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FREQUENCY OF TYPE-II RESPIRATORY FAILURE IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Original Research

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is characterized by bronchial obstruction and impaired alveolar ventilation, leading to inadequate gas exchange and potential hypercapnia. In COPD, respiratory muscle dysfunction and structural airway changes exacerbate ventilation issues, increasing the risk of type II (hypercapnic) respiratory failure. This study investigates the frequency of type II respiratory failure in COPD patients, a complication linked to high morbidity and mortality.

Objective: To determine the prevalence of type II respiratory failure in patients with COPD.

Methods: This descriptive cross-sectional study was conducted from August 2023 to June 2024 at Saidu Group of Teaching Hospitals, Saidu Sharif, Swat, after approval by the hospital's Ethical Committee. Patients were recruited from the Outpatients Department. Sample size was calculated using the WHO sample size formula based on an expected frequency of type II respiratory failure of 25%, with a 5% margin of error and a 95% confidence interval, resulting in a total of 118 participants. Clinical data were collected, including demographics, spirometry, and arterial blood gas analyses, with type II respiratory failure defined by a $PaCO_2 \geq 45$ mmHg.

Results: Of the 118 patients, 82 (70%) were male and 35 (30%) female, with ages ranging from 40 to 65 years. Moderate stage 2 COPD was most common, accounting for 47.5% of cases. Type II respiratory failure was observed in 28 patients (24%).

Conclusion: This study highlights a significant prevalence of type II respiratory failure among COPD patients, particularly in older males. Notably, type II respiratory failure does not appear directly correlated with COPD severity as measured by GOLD staging.

Keywords: Chronic Obstructive Pulmonary Disease, Respiratory Failure Type II, Hypercapnia, Arterial Blood Gases, Spirometry, Prevalence, Aged.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) encompasses a group of lung disorders that hinder breathing, primarily affecting middle-aged or older smokers (1). COPD manifests mainly in the forms of emphysema and chronic bronchitis, conditions marked by progressive airflow limitation due to the adverse impact of irritative gases and pollutants on the lungs. The severity of COPD varies significantly across individuals due to its heterogeneous nature and the presence of comorbidities (2). Numerous studies and theories have been proposed to explain the pathophysiology of COPD. According to the British Thoracic Society, the presence of chronic cough and sputum production is critical to its diagnosis (3). Other hypotheses, such as the Dutch hypothesis by Prof. Orie, suggest an underlying increased airway responsiveness (4), while the Swedish hypothesis emphasizes genetic predispositions to COPD. These perspectives collectively highlight the complexity of COPD, which involves increased airway reactivity, a heightened response to infections, aberrant cellular repair, and a predisposition to various complications and comorbid disorders (5).

In 2015, COPD was estimated to affect approximately 104.7 million men (95% UI, 96.0 to 113.8 million) and 69.7 million women (64.2 to 75.4 million) globally, a considerable rise from previous figures recorded in 1990. The incidence of COPD has escalated by 44.7% since 1990, and it is projected to rank as the fourth leading cause of death by 2040 (6). Tragically, COPD accounted for an estimated 3.2 million deaths worldwide in 2015, reflecting an 11.6% increase from 1990 (7). Often, individuals with COPD seek medical attention at advanced stages, by which time their disease may have progressed to a critical level, impairing their ability to ventilate adequately due to obstructed alveoli. This results in hypoxia and hypercapnia, ultimately leading to type II respiratory failure (8). Hypercapnia, a key indicator in COPD, is characterized by elevated arterial carbon dioxide (CO_2) levels ($PaCO_2 > 45$ mmHg) coupled with a pH of less than 7.35, typically due to respiratory pump failure or excessive CO_2 production. The severity of COPD is stratified according to the GOLD criteria, which categorizes it into four grades based on spirometry results and FEV1 values (9). Furthermore, the modified alveolar ventilation equation indicates that $PaCO_2$ levels are proportionally linked to CO_2 production (VCO_2) and inversely related to CO_2 elimination (alveolar ventilation), a balance that can vary with factors such as age and pregnancy. Given the significant impact of COPD on respiratory function, this study aimed to determine the frequency of type II (hypercapnic) respiratory failure in patients with COPD presenting at a tertiary care facility in the Saidu Group of Teaching Hospitals in Saidu Sharif.

