

ΔSpO_2 /Distance Ratio from the Six-Minute Walk Test in Evaluation of Patients with Chronic Obstructive Pulmonary Disease

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Abstract: Introduction: The six-minute walk test (6MWT) contains two independent components: walk distance (6MWD) and oxygen saturation (SpO_2). 6MWD does not give detailed data on numerous COPD associated disorders. As oxygen desaturation plays a key role in exercise limitations, a few new parameters integrating oxygen desaturation during exercise along with walk distance are necessary. So, this study was conducted to assess the relationships between ΔSpO_2 /distance ratio and pulmonary function test in addition to extent of pulmonary emphysema in COPD patients. Material and methods: 57 stable COPD patients who attended the outpatient clinic of chest medicine department. Mansoura university. were enrolled. Included patients were classified according to GOLD airflow limitation. Age, sex, and modified Medical Research Council dyspnea score (mMRC) were recorded. furthermore, every patient completed the 6MWT and underwent a pulmonary function test and a CT scan to evaluate the degree of pulmonary emphysema. Results: ΔSpO_2 /distance ratio was moderately correlated with DLCO%, FVC % and GOLD classification. However, strong correlation was found with FEV1% and RV%. mMRC was weakly correlated with ΔSpO_2 /distance ratio. In addition, weak nonsignificant correlation was found between ΔSpO_2 /distance ratio and extent of pulmonary emphysema as measured by HRCT volumetry. A significant moderate correlation was noticed between the ΔSpO_2 /distance ratio and 6MWD ($r = -0.5$, $p < 0.001$). a significant strong correlation was observed between the ΔSpO_2 /distance ratio and ΔSpO_2 ($r = 0.87$, $p < 0.001$). Conclusion: ΔSpO_2 /distance ratio could be a simple and valuable index for the evaluation of exercise capacity in COPD individuals and might be utilized to predict severity of airway obstruction, pulmonary diffusing capacity disorder and severe hyperinflation.

Keywords: ΔSpO_2 /distance ratio; 6 min walk test; COPD; exercise capacity

1. Introduction

Lung emphysema reduces quality of life and has been linked to worsening pulmonary function [1]. Although computed tomography (CT) can give a wealth of information regarding chronic obstructive pulmonary disease (COPD), including the degree of emphysema, it could not be applied in every circumstance [2].

The assessment of functional capacity is becoming increasingly essential in management of patients with chronic pulmonary disorders [3].

The six-minute walk test (6MWT) is a uncomplicated and cheap test that is applied globally to measure the exercise capacity of COPD patients [4]. Although the debate surrounding the usage of walked distance or oxygen desaturation for significant relationship with pulmonary function or survival information, new experiments have determined the effectiveness of utilizing the 6MWT to assess the efficacy of medications in individuals with interstitial lung illnesses, pulmonary rehabilitation follow up, transplantation design

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principles, and indication for oxygen supplementation reporting that it provide a excellent association with the functional capacity and survival of these cases [5,6].

The six-minute walk distance (6MWD) and the extent of exercise-induced oxygen desaturation (EID) assessed during the 6MWT have been linked to degree of pulmonary emphysema [7].

The objective of the current research was to detect the relationship between ΔSpO_2 /distance ratio, pulmonary function test, and the level of pulmonary emphysema in COPD patients.

2. Material and Methods

57 stable COPD patients who attended the outpatient clinic of chest medicine department. Mansoura university. were enrolled in this diagnostic study. The present study was performed within the prerequisite ethics guidelines of Mansoura institutional research board ethics committee (code number: R.21.07.1380) The diagnosis of COPD was built on Global initiative for chronic Obstructive Lung Disease (GOLD) guidelines 2021. Patients with A) a prior lung operation, B) exacerbation for a minimum 3 months preceding the 6MWT, C) inability to correctly carry out the 6MWT, lung function test, and CT, D) pulmonary hypertension and heart failure, E) BMI >30 and F) the usage of long-term oxygen therapy were excluded.

