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Original Article

Evaluating the Significance of Inspiratory Volumes and Capacity in Chronic Obstructive Pulmonary Disease

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Abstract

Background: Smoking-induced Chronic obstructive pulmonary disease (COPD) is a chronic lung condition causing airflow obstruction and inflammation, leading to symptoms like breathlessness and fatigue. While expiratory issues are well-studied, the impact of inspiratory function on symptoms is less understood.
Objective: To measure inspiratory volumes and capacities, as well to establish a relationship between these variables and clinical characteristics of COPD.
Study type, settings & duration: This cross-sectional study performed at Mayo Hospital, Lahore from March to October 2022.
Methodology: A total of 320 samples were divided into two groups, i.e., COPD and healthy control. Spirometry was performed to correlate lung function with serum SPD levels. We developed a regression model to assess the relative contribution of each variable to the inspiratory functions. Data was analyzed by using Statistical Package for Social Sciences (SPSS) version 16. Continuous metric variables will be described as mean ±SD.
Results: Of the 320 samples, 192 were from males (60%) and 128 (40%) were from females. Mean age of individuals in study was 45±6.11 year. The level of peak inspiratory flow rates among COPD patients (2.15±0.98) were lower (p =0.000) as compared to healthy control (4.06±1.33). Likewise, PIF% predicted was lowered (p =0.000) in COPD (26.91±11.90) as compared to healthy controls (45.67±16.17). Forced inspiratory vital capacity was lowered (p =0.000) among COPD (1.99±0.80) as compared with the control (3.40±0.87) group.
Conclusion: The study suggests that inspiratory volumes and capacities are crucial for hospital admission, diagnosis, management, and staging of COPD. These metrics are significantly lower in COPD patients than in healthy individuals.
Key words: COPD, smoking, exacerbations, regression model, inspiratory volumes, expiratory volumes.

Introduction

Smoking-induced lung disease, often known as a Chronic obstructive pulmonary disease (COPD), states to lung disease in which a long-lasting inflammation occurs in the lungs and extra pulmonary peripheral tissues, resulting in airflow obstruction.[1] When you smoke, you restrict your airflow for the rest of your life. This is due to the lungs' inflammatory response to the hazardous chemicals or particles inhaled by cigarette smoking,[2] which is usually permanent. According to the American Thoracic Society and the European Respiratory Society guidelines, chronic respiratory illnesses have major systemic repercussions.[3]

COPD is a significant cause of disability, death and poor quality of life in the United States and other developed countries. While exertional dyspnea remains the most frequently reported cause of poor quality of life in these patients, sleep disruption and morning weariness are the second

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Authors Contribution

JM & BI conceptualized the project. MM & MM* did the data collection. FH & AB did the literature search. FH & TM performed the statistical analysis. Drafting, revision & writing of manuscript were done by JM & MM*.

most frequently reported symptoms. Other COPD signs, such as hyperinflation of the lungs, increased respiratory effort, alterations in gas exchange with sleep disorders in COPD patients.[4] Obstructive sleep apnea (OSA) is a well-known cause of sleep disruptions and morning weariness in people with COPD.[5]

When the upper airway is obstructed, compensatory responses help to prevent hypoventilation. In reaction to upper airway blockage, inspiratory duty cycle [the ratio of inspiratory time (Ti) to respiratory cycle length increases[6]. However, this increase in Ti is offset by a reduction in expiratory duration (Te).[6] COPD patients, on the other hand, typically have a prolonged Te to compensate for the disease's inherent expiratory flow restriction and positive end expiratory pressure.[7] It is likely that presence of expiratory flow limitation lowers the duty cycle sensitivity to upper airway obstruction in persons with COPD over the course of the disease

Exercise capacity declines in COPD and worsened quality of life for the patients and even associated with mortality.[8] This decline is not associated with airflow limitation as measured by expiratory volumes but rather inspiratory capacities.[9] It is essentially the volume and capacity of the expiratory system that are measured in order to diagnose COPD. Some preliminary study has suggested a relationship between inspiratory function and clinical symptoms in smokers with COPD, but the subject has received little attention to date. The aim of current study was to measure inspiratory volumes and capacities, as well to establish a relationship between these variables and clinical characteristics of COPD.

Methodology

This cross-sectional study was conducted at Mayo Hospital, Lahore from March to October 2022. In current study, a sample size of 320 was statistically calculated and ascertained through non-probability convenience sampling. The subjects were selected by advertisements using posters at different public places and majorly from Mayo hospital by non-probability convenience sampling after taking consent from patients.

