RESEARCH PAPER

# Relationship of FEV1% Predicted With PaO2 and PaCO2 in COPD

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## Abstract

**Background:** Chronic Obstructive Pulmonary Disease (COPD) is the third leading cause of death worldwide, yet it remains underdiagnosed and often detected late. Spirometry confirms and stages COPD, while arterial blood gas (ABG) analysis helps assess ventilation status through $PaO_2$ and $PaCO_2$ levels, guiding clinical decisions. This study aimed to evaluate the relationship between $FEV_1$% predicted and arterial blood gas parameters in COPD patients.

**Methods:** This study was conducted on 50 patients with previously diagnosed COPD. Participants were enrolled in the study by the nonprobability convenient sampling technique according to inclusion and exclusion criteria. Spirometric evaluation and ABG analysis of participants were done and recorded.

**Results:** The mean FEV1% predicted, PaO2 and PaCO2 were 36.94±17.79,73.56±11.41 and 37.03 ± 4.42 respectively. There was a moderate positive correlation between FEV1% predicted and PaO2 (*r=0.502; *p<0.001), but no significant correlation with PaCO2 (*r=0.261; p=0.067) was found.

**Conclusion:** FEV1 percent predicted, PaO2 and PaCO2 level decline as disease progresses in patients with COPD. FEV1 % predicted correlates with partial oxygen pressure but not with partial carbon dioxide pressure in COPD.

**Key words:** COPD, FEV1 % predicted, PaO2, PaCO2

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## BACKGROUND

Chronic obstructive pulmonary disease (COPD) is a preventable and treatable disease. It is among the most common obstructive diseases characterized by persistent respiratory symptoms and progressive airflow limitations. It is due to airway and alveolar abnormality usually caused by chronic exposure to noxious particles or gases.[1] Corresponding physiologic changes of the disease include mucus hypersecretion, lung hyperinflation, airflow limitations, gas exchange abnormality, pulmonary hypertension, and cor-pulmonale.[2] COPD is among the vital health issues that are considered to have increasingly more importance as a cause of death day by day.[3,4]

It is the third leading cause of death globally at present and placed fifth regarding disease burden.[5] The prevalence of COPD is proportional to the occurrence of risk factors in the society. Cigarette smoking is the major risk factor for COPD, particularly in developed countries. However, in low-income countries, associations with several other risk factors are also identified, such as biomass smoke exposure, occupational exposures to dust and fumes, pulmonary tuberculosis, open air pollution, low socioeconomic conditions, and chronic asthma.[6]

COPD is often underdiagnosed and, in most instances, diagnosed late in its course. So spirometry should be promoted for early identification of the patients and even screening.[7] Pulmonary function testing, or spirometry, is considered an important diagnostic tool for the diagnosis of the disease and is confirmed and staged with the help of it.[8] The need for spirometry for diagnosis of COPD has been generally accepted since the GOLD guidelines were published. That has now been placed as 'gold standard'. Recommendations of GOLD include a post-bronchodilator forced expiratory volume in the first second (FEV1)/forced vital capacity (FVC) less than 70%, which confirms the diagnosis, alongside FEV1 that stages the disease.[9] The spirometric classification of severity of COPD has four stages: stage 1, mild (FEV1≥80% predicted); stage 2, moderate (FEV1 50-79% predicted), stage 3, severe (FEV1 30-49% predicted); and stage 4, very severe (FEV1<30% predicted).[10] Hypoxemia and hypercapnia are frequent complications associated with the disease. Oximetry or arterial blood gas (ABG) analysis has great value to confirm hypoxemia.[11] As the disease worsens, these analyses are more important in the diagnosis, prognosis, and management COPD.[12] It also helps to evaluate the ventilatory status of the patient and steer the decision making.[13] Further additional informations from a set of ABG analysis can be most helpful in severe exacerbations of COPD. The partial pressure of oxygen (PaO2) reflects the level of oxygenation, and the partial pressure of carbon dioxide (PaCO2) reflects ventilation and the elimination of carbon dioxide.[11] Respiratory failure may follow, as COPD is advanced. When PaO2 become less than 60 mmHg (8kPa), it is defined as respiratory failure and divided into type I and type II. In type I of respiratory failure, $PaCO_2$ is less than 45 mmHg (6kPa) and $PaO_2$ is also low (hypoxemia). Type II respiratory failure is when PaCO2 become higher than 45 mmHg (6 kPa) (hypercapnia) and $PaO_2$ falls below 60 mmHg (8 kPa).[14] For assessments of acute respiratory failure and diagnosis of chronic respiratory failure, ABG analysis is applicable. When forced expiratory volume in the first second (FEV1) is less than 50% of that predicted, or when there are clinical signs suggestive of respiratory failure or right-sided heart failure, arterial blood gas measurements should be performed.[15]

