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Correlation between FEV1 and Polycythemia in Chronic Obstructive Pulmonary Disease

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A B S T R A C T

Introduction: Chronic obstructive pulmonary disease (COPD) is linked with progressive but not fully reversible airflow obstruction. Spirometry is the gold standard test for diagnosis of COPD with FEV1/FVC <70%. Forced expiratory volume in one second (FEV1) is used to divide COPD severity into different categories.

Objective: To determine the correlation between FEV1 and Polycythemia in COPD.

Methodology: A cross-sectional study was conducted at Department of Pulmonology, Khyber Teaching Hospital (KTH), Peshawar from September, 2021, to March, 2022. After taking written approval from CPSP, all COPD patients of Medical and Pulmonology unit of KTH Peshawar fulfilling the inclusion criteria were assessed. Written informed consent was taken from all study patients. On arrival a detailed history was taken followed by physical examination with special focus on the presence of polycythemia. Data was analysed by SPSS version 23.

Results: Out of total 140 patients, the majority (60.3%) were females. The mean age was 54.93 (± 9.31) years while the mean duration of COPD was 7.57 (± 3.42) years. The mean BMI was 27.27 (± 4.08) Kg/ m^2. Polycythemia was observed in these 11 (08%) patients. By applying the Chi-square test, there was no statistically significant association between FEV1 and polycythemia (p = 0.69). On Pearson co-efficient correlation, there was no significant correlation between FEVI and polycythemia (rr=0.08, p =0.34).

Conclusion: COPD is an important health issue that can lead to a number of complications including polycythemia. FEV1 has no significant association with polycythemia. However, earlier screening for polycythemia is recommended to avoid the sequalae of this complication in patients with COPD.

Keywords: Polycythemia, hematocrit, Chronic obstructive pulmonary disease, FEV1, correlation

Introduction

Chronic obstructive pulmonary disease (COPD) is a prevalent pulmonary condition characterized by persistent airflow obstruction that significantly impacts the quality of life. COPD is a progressive disease, and while its symptoms can be managed, it is considered irreversible. This condition typically results from prolonged exposure to noxious particles and gases, such as those found in cigarette smoke, industrial pollutants, and biomass fuel emissions. These substances are thought to trigger chronic inflammation in the airways and lung parenchyma, causing structural remodeling and functional impairment.[1,2] The disease poses a major global health challenge and is currently the fourth leading cause of death worldwide. The World Health Organization estimates a prevalence of approximately 10.3%, with projections indicating an increase in both prevalence and mortality in the coming decades due to aging populations and sustained tobacco use.[3,4]

COPD diagnosis primarily relies on spirometry, a simple yet essential pulmonary function test. Spirometry measures lung function, particularly the forced expiratory volume in one second (FEV1), and determines the degree of airflow obstruction. In patients with COPD, spirometry often reveals fixed or partially reversible airway obstruction, confirming the diagnosis. Additionally, FEV1 levels are used to stage the severity of the disease, ranging from mild to very severe.[5] Early diagnosis and effective management strategies are crucial, as timely intervention can significantly reduce disease progression and improve patient outcomes. Despite advances in treatment, COPD remains a significant burden due to its chronic and progressive nature, and its associated morbidity and mortality.[6]

One of the reasons for the high burden of COPD is its systemic complications, which extend beyond the lungs. Among these, polycythemia is a well-recognized complication that arises due to chronic hypoxemia and, in some cases, carboxyhemoglobinemia resulting from cigarette smoking. Polycythemia is defined as an increase in red blood cell (RBC) mass and is attributed to heightened erythropoietin production, which is stimulated by reduced oxygen levels.8,9 While the physiological response aims to improve oxygen transport, excessive RBC production can lead to hyperviscosity, impairing circulation and increasing the risk of complications such as thromboembolic events, myocardial infarction, and stroke.10 Patients with polycythemia may present with symptoms like headache, dizziness, visual disturbances, and physical signs such as facial plethora and cyanosis. Recognizing and managing these symptoms early is essential to avoid severe outcomes.

Several studies have explored the relationship between FEV1 and polycythemia in COPD patients. For instance, Kim MH et al. demonstrated a positive correlation between FEV1 and polycythemia, with a reported correlation coefficient of 0.37 ($p<0.01$).[11] This suggests that as FEV1 declines, the likelihood of developing polycythemia increases. Similarly, Hashim KP et al. found a 97% prevalence of polycythemia in COPD patients and noted significant correlations between polycythemia, smoking severity, and COPD stage.[12] These findings underscore the complex interplay between lung function decline and systemic complications in COPD patients.

