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Relationship between FEV1 and PaO_2 , $PaCO_2$ in Patients with Chronic Bronchitis

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ABSTRACT

***Background**: It is necessary to determine the value of PaO_2 and $PaCO_2$ in COPD patients for diagnosis the severity of chronic bronchitis diseases and their separation from other diseases.*

For the diagnosis of COPD diseases and their separation from other diseases and for having a criterion for treatment with oxygen, we need to know the amount of Pao_2 and $PaCO_2$ in patients; ABG is an invasive and difficult procedure.

***Materials and Methods**: This cross sectional study was carried out on 118 consecutive patients with chronic bronchitis referring to Afshar hospital in Yazd in order to determine the correlation between spirometry FEV1 and ABG parameters.*

***Results**: The study population included 82 (69.5%) males and 36(30.5%) females with the mean age of 71.6±9 years. The mean FEV1 (% pred.) was 42.88±15.12, mean PaO_2 was 55.31±13.51 mmHg and mean $PaCO_2$ was 51.64±10.56 mmHg. FEV1 was positively correlated with PaO_2 ($r=0.418$, $p<0.0001$) and inversely correlated with $PaCO_2$ ($r= -0.533$, $p<0.0001$).*

Conclusion**: One could establish a reliable equation indicating the correlation between FEV1 and PaO_2 as well as $PaCO_2$ in patient with chronic bronchitis.* ***(Tanaffos 2004 3(10): 41-46)

***Key Words**: Chronic Obstructive Pulmonary Disease, PaO_2, $PaCO_2$, FEV1*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a group of chronic respiratory diseases, which develops gradually and often results in a decrease in the maximum of expiratory flow rate. The disease includes emphysema and chronic bronchitis with two separate processes but in relation with each other. It is estimated that 16 million people in America are suffering from COPD. Males suffering from the disease outnumber females and the disease is observed in blacks more than whites.

The spread of the disease will increase among low economical classes of the society as well as people who have Intrauterine growth retardation (IUGR). Subjects are more commonly affected during the seventh and eighth decades of life and it is the forth cause of death in the USA (1,2,3). The most important complications of the disease are hypoxemia and increase in pulmonary artery blood pressure that may effectively be treated with oxygen (2,3,4,5).

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To meet this demand, $PaO_2 \leq 55$mmHg or PaO_2=50-60 mmHg should be maintained with hematocrit more than 55% or by increasing pulmonary artery blood pressure which requires measurement of artery blood gases (ABG) which is an invasive procedure with special techniques and condition and high expenses. But by substituting spirometry and measuring FEV1 percentage which is an available, simple and non-invasive method, much more success could be achieved to delay the development of pulmonary hypertension (3,4,6,7).

A study was carried out by Somfay et al. on 52 COPD patients. The spiro-ergometry showed a linear correlation between FEV1 and VO_2Max and $PaCO_2$ and PaO_2; however, the study on COPD patients was performed while they were doing exercise (8). Kaneta et al. demonstrated that, perfusion index (PI), indicative of PaO_2 has a strong association with FEV1 in patients with emphysema but not with other PFT indices (9). Another study performed on 53 COPD patients (FEV1=0.92±0.40) (PaO_2=69mmHg) investigated the relationship between exercise (6 meters walking), dyspnea and FEV1. Authors concluded that dyspnea and PaO_2 has a close relationship with FEV1 at rest and during exercise (10).

In contrast, Ries et al. reported FEV1 is not a useful index to determine PaO_2 in COPD patients during exercise (11).

Neukirch et al. showed a linear correlation between PaO_2, and $PaCO_2$ with spirometry during exercise (12).

Delclaux et al. conducted a study on old COPD patients in France. They reported a mean PaO_2= 72.5±10.8 mmHg, mean FEV1 =53% pred. and mean $PaCO_2$=40.5±6.1 mmHg. These parameters did not associated with the age, but there was a negative linear association between FEV1 and $PaCO_2$ (13).

MATERIALS AND METHODS

For this cross-sectional study, COPD patients, preferably chronic bronchitis, were selected. Diagnosis was made based on a thorough history, physical exam, CXR, spirometry and arterial blood gas (ABG) analysis. Between the year 1999 and 2000 118 consecutive cases referring to Afshar hospital in Yazd with signs and symptoms of their disease exacerbation were included in our study.

The day before discharge, patients underwent spirometry (Fukuda St 300) and ABG (EVL 2000) without any oxygen supplementation. Initial variables including age, sex, FEV1 (percentage of pred.), PaO_2 (mmHg) and $PaCO_2$ (mmHg) were assessed. Meanwhile, a complete questionnaire were filled. Data analysis was achieved through ANOVA and regression analysis with SPSS software.

RESULT

Study population included 82 (69.5%) males and 36(30.5%) females with the mean (±standard deviation) age of 71.6±9 years (range, 45-100 years). There was no significant difference in age between sexes. The mean FEV1 (% pred.) was 42.88±15.82, PaO_2 was 55.31±13.51 mmHg, and the mean $PaCO_2$ was 51.64±10.56 mmHg. Table 1 shows these parameters according to the sex. Statistical analysis failed to show any significant association between males and females.

Table 1. Values of PaO_2, $PaCO_2$ and FEV1 in 118 COPD patients according to the sex.