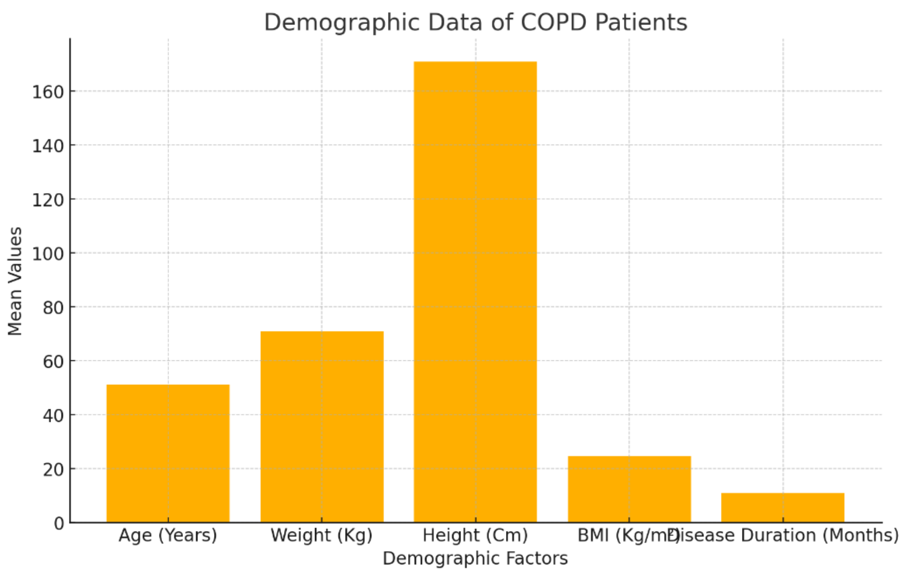
METHODS

This descriptive cross-sectional study was conducted from August 2023 to June 2024 at the Saidu Group of Teaching Hospitals in Saidu Sharif, Swat, following approval from the hospital's Ethical Committee. Patients admitted from the Outpatients Department were assessed for eligibility. The sample size was calculated using the WHO sample size formula, with a 25% expected frequency of type II respiratory failure based on a previous study, a 5% margin of error, and a 95% confidence interval. The resulting sample size was 118 participants (10). A non-probability consecutive sampling technique was employed to select participants. The inclusion criteria comprised known COPD patients aged 40–65 years, with symptoms of shortness of breath (respiratory rate >22 breaths per minute) and referred to the medical department. Exclusion criteria included patients with documented physical abnormalities of the chest, those with a Glasgow Coma Scale (GCS) score lower than 5, and individuals with lung pathologies other than COPD.

Informed consent was obtained in writing from each participant before data collection, with all procedures conducted in accordance with hospital policy. Data on height, weight, BMI, age, sex, and duration of COPD were collected for each participant. Spirometric classification according to the GOLD stage was performed using the Contec® SP100 machine. Arterial blood samples were collected in heparinized syringes under aseptic conditions and analyzed for arterial blood gases (ABG) to record $PaCO_2$ levels. Type II respiratory failure was identified when $PaCO_2$ was ≥45 mmHg. Data were compiled on a designated proforma and analyzed using Excel. Continuous variables, including age, weight, height, BMI, COPD duration, predicted FEV1, and $PaCO_2$ levels, were presented as mean ± standard deviation. Categorical variables, such as gender, presence of type II respiratory failure, and GOLD stages, were reported as frequencies and percentages. Effect modifiers, including age, sex, COPD duration, GOLD stage, and BMI, were stratified against type II respiratory failure, with statistical significance set at $p<0.05$.