Arterial puncture has many disadvantages, although it has great value in the clinical assessment of COPD patients.[16] As this procedure is more or less painful, ABG analysis is challenging. Local hematoma, infection, occlusion, and embolization with ischemic injury to the fingers, etc., can also be associated with the procedure.[17] Therefore, it necessitates specialized techniques that incur high costs. In contrast, spirometry and measuring FEV1 percentage is a much simpler and non-invasive method. By substituting ABG analysis with spirometry, much more success could be achieved. For years researchers have been trying to establish the relationship between spirometry and arterial blood gas values in COPD patients, and several studies were carried out to correlate between them. The present study is designed to find out whether spirometry results, especially FEV1%, could help us determine PaO2 and PaCO2 in patients with COPD.

## Material and Method

This cross-sectional observational study was carried out in the department of physiology, Sylhet MAG Osmani Medical College, Sylhet, from January 2018 to December 2018. All patients with chronic obstructive pulmonary disease admitted to the department of medicine, Sylhet MAG Osmani Medical College, Sylhet, were the study population, and those fulfilling the inclusion criteria were enrolled as the sample population. In this study a total number of 50 patients with previously diagnosed COPD was included using the non-probability convenient sampling method. The patients with a history of other obstructive and restrictive lung diseases, such as bronchial asthma, bronchiectasis, and fibrosis, as well as bronchogenic carcinoma, pneumonia, left ventricular failure, etc., were excluded. The mean age of the participants was 62.16 ± 7.77 years; among them, 64% were male and 36% were female. The spirometric procedure of the subject was done in the sitting position. On the day of examination, the subject was requested to wear light and loose clothes. The detailed procedure was explained and demonstrated to the subject. He/she was asked to take rest and remain quiet for 5 minutes prior to the procedure. A spirometer (COSMED micro Quark USB spirometer) with a disposable mouthpiece was used. Related data (age, height, weight) of subjects was inputted in the switched-on spirometer. The subject was asked to breathe in forcefully to the best of his/her ability. Then after his/her nose was closed with a nasal clip, he/she was asked to exhale as much as possible into the mouthpiece. During the procedure the disposable mouthpiece should be in either hand, approximately horizontal, and the subject should put the lips tightly around the mouthpiece. The subject was allowed to take a rest for two minutes in between maneuvers. The maneuver was repeated several times, and three maximum values were recorded. Among these, a maximum of three were selected automatically and printed out for final data computation. Needed data, i.e., predicted value, measured value, and percentage of predicted value of FVC, FEV1, FEV1%, and VC of each subject, were collected.

At the same time, an arterial blood sample was collected from the radial artery of the subject. A pre-heparinized syringe was used for the procedure. While lying flat on his/her back, the radial artery was located, and a modified Allen test was performed for collateral circulation. After disinfecting the sampling site with 70% alcohol, a needle was inserted at a 45-degree angle. The syringe should be held like a dart, advanced into the radial artery until a blood flashback appears in the syringe, and allowed to fill up to the appropriate level. The immediately collected sample was analyzed in an autoanalyzer (ABL 80 FLEX). Then data were collected by using a structured questionnaire designed for the study. Collected data were processed and analyzed with the help of Statistical Package for Social Science (SPSS) Version 22.0. Qualitative data were expressed as frequency and percentages. Quantitative data were expressed as mean and standard deviation, and comparison was done using unpaired t-tests and ANOVA, and the relationship between two numerical variables was done using Pearson's correlation coefficient test. A p-value of $<0.05$ was considered statistically significant.