Included patients were classified according to GOLD airflow limitation [8]. Age, sex, and modified Medical Research Council dyspnea score (mMRC) were recorded. Furthermore, each patient completed the 6MWT and underwent a pulmonary function test and a CT scan to evaluate the degree of pulmonary emphysema.

2.1. Six-Minute Walk Test

The 6MWT was done using the American Thoracic Society (ATS) guidelines recommendations [9]. Each patient was advised to walk in six minutes, through which spot check measurement of peripheral oxygen saturation (SpO_2) was recorded using pulse oximeter at starting point and then after 6 min. Alternations in SpO_2 (ΔSpO_2) throughout the 6MWT were analyzed by subtracting the measurements at starting point from those instantly following walking 6 min [10]. The ΔSpO_2 distance ratio was determined as the ratio of ΔSpO_2 to the Six-minute walk distance (6MWD) $\times 100$.

2.2. Pulmonary Function Test

The lung function test was done in accordance with the ATS guidelines [11] and measured forced vital capacity (FVC), forced expiratory volume in one second (FEV1), the diffusion capacity of the lung for carbon monoxide (DLCO) and RV/TLC. Each One was stated as percentages of the predicted values (%FVC, %FEV1, %DLCO, RV% and RV/TLC, respectively).

2.3. Extent of Emphysema

HRCT densitovolumetry (consist of both helical CT and a HRCT along with slice width of ≤ 1 mm for volumetric calculation of emphysema) was accomplished utilizing 128 multidetector CT scanner. HRCT (computer-assisted analysis) had been applied to verify the heterogeneity of lung emphysema. The pixel index was identified as the relative zone of the CT image that had pixels between -1024 and -950 HU. In addition to the sagittal and coronal planes, computer multiplane restorations of CTs into three-dimensional images have being utilized to detect HRCT volumetry of the highly involved emphysematous area of the lungs [12].

2.4. Statistical Analysis

Data was investigated utilizing SPSS software V.26. Continuous data was shown in the manner of mean (SD) or Median (min-max) based on the results of Shapiro Wilk

testing for the assumptions of normal distributions of data. nominal data Spearman correlation was used to test the association between $\Delta\text{SpO}_2/\text{distance}$ ratio and other continuous variables. The best cutoff values to predict $\%\text{FEV}_{1.0} < 50\%$ [8] as an index of severe or very severe airway obstruction, $\%\text{DLCO} < 75\%$ as an index of pulmonary diffusing capacity disorder [13] and $\text{RV} \geq 175\%$ of predicted as an index of severe hyperinflation [14] were detected by using Receiver operating characteristic (ROC) curves.

3. Results

This study involved 57 COPD patients (mean age was 56 years old). 86% of them were males. Most of studied patients had GOLD 3 of airflow limitation and grade 3 of mMRC (68.4% and 49.1% respectively) (Table 1).

Table 1. characteristics of studied patient.

	<i>n</i> = 57	%
Sex		
Male/female	49/8	86/14
Age: years (mean $\pm$ SD)	56.4 $\pm$ 7.8	
FEV1% (mean $\pm$ SD)	42.5 $\pm$ 13	
FVC % (mean $\pm$ SD)	12.9 $\pm$ 61.17	
DLCO % (mean $\pm$ SD)	77.8 $\pm$ 19.5	
RV median (minimum–maximum)	183.8 (105–457)	
RV/TLC median (minimum–maximum)	142 (78–273)	
HRCT volumetry median (minimum–maximum)	496.3 (36.9–2137.2)	
6MWD (m) median (minimum–maximum)	401.3 (45–578)	
ΔSpO_2 % median (minimum–maximum)	3 (0–18)	
$\Delta\text{SpO}_2/\text{distance}$	0.9 (0–4.1)	
mMRC		
0/1/2/3/4	2/9/13/28/5	3.5/15.8/22.8/49.1/8.8
GOLD		
1/2/3/4	1/13/37/4	1.8/22.8/68.4/7

As regard correlation between $\Delta\text{SpO}_2/\text{distance}$ ratio and pulmonary function results of studied patients, the ratio was moderately correlated with DLCO%, FVC% and GOLD classification ($r = -0.4$ and 0.4 and $p = 0.001$) However, strong correlation was found with FEV1% and RV% ($r = -0.6$ and $p = 0.001$ and 0.003 respectively). mMRC was weakly correlated with $\Delta\text{SpO}_2/\text{distance}$ ratio ($r = 0.2$ and $p = 0.04$) (Table 2).