Adults of Both genders (Male & Female) were included in the study without a medico-legal cases. However Patients having multiple co-morbid conditions and those on long term antimicrobial therapy were excluded.

Examination, history and laboratory tests were recorded on proforma. A clinical diagnosis of COPD was made in the subjects with a history of smoking, chronic cough, sputum production and airflow obstruction on spirometry. Two groups were made with nonsmokers and current or ex-smokers with no airflow limitation by spirometry in the control group (Group 1) and smokers or nonsmokers with airflow limitations in another group (Group 2). Spirometry was performed to correlate lung function with serum SPD levels. For the hospitalized patients experiencing exacerbations, spirometry was done after 7 to10 days when patients were stable enough to perform the spirometry.

After getting consent Forced expiratory volume which is the measurement of how much air a person can exhale when they force an exhalation in one second (FEV1), Forced vital capacity which is the maximum amount of air a person can exhale after inhaling deeply (FVC); Forced expiratory volume in one second/Forced vital capacity ratio (FEV1/FVC) was assessed. In addition, all inspiratory functions along with Forced inspiratory vital capacity (FIVC), Forced inspiratory volume in one second (FIV1), and peak inspiratory flow rate (PIF), and forced inspiratory volume in one second/Forced vital capacity ratio (FIV1/FVC), as well as their respective percentages and predicted values were recorded. In case of outdoor patients who were experiencing less severe exacerbations, spirometry was done when they were presented to the hospital.

Data was analyzed by using Statistical Package for Social Sciences (SPSS) version 16. Continuous metric variables will be described as mean ±SD. Comparisons between groups was made by the student t-test. Linear logistic regression was applied by assessing the effect of different variables like serum SP-D levels and BMI on forced Inspiratory capacity. Significance set as $p \leq 0.05$.

The ethical approval was obtained from the Ethical Review Committee of The University of Lahore, Lahore vide letter no. IMBB/BBBC/22/545.

Results

A total of 320 patients consisting of 192 males (60%) and 128 females (40%) with male to female ratio of 1.5:1 were included in the study. The Mean age of patients remained to be 45±6.11 years. The biomarkers of fibrinogen, IL-6, and SP-D, which are crucial in determining the severity and staging of COPD, have a substantial correlation with the disease. The current study assessed the relationship between clinical outcomes in patients with chronic obstructive pulmonary disease, inspiratory volumes and demographic factors.

