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Research Article

Oxygen Titration through Gasometric Variables in Patients with Chronic Obstructive Pulmonary Disease: Portable Concentrators and Cylinders

Selma Denis Squassoni*, Claudia Lunardi, Thais de Almeida Navega, Barbara Klarge Carlos Cunha, Franco Chies Martins, Monica Silveira Lapa and Elie Fiss

Pulmonology Discipline of the Centro Universitário Ciências da Health ABC Medical School (PRP-FMABC) São Paulo, Brazil

***Corresponding Author:** Selma Denis Squassoni, Auxiliar Teacher, Pulmonology Discipline of the Centro Universitário Ciências da Health ABC Medical School (PRP-FMABC) São Paulo, Brazil.

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Abstract

Objective: To compare oxygen titration (O_2) during the six-minute step test (TD6') with the use of a portable concentrator (POC) and an O_2 cylinder in patients with severe to very severe chronic obstructive pulmonary disease (COPD).

Methods: Twenty COPD patients with ODP were included for ≥ 12 h/day, of which 11 concluded a protocol that was performed in two days. On the first day, the titration with O_2 was carried out in a cylinder and on the second day with POC. Venous blood gases were measured at three time points: firstly, in the basal period at rest in room air; secondly, after reaching SpO_2 ≥ 90%; and thirdly, after the TD6'.

Results: Three completed the titrations, one maintained SpO_2 ≥ 90% cylinder, 4 failed to finish the TD6', 2 did not reach SpO_2 90%, neither did they complete the test.

Conclusion: There were similarities in SpO_2 at rest and in submaximal effort for both oxygen sources.

Keywords: *Pulmonary Disease; Chronic Obstructive; Oxygen Inhalation Therapy; Blood Gas Analysis*

Abbreviations

O_2: Oxygen; COPD: Chronic Obstructive Pulmonary Disease; home oxygen therapy (ODP); PaO_2: Partial Pressure of Oxygen; $SatO_2$: Blood Oxygen Saturation; POC: Portable O_2 Concentrator; PRP-FMABC: Pulmonary Rehabilitation Clinic of the Pulmonology Discipline of the Centro Universitário Ciências da Health ABC Medical School; SpO_2: Peripheral Oxygen Saturation; HR: Heart Rate; SBPT: The Brazilian Society of Pulmonology and Tisiology

Introduction

Chronic obstructive pulmonary disease (COPD) is a major cause of mobility and mortality worldwide, resulting in a substantial and growing economic and social impact [1]. In Brazil, this pathology ranks fifth among the causes of death, with an estimated prevalence of 12% in the population over 40 years [2].

COPD is defined as a common, preventable, and treatable disease, which is characterized by limitations to consistent airflow, which is generally progressive and associated with an exacerbated chronic inflammatory response of the airways and lungs against harmful particles or harmful gases. Exacerbations and comorbidities contribute to the general severity in individual patients [3] and it is known that the severity of these symptoms worsens the quality of life and is a huge liability for the health system due to the high number of hospitalizations it causes [4,5].

The destruction of bronchioles and alveoli is responsible for the loss of lung capacity, making the individual unable to perform gas exchange (hematosis) adequately, leading to changes in ventilation, perfusion, and pulmonary hyperinflation [6] from which the symptoms arise.

Dyspnea is the main complaint reported by patients during consultations [7]; however, this symptom is generally associated with an abnormal inflammatory response of the lungs, leading to pulmonary hyperinflation, placing the inspiratory muscles at a mechanical disadvantage and changes in the bronchi, bronchioles, and lung parenchyma, causing grave systemic consequences [8,9].

Approximately 67.7% of COPD patients progress to chronic respiratory failure, characterized by hypoxemia, leading to social, physical and psychological impairments [4,5].

