USEFULNESS OF PULSE OXIMETRY IN ASSESSMENT OF DYSPNOEA IN ASTHMA

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Background: This study was carried out to find usefulness of pulse oximetry in assessment of dyspnoea patients with asthma. M**ethods:** This study was carried out at Baqai Medical University Teaching Hospital. Fifty-three patients, 28 males and 25 females, suffering from asthma with age ranging between 16 to 70 years were included. They were subjected to Pulse Oximetry before and after the bronchodilator treatment when presented with acute dyspnoea. Simultaneous recording of spirometry was also done. **Results:** Mean oxygen saturation (SaO_2) increased from 93.11±4.33 to 95.17±3.59 percent (p<0.0001) as dyspnoea improved after bronchodilator treatment. Mean FVC increased from 1.81±0.84 to 2.21±0.92 L (p<0.01). Mean FEV_1 increased from 1.21±0.73 to 1.62±0.85 L (p<0.01). Mean PEFR increased from 1.67±1.07 to 2.31±1.28 L/min (p<0.0001). Mean percentage ratio (FEV_1/FVC) increased from 66.47±18.01 to 71.19±16.47 percent (p<0.0001). The correlation was found between SaO_2 and FEV_1, FVC and PEFR with R^2=0.1149, R^2=0.2487 and R^2=0.3193 respectively. **Conclusion**: Pulse Oximetry like spirometry is reliable for assessment of dyspnoea. Both are correlated. Pulse oximetry has value in assessment of dyspnoea in asthma.

Key words: Dyspnoea, Pulse Oximetry, Spirometry, Asthma.

INTRODUCTION

Dyspnoea is difficult, laboured, uncomfortable and unpleasant breathing.[1] It may be the chief presenting complaint of patients with underlying respiratory, cardiac, haematological or functional disorder. Many classifications of dyspnoea are being used in clinical practice including classification by Medical Research Council[2], Sherwood Jones[3], and New York Heart Association.[4] The main methods to assess dyspnoea are either indirect when an attempt is made to clinically define severity in terms of the disability brought on by the symptoms, or direct, which quantify the perceived intensity of the sensation that include the visual scales, spirometry and pulse oximetry.

Pulse oximetry has been used in monitoring the percentage of haemoglobin (Hb), which is saturated with oxygen.[5] Pulse oximetry provides estimate of arterial oxy-haemoglobin saturation (SaO_2) by utilizing selected wavelength of light to determine the saturation of pulmonary oxy-haemoglobin saturation (SpO_2).[6] The need to monitor the adequacy of arterial oxy-haemoglobin saturation arises in a variety of situations like monitoring oxygenation during anaesthesia, recovery phase and mechanical ventilation.[7] When patients are sedated for procedures like bronchoscopy and endoscopy, oximetry has been shown to increase the safety by alerting the staff to unexpected hypoxia.[8,9] Using pulse oximetry is helpful in the diagnosis and treatment of patients in emergency department.[10] Pulse oximetry is a useful and simple method for an objective evaluation of acute asthma and its complications but it is not prediction for a therapeutic decision.[11]

Both asthma and COPD including pulmonary emphysema and chronic bronchitis are diseases characterized by airway obstruction, consequently their clinical manifestations overlap.[12] A diagnosis of asthma is suggested by history and physical examination and is confirmed by spirometry that is one of the most common pulmonary function tests.[13,14] Spirometry is essential in monitoring the course of respiratory diseases.[15] In many situations it is adequate for lung function to be measured whenever the patient attends the asthma clinic.[16]

There are different primary spirometric parameters like Forced Vital Capacity (FVC), Residual Volume (RV), Total Lung Capacity (TLC) and Vital Capacity (VC).[17] In practice these parameters are assessed by measuring the maximum flow rate that can be achieved during forced expiration and occasionally during inspiration. Measurement of VC is an excellent means of detecting respiratory muscle weakness.[18] Forced expiratory tests are simple, easily repeated and inexpensive. Interpretation of the test not only helps in proper assessment but it also helps in better management of patients. However spirometry has its own limitations. It is technically difficult to perform spirometry especially in patients with dyspnoea Grade-3 and Grade-4.[19]