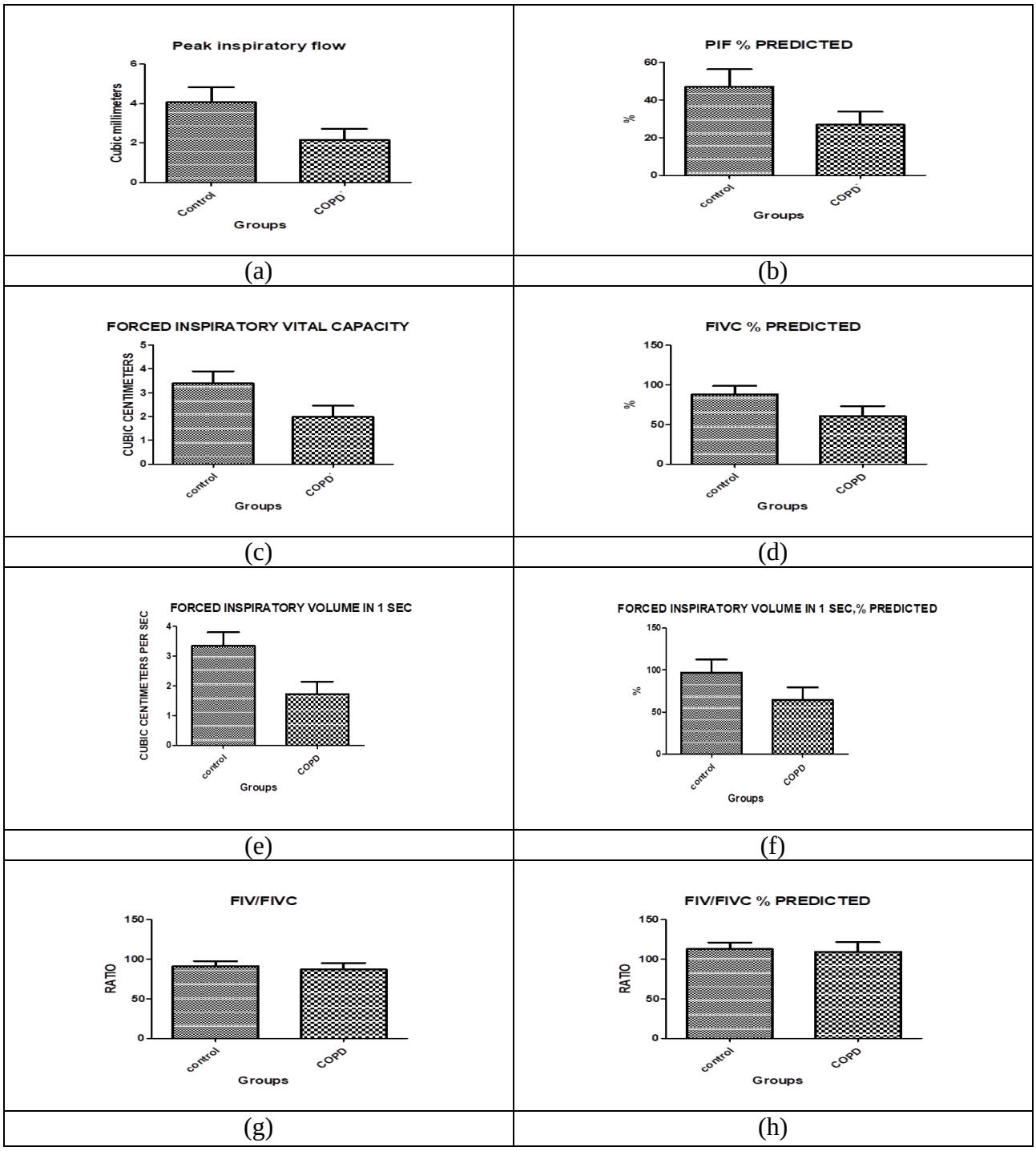

Figure: Graphical profile of spirometric variables of COPD versus controls.

Respiratory illness leads to decreased functional ability, severe dyspnea, a poor and impaired quality of life, and increased mortality rates. The prevalence of related cardiovascular disease, undernutrition that causes the breakdown and loss of muscle function, and other systemic illnesses that may eventually lead to lung cancer are among the most well-documented indicators.

The spirometric profile of COPD patients as compared to heathly individuals has been shown in Figure. Results of the present study showed that there were significantly (0.000) lower levels of peak inspiratory flow rates among COPD patients

(2.15±0.98) as compared to healthy controls (4.06±1.33). PIF% predicted was significantly (0.000) lowered in COPD (26.91±11.90) as compared to healthy controls (45.67±16.17). Forced inspiratory vital capacity was also significantly (0.000) lowered among COPD (1.99±0.80) as compared to controls (3.40±0.87). Forced inspiratory volume in 1st second, % predicted was also significantly (0.000) lowered in COPD patients (64.17±26.15) as compared to controls (97.19±27.09). The ratio of FIV1/FIVC was significantly (0.000) lowered in COPD patients (86.75±14.39) as compared to controls (91.04±10.90). However, FIV1/FIVC % predicted was not significantly (0.239) lower in COPD (109.36±20.50) as compared to controls (112.63±14.20) (Table).

Table: Multiple regression model.

Variables	*Cofficient*	*S.E*	*p-value*
Patient's Age	-0.035	0.008	0.00
BMI	0.060	0.023	0.013
Smoking	-0.897	0.738	0.234
Excerbation presence	0.291	0.252	0.257
Excerbation/year	-0.153	0.077	0.257
COPD or Controls	-0.721	0.366	0.059
Family affected	0.028	0.278	0.919

The multiple linear logistic regression model resulted in a significant effect of COPD on person's age (0.000), Body mass index (0.013), and presence of exacerbation per year (0.05) over the peak inspiratory flow rate of COPD patients as shown in Table.

Discussion

The fundamental characteristic of COPD is the presence of air flow restriction, which is caused by irritation and modification of the airways and resulting in inflammation. This condition is linked to parenchymal obliteration and the formation of emphysema.