The rationale for conducting this study lies in identifying COPD patients at risk of developing polycythemia due to progressively declining FEV1 levels. Early identification can facilitate timely implementation of preventive strategies, such as supplemental oxygen therapy, smoking cessation, and careful monitoring of hematocrit levels. These measures could potentially reduce the risk of thromboembolic events and improve the overall prognosis of patients. Furthermore, addressing this complication in a systematic and evidence-based manner will contribute to enhancing patient care and reducing healthcare costs associated with the long-term management of COPD and its complications.

Objective

To determine the correlation between FEV1 and polycythemia in COPD patients.

Methodology

This Cross-sectional study was conducted at Department of Pulmonology, Khyber Teaching Hospital, Peshawar over six months duration, from September, 2021 to March, 2022. The samples were collected using non probability consecutive sampling technique. A total sample size of 140 patients was studied. The sample size was calculated based on the WHO calculator for sample size determination using Correlation between FEV1 and Polycythemia, r (correlation) = 0.37 with confidence interval of 95%.[11]

All male and female patients having age of 40 to 70 years admitted in the Medical and Pulmonology wards with symptoms and spirometric features suggestive of COPD were included in the study. Patients with primary polycythemia, secondary polycythemia due to liver and kidney diseases and patients with bronchiectasis and sleep apnea syndromes were excluded. Polycythemia was defined as hematocrit (HCT) >48% in females & >52% in males determined through a complete blood count test (CBC) in hospital laboratory.

Data were collected after study approval from the CPSP. All COPD patients admitted in Medical and Pulmonology units of KTH Peshawar, fulfilling the inclusion criteria were enrolled. A properly written informed consent was obtained from all participants of the study. On arrival, a detailed history was taken and an examination was done with special focus on the presence of COPD with Polycythemia. Age, gender, duration of COPD, weight, height, BMI, and Hematocrit level were noted. Spirometry was done including determination of FEV1 and patients were classified on the basis of disease severity as per Global Initiative for Chronic Obstructive Lung Disease (GOLD) staging system.

All the data were recorded in a pre-designated proforma. Bias was eliminated by standardization of Spirometry and Hematocrit level as given in the operational definitions. Confounders were controlled by strictly following exclusion criteria and universal confounders (age, gender) were controlled during analysis phase by using stratification.

Data analysis was done with the help of statistical software, SPSS version 23. Mean ± SD were calculated for continuous variables like age, weight, height, BMI, duration of COPD, FEV1 and Hematocrit level. Frequencies and percentages were calculated for categorical variables like gender, Polycythemia, Gold stages of COPD and severity of COPD based on FEV1. The Chi square test was applied for the association between FEV1 and polycythemia. Affect modifiers like age, Gold stages of COPD and duration of COPD were controlled through stratification. Correlation between FEV1 and polycythemia was calculated by applying Pearson coefficient correlation test, keeping r>0.80 as a very strong correlation. P-value<0.05 was taken as statistically significant. The results were presented in the form of charts and Tables.

Results

A total of 140 patients of COPD were included. The basic demographic characteristics of the patients are given in Table 1.

These 140 patients were divided on the basis of gender.

Table 1. Demographic characteristics of patients (n=140)

Parameter	Mean and standard deviation
Age	54.93 years ± 9.31 SD
Duration of COPD	7.57 years ± 3.42 SD
Height of patients	1.61 meters ± 0.92 SD
Weight of patients	70.50 Kg ± 8.52 SD
BMI	27.27 Kg/ m^2 ± 4.08 SD

Among these 140 patients, the majority of these patients were females i.e., 85 patients (60.7%) were females (Figure 1).

The patients were categorized into two age groups for analysis. Group 1 consisted of patients aged between 40 and 60 years. This group included the majority of the participants, with 89 patients accounting for 63.5% of the total study population. Within this group, females represented the larger proportion, with 49 individuals (55%) being women. Group 2, on the other hand, comprised patients aged between 61 and 70 years. This group included 51 patients, making up 36.5% of the total. Among these, females were also in the majority, with 36 individuals (70.6%) belonging to this category (Table 2).