Table 2. Correlation between 6MWT parameters and characteristics of studied patients.

	6MWD Rho		ΔSpO_2 Rho		$\Delta\text{SpO}_2/\text{Distance Ratio}$ Rho	
	<i>p</i>		<i>p</i>		<i>p</i>	
DLCO%	0.02	0.8	−0.5	0.001	−0.4	0.001
FEV1%	0.4	0.001	−0.5	0.001	−0.6	0.001
FVC%	0.2	0.1	−0.4	0.001	−0.4	0.001
RV%	−0.6	0.005	0.4	0.03	0.6	0.003
RV/TLC	−0.3	0.02	0.3	0.004	0.3	0.006
GOLD	−0.2	0.02	0.4	0.001	0.4	0.001
mMRC	−0.1	0.3	0.2	0.02	0.2	0.04

HRCT volumetry	−0.05	0.7	0.3	0.02	0.2	0.3
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In addition, weak nonsignificant correlation was found between ΔSpO_2 /distance ratio and extent of pulmonary emphysema as measured by HRCT volumetry ($r = 0.2$ and $p = 0.3$) (Table 2).

Also, non-significant correlation was found between 6MWD and DLCO%, FVC%, mMRC and HRCT volumetry (Table 2).

During the 6MWT, ΔSpO_2 was weakly correlated with the 6MWD ($r = -0.3$, $p = 0.01$). In contrast, a significant moderate correlation was observed between the ΔSpO_2 /distance ratio and 6MWD ($r = -0.5$, $p < 0.001$). A significant strong correlation was observed between the ΔSpO_2 /distance ratio and ΔSpO_2 ($r = 0.87$, $p < 0.001$) (Table 3).

The results of ROC analysis for ΔSpO_2 /distance ratio as predictors of severity of air-flow limitation shows [(AUC, p): (0.81, ≤ 0.001)], Cut-off point was 0.23 (84.1% sensitivity and 75% specificity). However, Cut-off point as predictors of abnormal DLCO was 0.3 (72% sensitivity and 60% specificity). Cut-off point was 0.6 in prediction of hyperinflation with 100% sensitivity and 75% specificity (Table 4).

Table 3. Correlation between 6MWT parameters.

	Rho	p
ΔSpO_2 6MWD	−0.3	0.01
ΔSpO_2 /distance ratio 6MWD	−0.5	≤ 0.001
ΔSpO_2 /distance ratio ΔSpO_2	0.87	≤ 0.001

Table 4. Validity of ΔSpO_2 /distance ratio in prediction of COPD functional abnormalities.

Parameter	Cut Off Point	p value	Sensitivity	Specificity	AUC	95% CI
FEV1 < 50	0.23	≤ 0.001	1.84%	70%	0.81	(0.61–0.97)
DLCO% < 75	0.39	≤ 0.001	72%	60%	0.79	(0.65–0.91)
RV% $\geq 175\%$	0.6	≤ 0.001	100%	75%	0.95	(1.45–0.81)

4. Discussion

Previous researches have noticed that the 6MWD has a greater association with the severity and survival of individuals with interstitial lung disease than SpO_2 [15]. Eaton and colleagues discovered that the 6MWD is extremely repeatable and has an excellent predictive measure than SpO_2 attributable to its great variability [16]. 6MWD is highly effort dependent. Limited efforts may decrease the distance, preventing the development of hypoxemia. Nevertheless, hypoxemia can encourage dyspnea and decrease the distance contained. A combination of these two parameters might reduce the effect of this effort factor [17]. As a result, Pimenta et al. [17] established a new index, the desaturation distance ratio (DDR), based on the 6MWD and continuous peripheral oxygen saturation (SpO_2) readings in the 6MWT, to provide a more accurate method for functional evaluation of individuals with interstitial lung disorders.