## Result

The mean age of the participants was 62.16 ± 7.77 years, and the mean age of the male participants 63.72 ± 8.05 years and that of the female participant 59.39 ± 6.59 years did not differ significantly (t=1.943; p=0.058) (Table-1). The mean BMI of the patients was 22.53 ± 1.63 kg/m$^2$; the mean BMI of the male participants was 22.41 ± 1.80 kg/m$^2$, and that of the female participants was 22.74 ± 1.30 kg/m$^2$, which did not differ significantly (t=-0.694; p=0.491) (Table-1).

**Table 1. Distribution of the participants by age and BMI**

| Parameters | Total (N=50) | Male (N=32) | Female (N=18) | Test value | p-value |
|---|---|---|---|---|---|
| Age (years) | 62.16 ± 7.77 | 63.72 ± 8.05 | 59.39 ± 6.59 | t=1.943 | *p=0.058 |
| BMI (Kg/$M^2$) | 22.53 ± 1.63 | 22.41 ± 1.80 | 22.74 ± 1.30 | t=-0.694 | *p=0.491 |

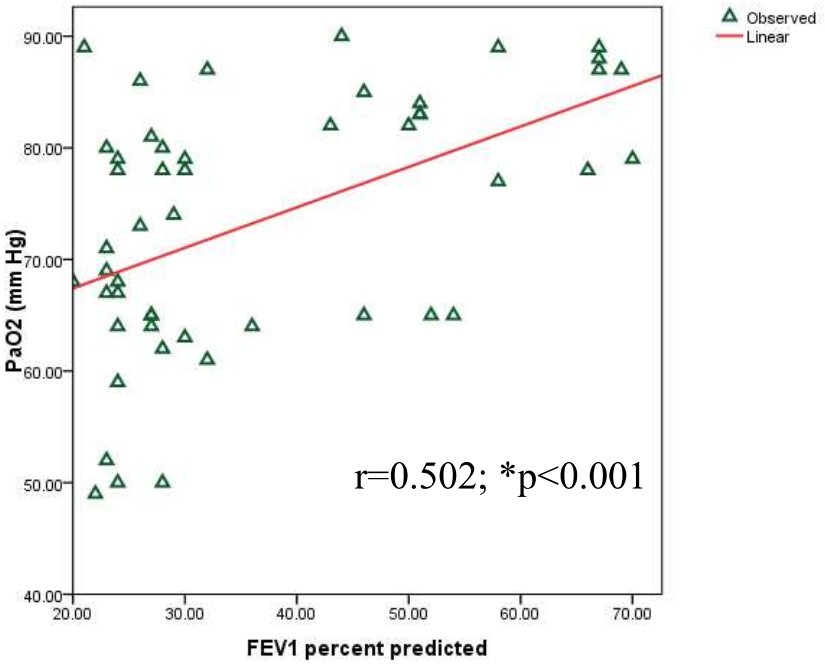
*unpaired 't' test was employed to analyze the data.

The mean FEV1 percent predicted of participants was 36.94±17.79, with 33.34±14.24 in males and 43.33±16.77 in females. The mean FEV1 percent predicted of males was significantly lower compared to females (t=-2.233; p=0.030). The mean PaO2 (mm Hg) of participants was 73.56±11.41, with 72.28±10.89 in males and 75.83±12.26in females. The mean PaO2 did not differ significantly (t=-1.058; p=0.295). The mean $PaCO_2$ (mm Hg) of participants was 37.03 ± 4.42, with 37.33 ± 4.94 in males and 36.50 ± 3.38 in females. The mean $PaCO_2$ did not differ significantly (t=0.636; p=0.528) (Table 2).