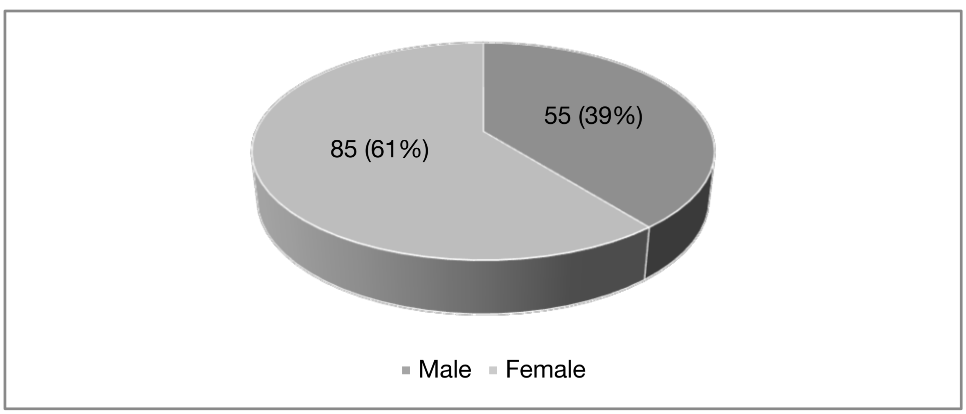

Figure 1. Gender base distribution of study cases

Table 2. Distribution of patients based on age (n=140)

	Age of patients	Gender of patients	Frequency (%)	p-value
Group 1	40-60 years	Males 40 (45%)	89 (63.5%)	0.07
		Females 49 (55%)		
Group 2	61-70years	Males 15 (29.4%)	51 (36.5%)	
		Females 36 (70.6%)		
Total	40-70 years	Males 55 (39.3%)	140 (100%)	
		Females 85 (60.7%)		

The study participants were divided into four groups on the basis of severity of the disease according to GOLD stage of COPD. Majority of patients i.e., 37 (26.4%) patients were in very severe stage (Gold stage IV) of the disease, followed by moderate stage of the disease (Gold stage II) i.e., 36 patients (25.7%) (table 3).

The mean FEV1 in this study was 53.77 ml ± 23.17 SD of the predicted value while the mean hematocrit level was 47.42% ± 2.29SD. Polycythemia was found in 11 (8%) patients. There a was no significant association between FEV1 and polycythemia (p =0.69) by applying the Chi-square test (Table 4).

The frequency of polycythemia was stratified on the basis of gender. In male patients, three (5.45%) patients were found to have polycythemia while in female patients, eight (9.4%) patients had polycythemia. The difference was statistically insignificant (p=0.39) (Table 5).

Stratification of polycythemia on the basis of age was done with the following results. In patients aged 41 to 60 years, six (9%) patients were found to have polycythemia while in patients aged 61 to 70 years, five (9.8%) patients were reported with polycythemia. The difference was statistically insignificant (p=0.51) (Table 6).

The Frequency of polycythemia was stratified on the basis of GOLD stage of COPD as well. In patients with both GOLD stage I and II, two (06%) patients were found to have polycythemia, in patients with GOLD stage III, four (12.5%) patients had polycythemia while in patients with GOLD stage IV, three (08%) patients were detected with polycythemia. The difference was statistically insignificant (p =0.70) by applying the Chi-square test (Table 7). By applying the Pearson correlation test, there was insignificant correlation between FEV1 and polycythemia (rr= .08, p=0.34). This proves the null hypothesis of our study that FEV1 is not correlated with polycythemia in patients with COPD.

Discussion

In our study, the prevalence of polycythemia in patients with COPD was 8%(n=11). The prevalence of polycythemia in COPD is reported to be 10.8%, which is consistent with the results of our study.[7] Zhang J et al reported a 6.63% prevalence of polycythemia in their study.[8] Fawzy A et al reported an 11.7% prevalence of polycythemia in their study.[14]

In our study, there was no significant correlation between FEV1 and polycythemia (rr= 0.08, p=0.34). Kollert F et al

Table 3. Distribution of patients based on disease severity (n=140)

Severity of the disease	Frequency (%)	Percent
Mild COPD (Gold Stage I)	35	25.0
Moderate COPD (Gold Stage II)	36	25.7
Severe COPD (Gold Stage III)	32	22.9
Very severe COPD (Gold Stage IV)	37	26.4
Total	140	100.0