The DDR was initially calculated to assess the decrease in the SpO_2 each 2 seconds by drawing the curve of SpO_2 , instead of measuring the easy subtraction of SpO_2 between baseline and post walk values [17]. However, in the present study conducted on COPD patients, we measured the SpO_2 not each 2 s but instead we subtracted the values of SpO_2 at baseline from those instantly after walking 6 min to calculate ΔSpO_2 .

ΔSpO_2 /distance ratio appears to be more simply measured in clinical situations as a spot check assessment of SpO_2 by pulse oximetry is common and available in every health

care facility, especially those with limited resources, than continuous SpO₂ assessment. Continuous SpO₂ measurement needs wearable finger pulse oximeters which is expensive and is not commonly available. In addition, results of this study demonstrated that $\Delta\text{SpO}_2/\text{distance}$ ratio not inferior to DDR in evaluation of COPD patients when compared with results of other researches.

In Pimenta et al. [17], correlation analysis revealed significant and strong correlation between DDR and predicted DLco in patients with interstitial lung disease. However, there was no correlation between DDR or other 6MWT variables with lung volumes (TLC and RV). Similarly, in present study, the $\Delta\text{SpO}_2/\text{distance}$ ratio was moderately correlated with DLCO%, FVC% and GOLD classification of included COPD patients. However, strong correlation was found with FEV1% and RV%.

Ijiri et al. [18] demonstrated that DDR was tightly correlated with lung functions in individuals with COPD, like the tight association of the 6MWD with reduced lung function. Also, in this study, $\Delta\text{SpO}_2/\text{distance}$ ratio was correlated with DLCO%, FVC%, GOLD classification, FEV1%, RV% and mMRC. In contrast to Ijiri et al. [18] no significant correlation was noticed between 6MWD and DLCO% in this study.

Furthermore, Mak et al. [19] found that 6MWD not correlated with oxygen desaturation through the walk and assumed that patients with obstructive airway diseases who think themselves the most disabled by breathing difficulty have the smallest 6MWD but do not essentially have considerable desaturation. In consistent with Mak et al. 19 findings, ΔSpO_2 was weakly correlated with the 6MWD in this study ($r = -0.3$, $p = 0.01$) and a significant moderate correlation was observed between the $\Delta\text{SpO}_2/\text{distance}$ ratio and 6MWD. Also, Ijiri et al. [17] found significant correlation between the DDR and ΔSpO_2 ($r = -0.656$, $p = 0.001$) as well as the reduction in SpO₂ was not significantly correlated with the 6MWD.

Fujimoto et al. [2] utilized two forms of the DDR (DDR-original and DDR-simple) in COPD patients. For DDR-simple, desaturation area (DA) was resulted from the sum of the differences between 100% and the recorded SpO₂ sampled once a minute. In addition, Fujimoto et al. 2 concluded that DDR revealed high correlations with both %FEV1.0 and %DLCO and DDR is better than either 6MWD or lowest SpO₂ separately in suggesting COPD parameters. The results for DDR-original and DDR-simple were identical in all statistical examinations. This indicates that DDR-simple is equal to DDR-original in suggesting COPD parameters.

In this study, weak non-significant correlation was found between $\Delta\text{SpO}_2/\text{distance}$ ratio and extent of pulmonary emphysema as measured by HRCT volumetry. However, DDR might be a helpful index that determines the degree of a pulmonary emphysema and pulmonary hypertension in Fujimoto et al. [2].

The present study has some limitations such as, small number of studied patients, lack of control group, patients on long term oxygen therapy not included, and the association between $\Delta\text{SpO}_2/\text{distance}$ ratio and prognosis of COPD not studied. Further studies are necessary to detect the role of $\Delta\text{SpO}_2/\text{distance}$ ratio in patients on long term oxygen therapy, predicting mortality, and response to treatment COPD patients.

5. Conclusions

$\Delta\text{SpO}_2/\text{distance}$ ratio could be available, simple and valuable index for the evaluation of exercise capacity in COPD patients and might be utilized to predict severity of airway obstruction, pulmonary diffusing capacity and hyperinflation.

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