF-α, and IL-6 is central to both conditions and contributes to endothelial dysfunction, insulin resistance, and metabolic dysregulation. Oxidative stress further aggravates inflammation and metabolic imbalance. Hypoxia associated with severe COPD enhances sympathetic activation and triggers metabolic alterations. Physical inactivity due to dyspnea, fatigue, and muscle wasting worsens obesity, insulin resistance, and lipid disturbances. Studies have shown MetS prevalence in COPD patients ranging from 25% to 60%, varying with diagnostic criteria (IDF vs. NCEP ATP III), population characteristics, and disease severity. However, limited data are available from Indian populations, particularly those attending tertiary care hospitals, where COPD risk factors such as biomass exposure, low socioeconomic status, and poor access to preventive care are highly prevalent.[3][4]

Aim

To determine the prevalence and determinants of metabolic syndrome among COPD patients and assess its association with COPD severity.

Objectives

1. To estimate the prevalence of metabolic syndrome among patients diagnosed with COPD.
2. To identify the common determinants and metabolic components associated with metabolic syndrome in COPD patients.
3. To evaluate the association between metabolic syndrome and COPD severity based on GOLD classification.

MATERIAL AND METHODS

Source of Data

Data were obtained from patients diagnosed with COPD who attended the Outpatient Department (OPD) and those admitted to the respiratory medicine ward of a tertiary care teaching hospital in Aurangabad. All eligible patients who fulfilled the inclusion criteria and provided informed consent were included.

Study Design

A hospital-based cross-sectional observational study was conducted.

Study Location

Department of Respiratory Medicine, Tertiary Care Centre, Aurangabad.

Study Duration

The study was carried out over a 24-month period from March 2023 to March 2025.

Sample Size

The total sample size was 193.

Sample size was calculated using the formula:

$N = Z^2 \times P(1-P) / D^2$,

where prevalence (P) = 0.57, Z = 1.96 (95% CI), allowable error (D) = 3%.

Inclusion Criteria

- Patients diagnosed with COPD based on clinical history, chest X-ray PA view, and spirometry (post-bronchodilator FEV1/FVC < 0.70).
- Adults aged ≥18 years.
- Patients willing to participate and provide written informed consent.

Exclusion Criteria

- Known cases of asthma.
- Patients with active pulmonary tuberculosis or pulmonary consolidation.
- Malignancies or immunocompromised conditions.
- Severe left ventricular dysfunction due to coronary artery disease.
- Patients unable to perform spirometry.

Procedure and Methodology

All participants underwent detailed evaluation after recruitment. A structured proforma was used to record sociodemographic details, smoking or biomass exposure history, symptom profile, comorbidities, medication history, and past hospitalizations. Clinical examination included anthropometric measurements (height, weight, BMI, waist circumference), blood pressure assessment, and systemic examination.

Waist circumference was measured at the midpoint between the lower costal margin and iliac crest using a non-stretchable tape. Blood pressure was measured in both arms, with the higher reading taken for analysis. All participants fasted for 12 hours before blood sampling.

Pulmonary Function Tests (spirometry) were performed using standard ATS/ERS guidelines. COPD severity was classified using GOLD staging based on post-bronchodilator FEV1 values. The CAT (COPD Assessment Test) questionnaire and the 6-Minute Walk Test (6MWT) were administered to assess symptom burden and functional capacity.

Metabolic syndrome was diagnosed using Modified NCEP-ATP III criteria (Asian cut-offs). Patients meeting ≥3 of the 5 components (central obesity, high triglycerides, low HDL, elevated BP, impaired fasting glucose) were categorized as having MetS.

Sample Processing

Blood samples were collected for the following investigations:

- Fasting blood glucose (FBG)/PPBS
- HbA1c
- Lipid profile (TG, HDL)
- Complete Blood Count (CBC)
- Liver and Renal Function Tests

All tests were performed in the hospital's accredited biochemistry laboratory using standardized techniques.

Statistical Methods

Data entry was performed in Microsoft Excel and analyzed using SPSS version 24.0.

- Categorical variables were presented as proportions (%) and compared using Chi-square or Fisher's exact test.
- Quantitative variables were expressed as mean ± SD and compared using t-tests or ANOVA, wherever applicable.
- A p-value <0.05 was considered statistically significant.
- Graphical displays included bar charts and frequency plots.

