ORIGINAL ARTICLE

The association between forced expiratory volume in one second (FEV1) and pulse oximetric measurements of arterial oxygen saturation (SpO2) in the patients with COPD: A preliminary study

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Background: The study was aimed to explore the association between arterial oxygen saturation (SpO2) and spirometer parameters of disease severity in chronic obstructive pulmonary disease (COPD) patients with a view to identify whether the pulse oximetry can be used as an alternative to arterial values in the clinical management of COPD patients in a routine practice. **Materials and Methods:** Thirty-one patients with COPD were included in this study. After evaluation of each patient through history taking, physical examination and chest X-ray, SpO2 % and data regarding spirometry (FEV1% predicted and FEV1/FVC % predicted) in all patients were measured. Linear correlations among the variables were analyzed using the regression analysis. **Results:** In total 31 COPD patients according to the criteria established by the Global Initiative for Chronic Obstructive Disease (GOLD) were included in the study. There was not statistically significant correlation between FEV1 % predicted and SpO2 values ($P > 0.05$), but a great correlation existed between FEV1/FVC % predicted and SpO2 values ($r = 0.556$, $P < 0.001$). Median SpO2 values did not differ between GOLD stages (Kruskal-Wallis test: $P = 0.17$). **Conclusion:** The study may demonstrate that oxygen saturation measured by pulse oximetry appears to be independent of the degree of airways obstruction as quantified by the FEV1; although further evidence needs to be assessed these preliminary findings.

Key words: COPD, FEV1, GOLD, SpO2

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is presented mainly by bronchitis and emphysema in various combinations, often with asthmatic complications. Development of cor pulmonale and/or upper respiratory infections may exacerbate the clinical outcome in chronic course of the disease.[1,2]

The patients are usually referred to emergency department due to intensification of COPD. Clinical examination as well as objective quantification of oxygenation is often critical for the clinical management of the patients. Arterial blood gas sample is often painful and carries the risk of local hematoma, infection and occlusion/embolization with consequent ischemic injury.[3] Alternatively, pulse oximetry has gained popularity for the measurement of oxygen saturation.[4] Hand-held pulse oximeters are usually applied in primary care due to small size, user-friendliness and affordable prices.[4] A meta-analysis of published studies has found a weighted mean correlation coefficient of 0.895 between the pulse oximetry and arterial blood sample.[5] In addition, pulse oximetry can be used in the patients with acute respiratory insufficiency and in the follow-up of chronic respiratory conditions or acute exacerbations of COPD.[3,6]

The available literature suggests that the use of pulse oximetry for COPD patients would be limited to acute events or specific situations.[3,7] However, the effectiveness of pulse oximetry in other COPD situations requires further investigation.

The study was aimed to explore the association between SpO2 and spirometer parameters of disease severity in COPD patients with a view to identify whether the pulse oximetry can be used as an alternative to arterial values in the clinical management of COPD patients in routine practice.

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MATERIALS AND METHODS

Participants and study design

The study sample comprised of 31 patients diagnosed with COPD, according to the criteria established by the Global Initiative for Chronic Obstructive Disease (GOLD)[8] who were consecutively referred to the Respiratory Outpatient Clinic of a university hospital between May 2011 and December 2012. All the patients were subjected to full medical history, general and local chest examination and chest X-ray. SpO2 saturation was acquired for every patient using a portable pulse-oximetry device (Oxipen®, EnviteCWismar, Germany). The percentage of hemoglobin oxygen saturation was measured after connecting the optical diodes on the patients' fingers. Each experiment was performed 3 times and the mean value was considered as the SpO2.

In the next step, data regarding the spirometry [forced expiratory volume in 1 second (FEV1) and forced vital capacity] in all the patients were measured.

Based on the GOLD criteria [10] , COPD was considered very severe (GOLD IV) if FEVI/FVC < 0.7 and FEV1 < 30% predicted or FEV1 < 50% predicted with respiratory failure or signs of right heart failure; severe (GOLD III) if 30 ≤ FEV ≤ 50%; moderate (GOLD II) if 50 ≤ FEV ≤ 80%, and mild (GOLD I) if the FEV 1 /FVC ratio was < 70 and FEV 1 ≥ 80% of the predicted value (8). Otherwise they were considered to have no lung disease (Normal) or GOLD stage 0 if they reported respiratory symptoms.[9,10]

The study complies with the declaration of Helsinki and was approved by the institutional ethics committee of our University, and all patients gave written informed consent.

Statistical analysis

For the statistical analysis, the Shapiro-Wilk test was used to determine the normality of the quantitative variables. The data were expressed as median, interquartile range; Man-Whitney U test and Kruskal-Wallis test were applied for quantitative comparison, and differences in categorical variables were examined using Chi-square test. Linear correlations among the variables were analyzed using the regression analysis. A *P* value of <0.05 was considered statistically significant. Statistical analysis was performed using an IBM computer and PASW software, version 18.0 (SPSS, Inc., Chicago, USA).