It was considered to evaluate the validity of pulse oximetry as an objective tool for the assessment of dyspnoea in asthma patients coming from the rural area of Karachi and to find whether pulse oximetry has correlation with spirometric values including Forced Expiratory Volume in 1st Second (FEV_1), FVC, Percentage ratio (FEV_1/FVC) and Peak Expiratory Flow Rate (PEFR). The purpose of the study was to show that in situations where it is technically difficult to perform spirometry, use of oximetry could provide

alternative means of dyspnoea assessment that can result in better management of patients.

MATERIAL AND METHODS

This study was carried in Fatima hospital and Institute of chest diseases, Baqai Medical University Karachi. Four hundred and seventy (470) patients were attended in the hospital but only fifty-three (53) met the inclusion criteria. Rest of the patients were dropped from the study. The 53 patients included 28 males and 25 females with age ranging from 16 to 70 years who presented with dyspnoea. Patients were evaluated in Outpatient Department/Emergency Room (OPD/ER) and on follow up after administration of the treatment that included bronchodilators delivered by inhalers and/or nebulizers. A written or verbal consent was taken from the patients before they were included in the study.

Patients suffering from asthma who presented with dyspnoea were assessed according to classification of dyspnoea by Medical Research Council.[20] The patients suffering from acute asthma who were able to perform spirometry were included in the study.

Patients having other causes of dyspnoea like pneumothorax, pneumonia, pleural effusion, pulmonary fibrosis, anaemia, cardiac failure and functional cases were excluded from the study by carefully evaluating them on clinical grounds including detailed history and clinical examination. The relevant investigations required to establish/exclude the diagnosis including chest x-ray, arterial blood gases, electrocardiogram, complete blood count, blood urea nitrogen and random blood sugar were done where appropriate.

The patients were subjected to pulse oximetry based on the principle of optical plethysmography and spectrophotometry to determine SaO_2. Digital probes were placed on index fingers of patients. The probes were fitted with two Light Emitting Diodes (LED's) and two sensors for measuring near red light for oxygenated haemoglobin and infrared light for measuring non-oxygenated haemoglobin. The reading was obtained on digital display on the oximeter (Ohmeda Digital Oximeter, Northern Scientific, Minnitresta, USA). All the necessary precautions were taken for obtaining SaO_2. Calibration and performance of the oximeter was according to the guidelines by the Society of Critical Care Medicine.[21]

The patients were also subjected to spirometry at an ambient room temperature between 22–38 °C. The calibration of the spirometer was performed with a 3 litres syringe (Calibration Syringe 3 Litres Vitalograph® Ltd) prior to the commencement of study according to the recommendations of the National Asthma Education Programme.[22,23] A daily calibration of the spirometer was not required with the model used in this study (Electronic portable spirometer. Micro Medical Plus, Model 1999). Spirometry variables were measured for a series of at least 3 acceptable forced expiratory readings.[24] The guidelines by American Thoracic Society (ATS) were followed for obtaining satisfactory spirometric values.[25] The best values were selected. Patients performing the test for the first time were asked to make two or more practice blows to learn the correct technique. Thereafter, three technically satisfactory blows were recorded.[26,27] A minimum exhalation time of six seconds was required to obtain maximal FVC results. Patients were given adequate rest of two to three minutes in between the tests. Applying nose clips bears no effect on the result of spirometry as a very insignificant amount of air is expelled through nose during a forceful expiration. Nose clips were not used in our study. Patients were made to sit upright while performing the test.[28] They were asked to take in a deep breath then to blow out in the mouthpiece of spirometer as hard and as long as possible.

Comparison of Pulse Oximetry in males and females was done before and after the treatment by finding means and calculating standard deviation. Student *t*-test was applied to test the hypothesis. Correlation was found between oximetry and spirometry by regression analysis.