Table 4. Association of FEV1 with polycythemia (n=140)

FEV1 predicted	Polycythemia in COPD		Total	P value
	yes	No		
≥ 80%	2 (6%)	33 (94%)	35 (100%)	0.69
50 to 79%	2 (5.6%)	34 (94.4%)	36 (100%)	
30 to 49 %	4 (12.5%)	28 (87.5%)	32 (100%)	
<30%	3 (8%)	34 (92%)	37 (100%)	
Total	11 (8%)	129 (92%)	140 (100%)	

also concluded no association between polycythemia and severity of COPD (based on FVE1), which is also consistent with the findings of our study.[15]

Chronic obstructive pulmonary disease (COPD) is characterized by persistent, preventable, and treatable but not fully reversible, and progressive airflow obstruction in lungs due to alveolar or airway abnormalities. The worldwide prevalence of COPD is 5%.[1] The chronic obstructive changes in this airway disease are due to the combination of small airways abnormalities accompanied by alveolar changes, the contribution of these factors varies from person to person.[13] The chronic inflammatory changes in COPD lead to structural changes which then cause narrowing of the small airways and destructive changes in lung parenchyma.[16]

The most documented risk factor for the chronic obstructive pulmonary disease is cigarette smoking while consumption of biomass fuel also plays a definitive role in its causation.[2] Polycythemia occurs due to chronic hypoxemia or/and carboxyhemoglobinemia.[7] Increased production of erythropoietin leads to increased stimulation for RBC production and as a result, RBC mass is increased. The affected person with polycythemia presents with vertigo, headache, blurring of vision, and plethora along with cyanosis. Complications of polycythemia include hemorrhages, thrombosis, stroke, myocardial infarction, and heart failure.[8,9] COPD is divided into various types on the basis of severity of the disease (GOLD stages of COPD) which are based on FEV1. This study aimed to determine the correlation of polycythemia with FEV1.

The mean age of our study participants was 54.93 years ± 9.31 SD. The mean BMI was 27.27 Kg/ m^2 ± 4.08 SD. The majority of patients (26.4%) were in very severe stage (GOLD stage IV) of COPD, followed by moderate stage of the disease (GOLD stage II) i.e., 25.7% of the patients. The mean hematocrit level was 47.42% ± 2.29SD.

In our study, the majority of patients (60.3%) were females. Ullah R et al. conducted a study for determining the frequency of secondary polycythemia in COPD and concluded that the majority of their patients (53.8%) were females which is also consistent with our study.[7]

Limitations of our study were: Firstly, we were unable to determine the role of other factors in the development of polycythemia in our patients as FEV1 alone may not determine the overall severity of COPD. Secondly, due to cross sectional design of our study causalty of variables could not be determined.

Table 5. Distribution of frequency of Polycythemia on the basis of gender (n=140)

Gender	Polycythemia in COPD		Total	P value
	yes	No		
Males	3 (5.45%)	52 (94.5%)	55 (100%)	0.39
Females	8 (9.4%)	77 (90.6%)	85 (100%)	
Total	11 (8%)	129 (92%)	140 (100%)	

Table 6. Distribution of frequency of Polycythemia on the basis of age (n=140)

Age	Polycythemia in COPD		Total	P value
	yes	No		
41 to 60 years	6 (9%)	83 (91%)	89 (100%)	0.51
61 to 70 years	5 (9.8%)	46 (90.2%)	51 (100%)	
Total	11 (8%)	129 (92%)	140 (100%)	

Conclusion

Chronic obstructive pulmonary disease is an important health issue that leads to a considerable number of complications including polycythemia. The severity of the disease (decrease in FEV1) was not found to have any significant correlation with polycythemia. Age, gender of patients and the severity of the disease (GOLD stages of COPD) had no significant association with polycythemia. However, earlier diagnosis of polycythemia in such patients may lead to earlier therapeutic measures which can reduce the risk of further complications.

Table 7. Distribution of frequency of Polycythemia on the basis of GOLD stage of COPD (n=140)

Age	Polycythemia in COPD		Total	P value
	yes	No		
41 to 60 years	6 (9%)	83 (91%)	89 (100%)	0.51
61 to 70 years	5 (9.8%)	46 (90.2%)	51 (100%)	
Total	11 (8%)	129 (92%)	140 (100%)	

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