Though, systemic effects of this disease is often seen in these patients that can result in reduced functional capacity, worsening dyspnea, impaired and poor quality of life, and augmented mortality rates. The top documented indices contain the occurrence of associated cardiovascular disease, undernourishment resulting in the destruction and loss of function of body muscles and other multiple systemic disorders that might result in lung cancer in the long run.[10] The purpose of this research was to evaluate the available results regarding inspiratory volumes and capacities in COPD patients of local population. Forced inspiratory volumes, including FIVC, FIV1, and PIF, and FIV1/FVC, as well as their respective percentages, predicted values were recorded in both COPD and controls and compared.

Patients with this illness have air trapping and an elevated lung ventilation rate, which obliterates the lung tissues and their blood vessels and obstructs the airway. Increased resting ventilation rates in people with this illness have been identified in recent years as a significant problem that triggers dyspnea and reduces exercise tolerance. The decrease in inspiratory capacity can be used to gauge the severity of dynamic hyperinflation. It is observed that basic healthcare facilities hardly ever examine the inspiratory capacity of these patients, which is why there is currently no data on them.

Patients having disease of COPD show reduced expiratory air flow rates as restrained by a decreased ratio of FEV1 to FVC that is FEV1/FVC. Though values of airflows are neceassay for COPD diagnosis and are commonly used to check stage of disease to correlate with symptoms and functional capabilities of patients.[11]

One of the Reasons for this derange in these volumes and capacities occur in COPD patients as compared to normal persons is mainly because of Hyperinflation in advanced COPD which is evaluated by radiography and it shows multiple manifestations characterized with an extended chest wall, enlarged retrosternal air space, short and flattened diaphragm, and reduced peripheral blood vessels and also augmented airway resistance, reduced lung elastic recoil and early airway closing results in an amplified functional residual capacity (FRC).[12]

Most of COPD patients show a varying grade of increase in ventilation rate at rest, but decrease in inspiratory capacity of the lungs may have no significances on gas exchange or may cause shortness of breath.in COPD patients, the tidal volume doesn't upsurge appropriately during exercise because in these patients IC is low and this leads to partial evacuating of the lungs during the expiration which is also called air trapping. And as the level of exercise increases this phenomenon get to worsen (and thus ventilation increases) and leads to increased rates of ventilation at rest and deteriorating air trapping and shortness of breath.[13]

A 40–50% of the BMI in males was made by skeletal muscles. In long term diseases like COPD, damage to the muscle mass befalls at a sluggish rate as compared to other diseases. However, in sarcopenia that happens during ageing loss of muscle mass occurs at much lower rates. Likewise, many studies confirmed that in COPD patients still a considerable amount of loss of muscle mass and changes is their structures has been noted. Statistics from recent studies on humans clearly shown that wasting of skeletal muscles is evident in COPD and is definite to muscle fiber belongs to IIA/IIx category.[13,14]

In addition to these anomalies, COPD is associated with impaired respiratory function, intolerance to exercise, poor health, a higher death rate, and the use of medical resources. Muscle wasting continues to increase in severe COPD as the disease worsens, resulting in a loss of muscle strength and shortness of breath during even light exertion, which reduces one's ability to work out. Increased muscle wasting has also been linked to an increased death rate because muscle weakness brought on by muscle wasting increases the frequency and intensity of exacerbations, which in turn increases hospitalization episodes and the likelihood of receiving mechanical support in the form of ventilators. Moreover, it is now proved with many studies that muscle wasting leads to decreased muscle strength in these patients is the most important factor for the cause of death.[15,16]

Add on effect created by skeletal muscle, lung muscles, and diaphragm weakness that leads to a decrease in tidal volume (the air that can be gulped or breathe out during one breathing cycle), it also affects the inspiratory reserved volume (the air that can be breathed in by force of muscles and energy after a normal tidal volume) and it also decrease expiratory reserved volume (the amount of air that can be breathed out by force after breathing out of normal tidal volume). All these changes results in decreased inspiratory capacity (extreme amount of air that can be breathed in after a resting state) and it is the summation of TV and IRV it also results in decreased vital capacity of the lung (total volume of the of air that is breathed out after highest breathing in) and it is collection of TV, IRV and ERV which is findings of our current study.

The study showed that inspiratory volumes and capacities played a suggestive role in hospital admission, diagnosis and management of COPD. It also played a very important role in the staging and severity of the disease. Inspiratory volumes and inspiratory capacities are significantly lowered in COPD patients as compared to normal individuals.

Conflict of interest: None declared.

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