RESULTS

The study was conducted on 31 patients with COPD, including 24 males and 7 females (mean age: 55.09 ± 11.61; range: 35-76 years). The pulse oximetry and spirometric variables of the patients are described in the Table 1.

Table 1: Physiological variables of the included patients

Variable	Median	Interquartile range
SpO2 %	92	74-99
FEV1 % predicted	66	21-95
FEV1/FVC % predicted	70	47-89
Stage of COPD	number	
0	3	
I	4	
II	19	
III	3	
IV	2	

SpO2 %: arterial oxygen saturation; % predicted: percentage of predicted value

There was not a significant association between FEV1 % predicted and SpO2 % (*P* value > 0.05), while there was a significant association between FEV1/FVC % predicted and SpO2 % ($r = 0.556$, *P* value < 0.001) [Figures 1 and 2].

In addition, the association among age with SpO2% , FEV1% predicted and also FEV1/FVC % predicted was not significant statistically (*P* value > 0.05).

The median FEV1 % predicted in the stage 0 was [median 90%, interquartile range (90%-95%)]; stage I was 83%, 75%-89%; stage II was 62%, 51%-79%; stage III was 45%, 38%-48% and also stage IV was 27%, 21%-33%, which was a significant differences among them in five stages of GOLD using Kruskal-Wallis test (*P* value < 0.05).

The median FEV1/FVC % predicted in the stage 0 was [median 74%, interquartile range (73%-89%]; stage I was 72.5%, 69%-78%; stage II was 70%, 58%-79%; stage III was 56%, 52%-70 % and also stage IV was 57.5%, 47%-68%, which was a significant differences among them in five stages of GOLD (*P* value < 0.05).

The median SpO2% in the stage 0 was [median 94%, interquartile range (93%-97%)]; stage I was 94.5%, 91%-99%; stage II was 92%, 86%-96%; stage III was 90%, 74%-96% and also stage IV was 93.5%, 93%-94%, which was not a significant differences among them in five stages of GOLD (*P* value >0.05).

DISCUSSION

COPD is the sixth prominent cause of death in the world, and is estimated to be the third killing and the fifth debilitating disease by the year 2020.[11] Direct measurement of the pulmonary function (spirometry) and arterial blood gas (ABG) analysis are indicated for the clinical management of COPD.[12,13]

Although pulse oximeters are extensively used in emergency departments, anesthesiology, and critical care, data on their efficacy in general practice is limited. In this

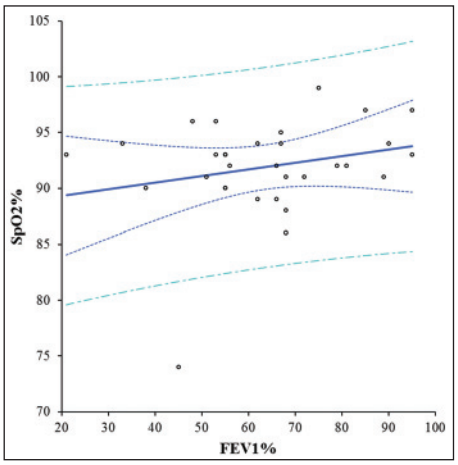

Figure 1: Correlation between FEV1% predicted and SpO2% in the included patients. The dotted curves represent the 95% confidence intervals of FEV1% for a given SpO2%

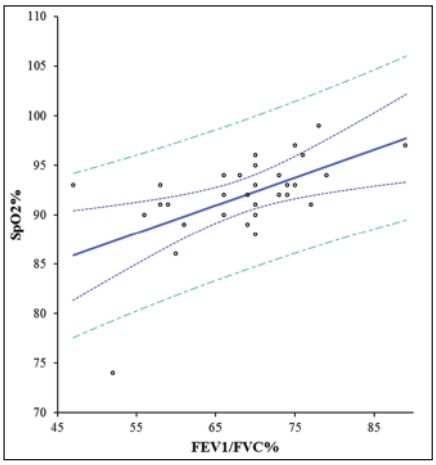

Figure 2: Correlation between FEV1/FVC% predicted and SpO2% in the included patients. The dotted curves represent the 95% confidence intervals of FEV1/FVC% for a given SpO2%

regard, studies have shown that these devices are only reliable when saturation is < 80%.[14]

We aimed to investigate the effectiveness of pulse oximetery for the determination of severity of COPD and respiratory failure.