**Table-2. Distribution of the participants by $FEV_1$ and $PaO_2$**

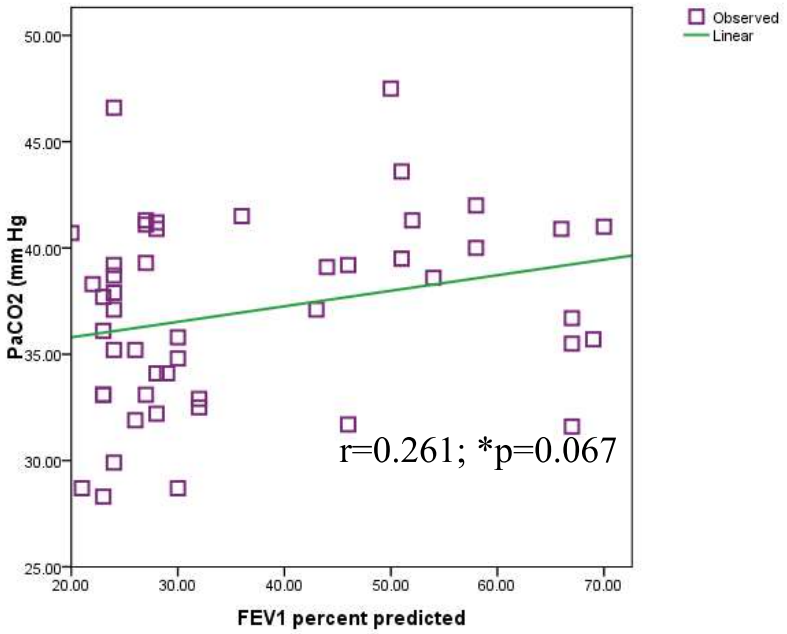
| Parameters | Total (N=50) | Male (N=32) | Female (N=18) | Test value | p-value |
|---|---|---|---|---|---|
| $FEV_1$ % predicted | 36.94±17.79 | 33.34± 14.24 | 43.33±16.77 | t=-2.233 | p=0.030 |
| $PaO_2$ (mm Hg) | 73. 37.03 ± | 72.28±10.89 | 75.83±12.26 | t=-1.058 | p=0.295 |
| $PaCO_2$ (mm Hg) | 37.03 ± 4.42 | 37.33±4.94 | 36.50± 3.38 | t=0.636 | p=0.528 |

*unpaired 't' test was employed to analyze the data.




*Pearson correlation was used to analyze the data.

Figure 1. Scattered diagram showing correlation between FEV1 percent predicted and PaO2 in participants (n=50), (*Pearson correlation coefficient: r=0.502; *p<0.001).




*Pearson correlation was used to analyze the data.

Figure 2. Scattered diagram showing correlation between FEV1 percent predicted and PaCO2 in participants (n=50), (*Pearson correlation coefficient: r=0.261; p=0.067).

## DISCUSSION

Chronic obstructive pulmonary disease (COPD) is defined in terms of airflow obstruction and operationalized as a low ratio of forced expiratory volume in 1 second (FEV1) to forced vital capacity (FVC). The airway obstruction in COPD is predominantly in the small airways of the lung periphery and results in a reduction in FEV1 and the FEV1 /FVC ratio, which progresses over time18.Hypoxemia and hypercapnia become increasingly common as COPD worsens.11

This study revealed the mean age of the participants with COPD was 62.16 ± 7.77 years. This observation was supported by Emerman et al., who stated the average age of the patients with COPD was 64.0 ± 8.5 years.19 Graat-Verboom et al. also supported this result, finding the mean age of patients with COPD was 65.6 (SE 0.4) years.20 Whereas Nusrullah et al. demonstrated a much lower mean age of COPD of 52.68 ± 10.51 years.21

This study revealed the mean age of the male participants was 63.72 ± 8.05 years and that of the female participants was 59.39 ± 6.59 years, which did not differ significantly (p=0.058). These results correlated with the study of Fard and Zarezadeh, who reported there was no significant difference at age.22 In this study the mean FEV1 percent predicted of COPD was 36.94 ± 17.79. This result was supported by Fard and Zarezadeh, who found that the mean FEV1 percent predicted in COPD patients was 42.88 ± 15.82.22 On the other hand, Güryay et al., found the mean spirometric percentage of predicted values of FEV1 was 23 ± 9.3%.23

The mean FEV1 percent predicted in COPD patients was 33.34 ± 14.24 in males and 43.33 ± 16.77 in females. The mean FEV1 percent predicted of males was significantly lower compared to females (p=0.030). Fard and Zarezadeh found that the mean FEV1 percent predicted in COPD patients was 42.93 ± 14.71 in males and 42.77 ± 16.25 in females. The mean FEV1 percent predicted of males was significantly lower compared to females (p>0.05).22