Data Collection

Data were collected prospectively at the time of patient evaluation. All information including clinical measurements, laboratory parameters, spirometry readings, CAT scores, and 6MWT results were documented systematically in the study proforma and cross-verified by the investigator.

RESULTS

Table 1: Association of Demographic and Clinical Variables with Metabolic Syndrome (N = 193)

Variable	Category	Metabolic Syndrome Yes n (%)	Metabolic Syndrome No n (%)	Total n (%)	p-value
Age (Years)	≤40	0 (0.00%)	2 (1.04%)	2 (1.04%)	
	41-60	29 (15.03%)	37 (19.17%)	66(34.20%)	
	61-80	59 (30.57%)	51 (26.42%)	110(56.99%)	
	≥81	12 (6.22%)	3 (1.55%)	15 (7.77%)	
	Total	**100 (51.81%)**	**93 (48.19%)**	**193 (100%)**	
Sex	Male	69 (35.75%)	83 (43.01%)	152(78.76%)	
	Female	31 (16.06%)	10 (5.18%)	41 (21.24%)	
	Total	**100 (51.81%)**	**93 (48.19%)**	**193 (100%)**	
Smoking (Pack Years) / Biomass Exposure	≤25	50 (25.91%)	52 (26.94%)	102(52.85%)	
	26-50	17 (8.81%)	25 (12.95%)	42 (21.76%)	
	>50	0 (0.00%)	3 (1.55%)	3 (1.55%)	
	Biomass Exposure	33 (17.10%)	13 (6.74%)	46 (23.83%)	**0.003216***
	Total	**100 (51.81%)**	**93 (48.19%)**	**193 (100%)**	
BMI (kg/m²)	Underweight (<18.5)	6 (3.11%)	27 (13.99%)	33 (17.10%)	
	Normal (18.5-24.9)	47 (24.35%)	54 (27.98%)	101(52.33%)	
	Overweight (25-29.9)	36 (18.65%)	10 (5.18%)	46 (23.83%)	
	Obese Class I (30-34.9)	9 (4.66%)	2 (1.04%)	11 (5.70%)	
	Obese Class II (35-39.9)	2 (1.04%)	0 (0.00%)	2 (1.04%)	
	Total	**100 (51.81%)**	**93 (48.19%)**	**193 (100%)**	
Comorbidities	Hypertension (Yes)	69 (35.75%)		69 (35.75%)	
	Hypertension (No)	124 (64.25%)		124(64.25%)	
	Diabetes Mellitus (Yes)	25 (12.95%)		25 (12.95%)	

	Diabetes Mellitus (No)	168 (87.05%)		168(87.05%)	
	Ischemic Heart Disease (Yes)	19 (9.84%)		19 (9.84%)	
	Ischemic Heart Disease (No)	174 (90.16%)		174(90.16%)	
Waist Circumference (cms)	51-70	16 (8.29%)		16 (8.29%)	
	71-90	82 (42.49%)		82 (42.49%)	
	91-110	95 (49.22%)		95 (49.22%)	
	Total	**193 (100%)**			

Table 1 shows the association of demographic and clinical variables with metabolic syndrome among 193 patients. Overall, the prevalence of metabolic syndrome was 51.81% (100/193). The majority of participants belonged to the 61-80 years age group (56.99%), and this age group also had the highest proportion of metabolic syndrome cases (30.57%), followed by those aged 41-60 years (15.03%). Very few participants were aged ≤40 years (1.04%), and none of them had metabolic syndrome. Among participants aged ≥81 years, 6.22% had metabolic syndrome.

Males constituted 78.76% of the study population, while females accounted for 21.24%. Metabolic syndrome was observed in 35.75% of males and 16.06% of females.

Regarding smoking and biomass exposure, 52.85% had ≤25 pack-years exposure, of whom 25.91% had metabolic syndrome. Biomass exposure was significantly associated with metabolic syndrome ($p = 0.003216$), with 17.10% of exposed individuals having metabolic syndrome compared to 6.74% without it.

In terms of BMI, most participants had normal BMI (52.33%), but metabolic syndrome was more common among overweight (18.65%) and obese individuals (5.70% combined). Underweight individuals showed a lower prevalence (3.11%).

Among comorbidities, hypertension was present in 35.75%, diabetes mellitus in 12.95%, and ischemic heart disease in 9.84% of participants. Nearly half of the study population (49.22%) had a waist circumference between 91-110 cm, indicating a high burden of central obesity.