RESULTS

A total of 118 patients were included in the study, with a gender distribution of 82 males (70%) and 35 females (30%), all aged between 40 and 65 years. The mean age of participants was 51 years (±10.1). The demographic data reflected an average weight of 70.84 kg (±11.34), an average height of 170.84 cm (±8.7), and a mean BMI of 24.72 kg/m² (±3.68). The mean duration of COPD among patients was approximately 11 months (±2.76).



The classification of patients based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) staging revealed that a significant proportion, 47.5%, were in the moderate, or stage 2, category of COPD. In terms of respiratory failure, 28 patients (24%) were found to have type II respiratory failure, characterized by a $PaCO_2$ level of ≥45 mmHg.

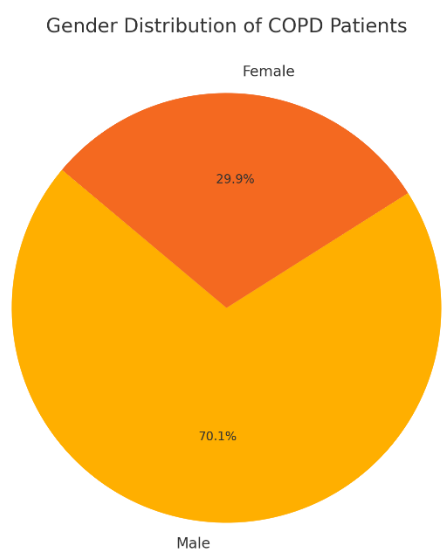
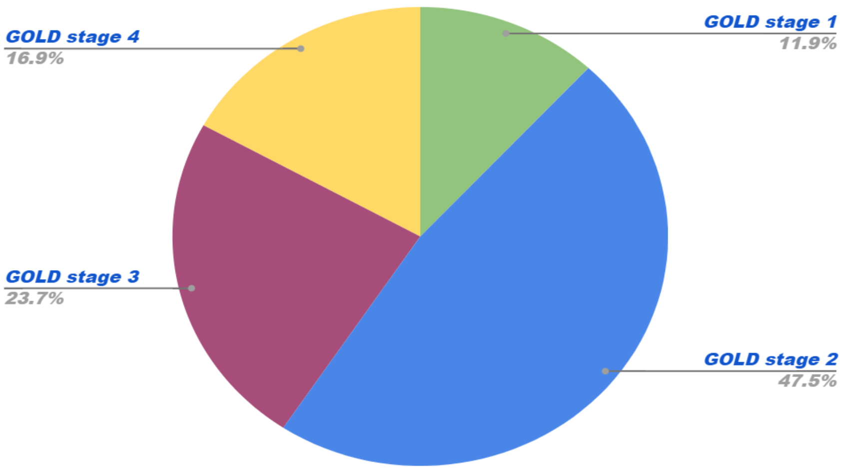


TABLE 1: DEMOGRAPHIC DATA

DEMOGRAPHICS	MEAN SD
Age (Years)	51±10.1
Weight (Kg)	70.84±11.342
Height (Cm)	170.84±8.700
BMI (Kg/m2)	24.72±3.6769
Disease Duration (months)	11±2.76



Data on continuous variables such as age, weight, height, BMI, and duration of disease were presented as mean ± standard deviation. Categorical data, including gender, GOLD stage, and the presence of type II respiratory failure, were expressed as frequencies and percentages. These findings highlight that the majority of the sample fell within the moderate COPD classification, with a notable portion exhibiting type II respiratory failure, aligning with the study's objective to assess the prevalence of this condition among COPD patients.