RESULTS

Out of 53 patients, 28 males with age ranging between 16 and 70 years (mean age 39.5±5.43 years) and 25 females with age ranging between 16 and 70 years (mean age 46.24±5.56 years) were included in this study. They were divided in four age groups, 16–25, 26–40, 41–55 and 56–70 years for both sexes. (Table-1)

All cases were analyzed for Pulse Oximetry values prior to and after the treatment. The minimum Oximetry value was 79% and maximum was 99% with mean 93.11±4.33% prior to treatment. Post treatment Oximetry was between 84% and 100% with mean 95.17±3.59% (p<0.0001). (Table-2)

The comparison of spirometric values, FVC, FEV_1, PEFR and ratio of the FEV_1 and FVC prior to and after the treatment was carried out in all the cases. The minimum value for FVC was 0.61 L and maximum 3.96 L with mean 1.81±0.84 L prior to treatment. Post treatment FVC was between 0.85 and 4.03 L with mean 2.21±0.92 L (p<0.01). The minimum value for FEV1 was 0.4 and maximum 3.82 L with mean 1.21±0.73 L prior to treatment. Post treatment FEV1 was between 0.47 and 3.73 L with mean 1.62±0.85 L (p<0.01). The minimum value for PEFR was 0.55 L/min and maximum 5.89 L/min with mean 1.67±1.07 L/min prior to treatment. Post treatment PEFR was between 0.58 and 5.64 L/min with mean 2.37±1.28 L/min (p<0.0001). The minimum values for FEV1/FVC% was 23% and 98% with mean 66.47±18.01% prior to treatment. Post

treatment FEV1/FVC% was between 37% and 100% with mean 71.19±16.47% (p<0.0001). (Table-3)

The correlation was found between pre treatment to post treatment change in SaO_2 and change in FEV_1, FVC and PEFR using regression analysis scores R^2=0.1149, R^2=0.2487 and R^2=0.3193 respectively. (Figure-1, 2, 3)

Table-1: Number of patients by age group

Years of Age	Male (n=28)	Female (n=25)
16–25	6 (21.43%)	4 (16%)
26–40	9 (32.14%)	5 (20%)
41–55	9 (32.14%)	7 (28%)
56–70	4 (14.28%)	9 (36%)

Table-2: Comparison of SaO_2 before and after treatment combined for both sexes (n=53)

Treatment	%SaO_2 (Mean±SD)
Pre-treatment	93.11±4.33
Post-treatment	95.17±3.59

Table-3: Comparison of FVC, FEV_1, PEFR and FEV_1/FVC% before and after treatment of dyspnoea (n=53)

Treatment	FVC (L)	FEV_1 (L)	PEFR (L/min)	FEV1/FVC %
Pre-treatment	1.81±0.84	1.21±0.73	1.67±1.07	66.47±18.01
Post-treatment	2.21±0.92	1.62±0.85	2.31±1.28	71.19±16.47

Figure-1: Correlation between SaO_2 and FVC

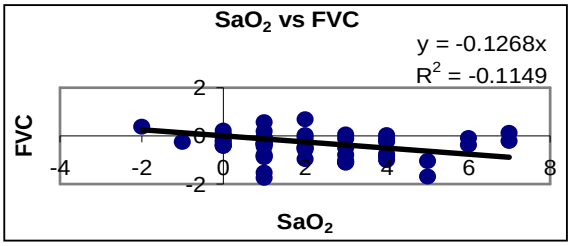


Figure-2: Correlation between SaO_2 and FEV_1

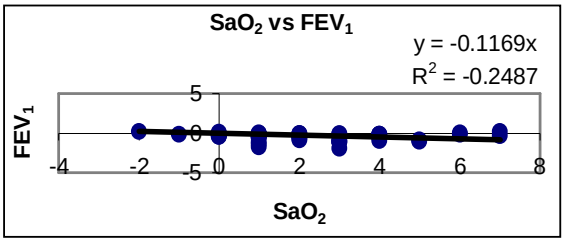
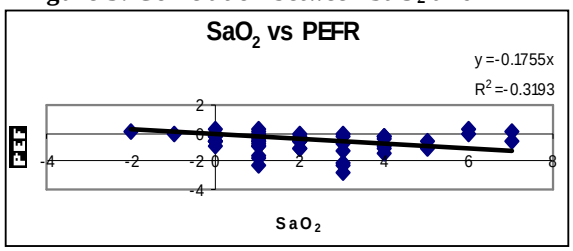