Variable	Male (n=82)	Female (n=36)
FEV1(% pred)	42.93±14.71 * (11.86-78.87)**	42.77±16.25 (23.4-90)
PaO_2 (mm/Hg)	56.28±13.63 (30.2-84)	53.12±13.19 (30.2-79)
$PaCO_2$ (mm/Hg)	51.89±10.71 (33.4-78.3)	51.09±10.35 (34.8-70.6)

* Values are presented as mean ± SD

** Figures in parenthesis show the lower and upper limits

There was no statistically significant correlation between age and FEV1 (r= 0.059), however, FEV1 had positive correlation with PaO_2 (r= 0.418, p<0.0001) and inverse correlation with $PaCO_2$ (r= - 0.533, p<0.0001). Since age and sex revealed to have non- significant association with FEV1, partial correlation was used to control effects of age and sex on FEV1, PaO_2, and $PaCO_2$ correlation. Their results are presented in table 2.

As shows, there is a slight difference in correlation co-efficient following controlling the effect of age (compare simple r with partial r), hence, we can ignore the effect of age. Meanwhile, correlation co-efficient did not show significant difference between male and female gender, therefore, we could generalize the total co-efficient correlation to both sexes.

In regression analysis, multiple r indicates the correlation between dependent variables (PaO_2 and $PaCO_2$) with linear combination of independent variables (FEV1 and age). Multiple r was significant for both PaO_2 and $PaCO_2$ (p<0.001). Furthermore, R2 shows the ratio of variance of dependent variables that is explained by independent variables.

The following formulae indicate the correlation between PaO_2 and $PaCO_2$ with FEV1 based on the regression analysis.

PaO_2 (mmHg)= 39.28+(0.37×%FEV1 pred) and $PaCO_2$ (mmHg)=67.61+ (0.37×%FEV1 pred.) where, their 95% confidence intervals were [32.49+(0.22×%FEV1 pred.)]-[46.06+(0.52×%FEV1 pred.)] (p<0.0001), and [62.47+(0.48×%FEV1 pred.)]-[72.56+(0.26×% FEV1 pred.)] (p< 0.001), respectively.

Ranges of FEV1 were in agreement with normal range of 15-90. The aforementioned equations show the mean PaO_2 and $PaCO_2$ for subjects who have definite FEV1. In order to compute PaO_2 and $PaCO_2$ for subjects who have a certain FEV1, the following equations should be used:

$$PaO_2\ (mmHg)= 39.28+0.37\%FEV1\pm0.164\times\sqrt{215.4+ (\%FEV1-42.88)^2}$$

$$PaO_2\ (mmHg)= 67.61+0.37\%FEV1\pm0.101\times\sqrt{29.53+ (\%FEV1-42.88)^2}$$

Table 2. Simple, partial and multiple correlation of FEV1 with PaO_2 and $PaCO_2$ based on sex

Sex	PaO_2				$PaCO_2$			
	r Simple	r Partial	R Multiple	R^2	r Simple	r Partial	R Multiple	R^2
Male	0.439	0.439	0.439	0.193	- 0.532	- 0.536	0.542	0.293
Female	0.383	0.358	0.458	0.209	- 0.539	- 0.525	0.553	0.305
Total	0.418	0.416	0.421	0.177	- 0.533	0.534	0.534	0.285

DISCUSSION

Measuring PaO_2 and $PaCO_2$ is the most important factor to determine the severity of COPD and draw an appropriate therapeutic approach; however, ABG, as the only acceptable diagnostic modality, is an invasive technique that is not available in most centers. The present study was conducted to find out whether spirometry results could help us determining PaO_2 and $PaCO_2$.

Chronic bronchitis and emphysema are two different entities with separate pathophysiology and clinical manifestations; however, due to similar etiology they may present as a unique disease.

Therefore, unlike prior studies, we have attempted to include subjects with clinical and paraclinical manifestation of chronic bronchitis, since airways involvement is the predominant pathology in chronic bronchitis, that will in turn cause further impairment in ABG results and may correlate more reasonably with FEV1. Whereas, in emphysema, shunting, reduced diffusion, and increased sensitivity of respiratory regulatory center to decreased level of PaO_2 may influence arterial blood gas levels; therefore, the association between FEV1 and ABG findings may be misdiagnosing.

Prior studies were all performed on subjects during exercise (8,12), with COPD (chronic bronchitis and emphysema), in emergency department (during disease exacerbation or in accompany with other diseases) (11,13), or even in emphysematous patients (the association between perfusion index and FEV1) (9). This is the only study conducting on patients with chronic bronchitis.

Our results revealed that, in chronic bronchitis, one could propose reliable equations to assess the correlation between FEV1 and PaO_2 and $PaCO_2$ provided that patient does not experience exacerbation period, and his/her FEV1 is within the 27.76-58% of the predicted value.

With this approach, we may guess that Delclaux study in which similar results have been obtained, was performed mainly on patients with chronic bronchitis.

CONCLUSION

Our results revealed a reliable equation indicating the correlation between FEV1 and PaO_2 or $PaCO_2$ in patients with chronic bronchitis. We strongly recommend similar studies to be performed on emphysematous patients. Meanwhile, differentiating these two entities (with HRCT) and of course, studying the above mentioned association in different states (resting, exercise, exacerbation period, and during remission) may yield to more reliable findings.

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