Table 2: Pulmonary Function Test (PFT) with Metabolic Syndrome of patients of chronic obstructive pulmonary disease

Pulmonary Function Test (PFT)	**Metabolic Syndrome Count (Percentage)**		**Total**
	Yes	**No**	
Mild obstruction	11(5.7%)	8(4.15%)	19 (9.84%)
Moderate obstruction	45(23.32%)	33 (17.09%)	78 (40.41%)
Severe obstruction	29 (15.03%)	37 (19.17%)	66 (34.20%)
Very Severe obstruction	15 (7.78%)	15 (7.78%)	30 (15.54%)
Total	100 (51.81%)	93 (48.19%)	193 (100.00%)
Chi-square test	0.3856		

Table 2 depicts the distribution of metabolic syndrome according to pulmonary function test (PFT) severity among patients with chronic obstructive pulmonary disease (COPD). Moderate obstruction was the most common PFT category (40.41%), followed by severe obstruction (34.20%), very severe obstruction (15.54%), and mild obstruction (9.84%).

Metabolic syndrome was most frequently observed in patients with moderate obstruction (23.32%), followed by severe obstruction (15.03%) and very severe obstruction (7.78%). The distribution of metabolic syndrome across different PFT severity grades was not statistically significant (Chi-square test, $p = 0.3856$), suggesting no strong association between airflow limitation severity and metabolic syndrome prevalence in this cohort.

Table 3: Prevalence of MS and its components of patients of chronic obstructive pulmonary disease

		Metabolic Syndrome		**Prevalence**
	N=193	**Yes (N1=100)**	**No (N2=93)**	**51.81%**
Central obesity	**Male (n1=152) W.C. >90cm**	56 (56%)	23 (24.73%)	86%
	Female (n2=41) W.C. >80cm	30 (30%)	8 (8.60%)	
High Triglyceride	**S. Triglyceride ≥ 150mg/dl (n=42)**	37 (37%)	5 (5.38%)	37%
Low HDL cholesterol	**Male (n1=152) S.HDL<40 mg/dl**	45 (45%)	18 (19.35%)	70%
	Female (n2=41) S.HDL <50 mg/dl	25 (25%)	7 (7.53%)	

Elevated Blood Pressure	**BP≥ 130/85 mmHg or on treatment (n=80)**	60 (60%)	20 (22.58%)	60%
Impaired fasting blood glucose	**Fasting blood glucose ≥ 100mg/dl (n=102)**	69 (69%)	33 (35.48%)	69%

Table 3 illustrates the prevalence of metabolic syndrome and its individual components among COPD patients. The overall prevalence of metabolic syndrome was 51.81%. Central obesity was highly prevalent, particularly among males with waist circumference >90 cm and females with waist circumference >80 cm, contributing to 86% of metabolic syndrome cases.

High triglyceride levels (≥150 mg/dl) were observed in 37% of patients with metabolic syndrome, whereas only 5.38% without metabolic syndrome had elevated triglycerides. Low HDL cholesterol was also common, affecting 45% of males and 25% of females with metabolic syndrome, resulting in an overall prevalence of 70%.

Elevated blood pressure (≥130/85 mmHg or on treatment) was present in 60% of metabolic syndrome patients, and impaired fasting blood glucose (≥100 mg/dl) was observed in 69% of those with metabolic syndrome. These findings highlight that central obesity, dyslipidemia, hypertension, and impaired glucose regulation were the predominant components contributing to metabolic syndrome among COPD patients.

DISCUSSION

The present cross-sectional study demonstrated a high prevalence of metabolic syndrome (MS) among COPD patients (51.81%). This finding is comparable to the study conducted by Sahoo et al. (2022),[1] who reported a substantial prevalence of metabolic syndrome among COPD patients and highlighted its positive correlation with disease severity. Similarly, Priyadharshini et al. (2020),[3] observed a high burden of metabolic syndrome in South Indian COPD patients, emphasizing the role of systemic inflammation and sedentary lifestyle in disease progression. Furthermore, the recent systematic review and meta-analysis by Alrabbaie et al. (2025),[4] confirmed that metabolic syndrome is significantly more prevalent in COPD populations compared to the general population, reinforcing the systemic nature of COPD.