Figure-3: Correlation between SaO_2 and PEFR



DISCUSSION

Measurement of dyspnoea in acute asthma is difficult.[29] The need for rating of shortness of breath arises in emergency room or outpatient department when patient presents with dyspnoea facing difficulties in expressing his discomfort.[30] A diagnosis of asthma is suggested by history and physical examination and is confirmed by spirometry.[13] Lung function testing is crucial for the diagnosis of COPD as reversible airway obstruction is the main feature of chronic airway inflammation.[31] It is not possible in acute severe shortness of breath to always perform spirometry. The prevalence of asthma when using spirometry data lies between 4% and 10% however health statistics do not fully account for asthma patients either, given the under diagnosis of this disease reported between 30% and 50%.[32]

We evaluated pulse oximetry as an alternative tool for assessment of dyspnoea because it is simple and non-invasive method of monitoring percentage of haemoglobin that is saturated with oxygen.[5] Pulse oximetry was used in determination of oxygen saturation in monitoring the severity of an acute exacerbation of asthma and or wheezing and was shown to have a prognostic value.[9] Routine pulse oximetry measurements resulted in significant changes in medical management of patients.[10] In our study severity of shortness of breath in asthma was evaluated in 53 patients comprising 28 males with their mean age 39.5±5.43 years and 25 females with mean age 46.24±5.56 years. SaO_2 was recorded before and after the bronchodilator treatment revealed significant increase in SaO_2 after the treatment. The mean SaO_2 increased from 93.11±4.33 to 95.17±3.59% with significant p-value. However pulse oximetry is not a useful test for selecting patients for screening spirometry in order to diagnose asthma.[33] We used pulse oximetry to find whether it has a value in assessment and subsequent management of asthma patients with respiratory discomfort who presented in OPD/Emergency Room of a hospital. It was found that pulse oximetry is useful in assessment and further management of these patients although it is not a substitute for spirometry that still remains the best diagnostic tool for asthma.

A single home overnight pulse oximetry recording may be insufficient for accurate assessment of nocturnal desaturation of haemoglobin in asthma patients hence continuous monitoring of SaO_2 was required.[34] In our study however a single oximetry value was significant in the assessment of dyspnoea. Baseline FEV_1, oxygen saturation and 6 meter walking test may have a diagnostic value for distinguishing asthma patients who may develop an adverse physiological reaction during respiratory procedure.[35] Pulse oximetry has been shown to increase the safety of patients when

they are sedated during procedures like bronchoscopy, endoscopy and anaesthesia by alerting the staff to unexpected hypoxia.[5,6] Similarly arterial oxygen saturation estimates can be used to make an appropriate management plan for asthmatic patients.

A comparison of spirometry before and after the bronchodilator treatment was made in our study. Therefore FEV_1 ($p<0.01$), FVC ($p<0.01$) and PEFR ($p<0.001$) were shown to improve after the treatment. The correlation between peak expiratory flow rate and cutaneous oxygen saturation from pre-treatment to post-treatment scores r= -0.31 was shown by Kendrick *et al.*[30] Similarly we found the correlation between change in pulse oximetry after bronchodilators and change in spirometric values using regression analysis. Therefore the change in SaO_2 versus change in FVC, FEV1 and PEFR scores $R^2=0.1149$, $R^2=0.2487$ and $R^2=0.3193$ respectively. As the oximetry improved spirometry improved after the treatment.

CONCLUSION

Pulse oximetry like spirometry is reliable for assessment of dyspnoea. Both are correlated. Pulse oximetry has value in assessment of asthma patients.

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