The use of prolonged home oxygen therapy (ODP) was confirmed to be beneficial to the quality. It increased life expectancy of COPD patients, being the main non-pharmacological treatment for patients with severe hypoxemia [10]. The main objectives of ODP are the reversal of hypoxemic changes, maintenance of hemoglobin and cardiac output, and tissue perfusion [11,12]. Although prolonged oxygen therapy improves general alertness, the available data are less clear regarding the changes in the quality of life and emotional state associated with this therapy [13].

ODP requires indications based on arterial blood gas and pulse oximetry tests that include the partial pressure of oxygen (PaO_2) in arterial blood ≤ 55 mmHg or an arterial blood oxygen saturation ($SatO_2$) of ≤ 88% in ambient air at rest. During exercise, peripheral SpO_2 should be < 90% on pulse oximetry [14]. For an adequate supply of O_2 flow, it is important to perform O_2 titration. The titration consisted of an individual assessment of the patient, whose objective was to reach SpO_2 > 90% at rest measured by a pulse oximeter [5], after which, the patient was encouraged to start the proposed physical exercise. The ideal O_2 flow for the correction of hypoxemia during physical activities should be maintained at SpO_2 > 90% [5].

ODP can be supplied in several ways, including a portable O_2 concentrator (POC) and an O_2 cylinder. The concentrator filters ambient air to obtain highly oxygenated air (87% to 93%) with no impurities. Works with electricity have the advantage of not generating storage disabilities or replacements, while the gas cylinder is used as a source [15,16].

The use of the O_2 cylinder is burdensome for patients and their family members, as the cylinders are heavy, empty quickly, and constantly need to be replaced with other ones, in addition to the difficulty of transporting and delivering oxygen to the patient's home and the difficulties and high cost associated with these procedures [16].

Aim of the Study

This study aimed to compare the similarity of the O_2 supply through the cylinder and the portable concentrator in patients with COPD.

Materials and Methods

This interventional, comparative study included 20 patients with moderate to severe COPD using ODP for more than 12 hours a day, recruited and monitored by the Pulmonary Rehabilitation Clinic of the Pulmonology Discipline of the Centro Universitário

Ciências da Health ABC Medical School (PRP-FMABC). The research was approved by the Ethics Committee of ABC Medical School (number 2,559,933). CAAE: 81717817700000082; All participants gave their written informed consent prior to their recruitment into the study.

We included COPD patients who previously used ODP for at least 12 hours a day by medical indication, of both sexes, were clinically stable, with maintenance medication, and patients without exacerbations in the last 3 months. The exclusion criteria were clinical instability, presence of physical or cognitive limitations, and absence of IC.

Data such as peripheral oxygen saturation (SpO_2) and heart rate (HR) were collected using the Nonin Onyx II Model 9550 pulse oximeter, Plymouth, Minnesota, USA. Other relevant data were obtained through the collection of venous blood gases (we opted for the intravenous one to save the patient from the pain of the puncture, as three gasometries were collected in the concentrator and three with cylinder).

The protocol was performed in two days (D1 and D2), with D1 titration with oxygen (O_2) in an O_2 cylinder of 4m^3 capacity; on D2, the same procedure was performed using the SimplyGo portable concentrator® from the Philips® brand.

The protocol adopted for D1 and D2 was based on the titration data that lasted approximately 2 hours or until $SpO_2 \geq 90\%$ was attained, and the participants underwent venous blood gas measurements at three instances: baseline period, prior to titration (T0), after reaching $SpO_2 \geq 90\%$ (T1) and after the effort titration (T2); for the adequate performance of the blood test, we opted for fixation of the venous access.

The initial blood gas analysis (T0) was performed after 20 min of rest under room air, after which 1 L/min of oxygen was administered through a nasal catheter (of the type connected to the O_2 cylinder). Every 20 min, the O_2 flow was adjusted to 0.5 L/min until $SpO_2 \geq 90\%$ was attained, and a new gasometry (T1) was performed.