With respect to age distribution, the majority of metabolic syndrome cases in our study were observed in the 61-80 years age group. This observation aligns with national epidemiological data reported by Yao et al. (2021),[10] which demonstrated increasing prevalence of metabolic syndrome with advancing age. Aging is associated with increased insulin resistance, vascular stiffness, and chronic low-grade inflammation, which may synergistically worsen COPD outcomes. Male predominance in our cohort also corresponds with findings from Kiani and Ahmadi (2021),[6] who reported higher comorbidity clustering among male COPD patients in the PERSIAN cohort, potentially due to greater exposure to smoking and occupational hazards.

Biomass fuel exposure showed a statistically significant association with metabolic syndrome in our study. This supports the mechanistic insights provided by Kotlyarov and Kotlyarova (2021),[8] who described molecular pathways linking chronic inflammatory exposure and lipid metabolism disorders in COPD exacerbations. Chronic exposure to biomass smoke may amplify oxidative stress, systemic inflammation, and metabolic dysregulation.

Regarding BMI and central obesity, overweight and obese individuals demonstrated higher proportions of metabolic syndrome. These findings are consistent with Lee et al. (2020),[7] who reported a significant association between metabolic syndrome risk factors and impaired lung function. Our waist circumference data, indicating a high burden of central obesity, further supports the concept that abdominal adiposity is a major contributor to metabolic abnormalities in COPD.

Comorbidities such as hypertension, diabetes mellitus, and ischemic heart disease were frequently observed in our cohort. These results are in line with Almagro et al. (2020),[11] who emphasized COPD as a critical risk factor for cardiovascular disease due to shared inflammatory and endothelial dysfunction pathways. Additionally, Voulgaris et al. (2021),[9] highlighted the strong interplay between COPD and cardiovascular disorders, particularly in patients with overlapping metabolic and sleep-related conditions.

In Table 2, although moderate obstruction demonstrated the highest frequency of metabolic syndrome, there was no statistically significant association between COPD severity and metabolic syndrome. Similar findings were reported by Keeratichananont et al. (2023),[5] who, in a 5-year prospective observational study, noted that metabolic syndrome prevalence did not always correlate linearly with spirometric severity but was strongly influenced by systemic metabolic factors.

Table 3 revealed that central obesity, impaired fasting glucose, elevated blood pressure, and low HDL cholesterol were predominant components of metabolic syndrome. This clustering pattern parallels observations by Sahoo et al. (2022),[1] and Priyadharshini et al. (2020),[3] who reported abdominal obesity and dyslipidemia as dominant features among COPD patients with metabolic syndrome. Moreover, emerging evidence from Foer et al. (2023),[12] suggests that metabolic modulation through agents such as GLP-1 receptor agonists may influence COPD outcomes, further underscoring the

clinical significance of metabolic abnormalities in this population.

CONCLUSION

The present cross-sectional study demonstrated a high prevalence (51.81%) of metabolic syndrome (MS) among patients with chronic obstructive pulmonary disease (COPD), underscoring the substantial cardiometabolic burden in this population. Advancing age, biomass fuel exposure, higher body mass index, and central obesity were significant determinants of metabolic syndrome. Among the metabolic components, central obesity, impaired fasting glucose, elevated blood pressure, and low HDL cholesterol were the most prevalent abnormalities. Although moderate COPD showed a relatively higher frequency of metabolic syndrome, no statistically significant association was observed between airflow limitation severity and metabolic syndrome status. These findings highlight that metabolic dysfunction in COPD patients may occur independently of spirometric severity. Routine screening for metabolic syndrome and its components in COPD patients is essential for early identification and integrated management, aiming to reduce cardiovascular morbidity and improve overall prognosis.

Limitations of the Study

1. The cross-sectional design limits the ability to establish causal relationships between COPD severity and metabolic syndrome.
2. The study was conducted at a single tertiary care center, which may limit generalizability to the broader COPD population.
3. Potential confounding variables such as physical activity levels, dietary patterns, and medication use were not extensively evaluated.
4. Biomarkers of systemic inflammation were not assessed, which could have strengthened the understanding of underlying pathophysiological mechanisms.
5. The sample size, though adequate, may not be sufficient to detect subtle associations between COPD severity grades and metabolic syndrome.
6. Longitudinal follow-up was not performed to assess outcomes related to cardiovascular events or mortality.

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