ABG analysis was done, and results revealed the mean $PaO_2$ (mm Hg) of COPD was 73.56±11.41. This finding was consistent with the study of Emerman et al., who stated that $PaO_2$ of COPD was 63.5 ± 11.8 mm Hg.19 Güryay et al., also found that $PaO_2$ of COPD was 60 ± 24 mm Hg, and Fard and Zarezadeh, found that the mean $PaO_2$ in COPD patients was 55.31 ± 13.51 mmHg, which is similar to other studies.23, 22

The mean PaO2 (mm Hg) of COPD was 72.28±10.89 in males and 75.83±12.26in females. The mean PaO2 did not differ significantly (p=0.295). This result correlated with the study of Fard and Zarezadeh, who reported that the mean $PaO_2$ (mm Hg) of COPD was 56.28±13.63 in males and 53.12±13.19 in females. The mean $PaO_2$ did not differ significantly (p>0.05).22

The mean $PaCO_2$ (mm Hg) of COPD was 37.03 ± 4.42. This finding was consistent with the study of Emerman et al. (1989), who stated that $PaCO_2$ of COPD was 39.7 ± 7.619. This finding was also supported by the study of Güryay et al., who found that the mean $PaCO_2$ of COPD was 46 ± 14 mm Hg, and Fard and Zarezadeh found that the mean $PaCO_2$ in COPD patients was 51.64 ± 10.56 mmHg. 23, 22

This study indicated that there was a moderate positive correlation between FEV1 percent predicted and partial oxygen pressure in COPD (r=0.502; p<0.001). This result correlated with the study of Fard and Zarezadeh, who found a moderate positive correlation between FEV1 and PaO2 (r= 0.418, p<0.0001).22 But this result disagreed with the study of Emerman et al. (1989), who found no significant correlation between $PO_2$ and the percent of the predicted normal FEV1.19

The present study demonstrated that there was no significant correlation between FEV1 percent predicted and partial carbon dioxide pressure in COPD (r=0.261; p=0.067). In this regard, Emerman et al., found a moderate correlation between $PaCO_2$ and the percent predicted FEV1.19 An inverse correlation between $PaCO_2$ and $FEV_1$ (r = -0.533, p < 0.0001) was reported in the study of Fard and Zarezadeh. [22]

## Limitations and recommendations

This study recognizes the limitation of a small sample size. Several practical challenges contributed to this constraint. Performing arterial blood gas (ABG) analysis on non-ICU patients was particularly difficult due to the invasive and painful nature of the procedure, as well as its high cost. Furthermore, the study was conducted within the limited timeframe of an academic setting. Although a smaller sample size may reduce the study's statistical

power and increase the margin of error, initial research with fewer participants can be advantageous. It allows for faster completion and lowers financial burden. Future studies should aim to include a larger sample size to enhance the accuracy and generalizability of the findings.

## Conclusion

After analyzing the results of the study, it is concluded that FEV1 percent predicted, PaO2 and PaCO2 level decline as disease progresses in patients with COPD. There was a significant positive correlation between partial oxygen pressure and FEV1 percent predicted in COPD ($r=0.502$; $p<0.001$), $p<0.001$), But there was no significant correlation between partial carbon dioxide pressure and FEV1 percent predicted. It is concluded that predicted FEV1 percent correlates with partial oxygen pressure but not with partial carbon dioxide pressure in COPD.

## List of abbreviations:

- COPD—Chronic obstructive pulmonary disease
- FVC - Forced vital capacity.
- FEV1 - Forced Expiratory Volume in the first second
- FEV1% - Forced Expiratory Volume in the first second percent predicted
- ABG: Arterial Blood Gases.
- PaO2 – Partial pressure of oxygen
- PaCO2 - Partial pressure of carbon dioxide

## Declarations:

**Ethical approval:** This study was approved by the ethical committee of Sylhet SMAG Osmani Medical College, Sylhet.

**Availability of data and materials:** The data that support the findings of this study are available from the corresponding author on reasonable request.

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**Author's contribution:** RNO study concept and design, investigation, data collection and analysis, writing the manuscript, creating graphs and tables, and critical revision of the manuscript. MSH, MRA, SMI study concept and design, administered the study, and critically revised the manuscript for important intellectual content; NIM, MB critical revision of manuscript.

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