The study showed no correlations between the disease severity (in terms of baseline airflow obstruction) and SpO2 in COPD patients. The recruited patients in the current study mostly have a stable condition and came to the clinic for their routine follow-up. This finding is in line with a number of studies that have documented a low degree of accuracy for the noninvasive assessment of saturation in stable COPD patients.[4]

Schermer *et al.* studied the application of pulse oximetry in 88 patients with deteriorating COPD which Spearman correlation coefficient for the association between baseline FEV1% predicted as documented in the patient's medical file and SpO2 was $r = 0.55$ ($P = 0.002$) for the patients with acute exacerbations.[4] On the other hand, in 207 patients with stable COPD, a weak correlation existed between post-bronchodilator FEV1 % predicted and SpO2 values (Spearman $r = 0.19$, $P = 0.006$; for current smokers: $r = 0.13$, $P = 0.252$ and for former smokers; $r = 0.19$, $P = 0.047$).[4] Also, median SpO2 values did not differ between GOLD stages (median test: $P = 0.079$).[4]

These observations suggest that pulse oximetry is mainly helpful when the symptoms are deteriorated because of severe airflow obstruction (FEV1 % predicted < 50%). This is consistent with the findings of previous studies indicating that the rate of tests with SpO2 < 92% increases when the FEV1 % predicted value is < 50% in stable COPD patients.[14]

It is noteworthy that our population was consisting of those suffering from mild to severe COPD who came to an outpatient clinic. Therefore, the findings of this study may be different from those acquired in hospital-based studies. In this regard, a Turkish study in the patients with severe COPD demonstrated a high sensitivity for both SpO2 and FEV1 in reflecting hypoxemia and hypercapnia (83.9 and 90.3%, respectively).[8] Although monitoring of saturation is recommended only for patients with severe disease,[15] pulse oximetry can identify those who might benefit from oxygen therapy or pulmonary rehabilitation.[4] Meanwhile, overestimation of arterial oxyhemoglobin saturation might occur in SpO2 values < 80%,[15] especially in the patients with darkly pigmented skin.[16,17]

Oxygen saturations are not helpful for the diagnosis of COPD; saturations of <98% provides a sensitivity of 79%, but specificity of only 37%.[18] However, pulse oximetry may help in determining the criteria for long-term oxygen therapy or the need for referral to hospital in acute exacerbations.[19] According to Dutch family practice guidelines, if pulse oximetry shows SpO2 > 92%, respiratory failure is unlikely in exacerbation of COPD (4). Moreover, initiation of oxygen therapy based on an oxygen saturation value < 90% is considered another possible application for pulse oximetry in the primary care.[4]

Although the current oximeters are practically accurate, they may produce false data in the presence of carboxyhemoglobinemia, hemodynamic instability, dark skin pigmentation, jaundice, and also during the exercise. The oximeter-indicated saturation may significantly overestimate arterial PO2, if the patient is alkalemic. Furthermore, pulse oximetry are not capable of detection of hypercapnia or acidosis.[20]

Furthermore, the study depicted a significant association between FEV1/FVC% predicted and SpO2% ($r = 0.556$, P value = 0.001). The FEV1/FVC ratio, also called Tiffeneau-

Pinelli[21] index, is a calculated ratio for the diagnosis of obstructive or restrictive lung disease.[22,23] It represents the proportion of a person's vital capacity that is exhaled in the first second of expiration. The above-mentioned finding was observed in Nomori *et al.* on 83 patients who underwent lobectomy for lung cancer.[24] A number of studies have showed that FEV1/FVC depends significantly on age in healthy subjects.[21] However, the current study did not show the correlation in the COPD patients, which could be due to small number of the included cases in our study. Further a larger study may clarify such association in COPD patients.

In this study the mean age was 55.09 ± 11.61 years with no significant relationship between age and FEV1% of predicted in COPD patients, and this was matching with the previous studies.[25]

Furthermore, the current study may demonstrate that FEV1 is essential for the diagnosis and quantification of the respiratory impairment resulting from COPD. But, FEV1 is known to poorly correlate with symptoms,[26] quality of life[27] exacerbation frequency[28] and exercise intolerance.[29]

In total, the study did not support that oxygen saturation measured by pulse oximetry to replace analysis of an arterial blood gas sample in the clinical evaluation of oxygenation in health care patients with COPD.

Finally, it should be mentioned that our study had some drawbacks. One of the most important limitations of this study is its small sample size. Unfortunately, we did not include a standardized assessment of dyspnoea in our study, which would have enabled us to investigate the relationship between the severity of dyspnoea and SpO2. Another limitation is that we did not measure arterial blood gas components, such as PaO2, which would have allowed us to acquire more comprehensive results. However, these findings support the claim that spirometric parameters, but not SpO2 level, could be useful indicators of the patient outcome, although further evidence needs to be obtained.

CONCLUSIONS

The study may demonstrate that oxygen saturation measured by pulse oximetry appears to be independent of the degree of airways obstruction as quantified by the FEV1; although further evidence needs to be assessed these preliminary findings.

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