DISCUSSION

The study aimed to investigate the prevalence of type II respiratory failure in COPD, with findings showing that 24% of the participants experienced this complication. This aligns closely with prior research indicating a prevalence of approximately 25% in similar patient populations (11). The results confirm the understanding that type II respiratory failure in COPD is commonly driven by factors such as airway obstruction, diminished lung elasticity, and alveolar damage, which collectively lead to increased blood carbon dioxide and reduced oxygen levels. Slight differences in prevalence between this and other studies may be attributed to variations in contributing factors, such as smoking rates and environmental exposures, which can differ significantly across regions and populations. Areas with high smoking prevalence tend to report elevated COPD rates and related complications, including type II respiratory failure (12). Environmental factors, including exposure to indoor and outdoor pollutants, occupational hazards, and the use of biomass fuels, also play a significant role in the development and progression of COPD. Additionally, genetic predisposition is an influential factor, with certain genetic variations affecting susceptibility to COPD-related respiratory failure. For example, a mutation in the SERPINA1 gene, which regulates the neutrophil elastase enzyme, leads to Alpha-1 antitrypsin deficiency (A1ATD), causing emphysema and lung tissue degeneration. This predisposition is further exacerbated by cigarette smoke exposure in individuals with A1ATD, accelerating lung deterioration. These findings underscore the multifactorial nature of COPD and the importance of understanding diverse etiologies in managing type II respiratory failure among COPD patients (13).

The study found a higher prevalence of type II respiratory failure among male COPD patients, a trend consistent with global studies indicating that men are more prone to COPD due to higher smoking rates. The slightly higher prevalence observed in this study may be linked to cultural and lifestyle factors, as men in Pakistan tend to have higher smoking rates and work in occupations where exposure to dust, fumes, and other contaminants is common. This occupational exposure raises additional concerns about vulnerability to COPD and related respiratory complications among men in the region (15). Age was another factor observed to influence the prevalence of type II respiratory failure in COPD. Studies by Hosseini et al. (2019) and other researchers have highlighted a correlation between advanced age and the incidence of type II respiratory failure in COPD (16). Age-related reductions in lung elasticity and alveolar hyperinflation contribute to CO_2 retention, thus increasing the risk of respiratory failure in older patients. In this study, however, the proportion of patients over the age of 55 was relatively low compared to similar studies conducted abroad. This difference may be due to early smoking initiation, lower life expectancy, lifestyle factors, and the prevalence of respiratory diseases in younger populations within this country (18).

Interestingly, the study did not find a statistically significant relationship between COPD severity based on GOLD staging and the prevalence of type II respiratory failure, a result that corroborates earlier findings showing substantial interindividual variability in COPD outcomes across different severity levels (19). Likewise, no significant association was observed between BMI and type II respiratory failure in COPD, consistent with prior research on the influence of BMI on COPD outcomes (20). The absence of a significant

BMI correlation may stem from the small sample size, which could have limited the detection of meaningful associations. Additionally, confounding variables such as smoking history, physical activity, medication usage, and comorbidities may have masked potential links between BMI and COPD outcomes (21). Further investigation through larger, more comprehensive studies that account for these confounding factors and examine diverse patient subgroups is necessary to better understand the role of BMI in COPD progression and respiratory failure risk. Strengths of this study include the focus on type II respiratory failure prevalence in a specific patient population, providing relevant data that align with international findings and localize understanding within a unique demographic. However, certain limitations were present. The study did not differentiate between COPD subtypes, such as chronic bronchitis and emphysema, nor did it address underlying causes of COPD. Categorizing patients under broader COPD labels rather than specific subtypes may have limited the ability to analyze the varied pathophysiological mechanisms contributing to type II respiratory failure. Including these distinctions would enhance the comprehensiveness and applicability of the findings.

CONCLUSION

This study underscores the significant prevalence of type II respiratory failure among COPD patients, particularly among males and older individuals. Findings indicate that while type II respiratory failure is more common in these groups, its occurrence does not appear to be directly linked to COPD severity as defined by GOLD staging. These insights contribute to a deeper understanding of the complex factors influencing respiratory outcomes in COPD, highlighting the need for targeted approaches in managing patients at higher risk of respiratory complications.

Author	Contribution
Shafiq Ahmad	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Ajmal Khan	Methodology, Investigation, Data Curation, Writing - Review & Editing
Muzamil Mahmood	Investigation, Data Curation, Formal Analysis, Software
Waqar Kabir	Software, Validation, Writing - Original Draft
Sajjad Ahmad	Formal Analysis, Writing - Review & Editing
Syed Nadeem Badshah	Writing - Review & Editing, Assistance with Data Curation

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