To assess physical effort, the 6-minute step test (TD6'), which consists of a submaximal effort, in which patients performed upward and downward movements on a step measuring 14 cm in height, 89 cm in length, and 32 cm in width with support for the upper limbs. HR and SpO_2 were measured every minute until 6 minutes were completed. Throughout the test, patients received an incentive voice command, and at the end, the last venous blood gas (T2) was measurement was performed [17].

Results and Discussion

Of the 20 selected patients, six did not meet the selection criteria, two died, one did not complete the protocol, while 11 completed the research.

The general characteristics of the patients are presented in table 1.

Demographic data	
Gender F/M	06/08
	Median ± DP
AGE (years)	69,21 ± 7,912
BMI (kg/cm)	29 ± 7,9
Weight (Kg)	77,9 ± 21,2
Height (cm)	164,1 ± 5,139
FEV_1 (%)	22,69 ± 24,34
Legend: BMI: Body Mass Index	

Table 1: *General characteristics of the patients.*

In table 2, we can observe the SpO_2 through the cylinder and concentrator in TD6'. Table 3 shows the venous blood gases at T0, T1 and T2.

SpO_2	Cylinder Median ± DP	Concentrator Median ± DP
SpO_2Initial	88,20 ± 1,50	89,40 ± 0,65
SpO_2 1'	90,40 ± 3,62	91,80 ± 3,58
SpO_2 2'	88,44 ± 4,00	90,55 ± 4,79
SpO_2 3'	87,50 ± 3,62	89,28 ± 4,92
SpO_2 4'	88,25 ± 4,13	88,57 ± 2,93
SpO_2 5'	89,00 ± 3,16	90,28 ± 4,02
SpO_2 6'	90,00 ± 3,16	90,83 ± 2,48

Table 2: *SpO_2 cylinder versus concentrator at TD6'.*

Legend: O_2initial: Quantity in liters of oxygen offered to the patient at rest; SpO_2rep: Oxygen saturation with patient at rest; SpO_2 1': Quantity in liters of oxygen offered to the patient in the first minute at TD6'; SpO_2 2': Quantity in liters of oxygen offered to the patient in the second minute at TD6'; SpO_2 3': Quantity in liters of oxygen offered to the patient in the third minute on TD6'; $SatO_2$ 4': Quantity in liters of oxygen offered to the patient in the fourth minute at TD6'; SpO_2 4': Quantity in liters of oxygen offered to the patient in the fourth minute in the TD6' SpO_2 5': Quantity in liters of oxygen offered to the patient in the fifth minute in the TD6' SpO_2 6': Quantity in liters of oxygen offered to the patient in the sixth minute on TD6'.TD6': Six-Minute Step Test.

	Cylinder	Concentrator	P
Ph1	7,34 ± 1,38	7,33 ± 0,16	0,17
Ph2	7,35 ± 0,13	7,35 ± 0,11	0,09
Ph3	7,31 ± 0,012	7,33 ± 0,0010	1,35
$PO_2$1	34,4 ± 0,0051	29,9 ± 0,95	0,96
$PO_2$2	39,29 ± 3,37	38,77 ± 3,78	0,27
$PO_2$3	41,37 ± 6,14	36,82 ± 4,00	0,65
$PCO_2$1	58,62 ± 4,12	58,15 ± 4,09	0,16
$PCO_2$2	56,48 ± 4,54	53,54 ± 4	0,93
$PCO_2$3	65,2 ± 0,966	60,6 ± 0,32	0,34
$HCO_3$1	30,99 ± 1,78	29,66 ± 1,70	0,89
$HCO_3$2	32,85 ± 1,22	26,65 ± 0,22	0,22
$HCO_3$3	32,8 ± 0,919	31,6 ± 0,36	0,36

Table 3: *Initial venous gasometry (T0), pre-stress (T1), and post-stress (T2) on the cylinder and the concentrator.*

Reference values of venous blood gases: PO_2: 25 to 40 mmHg - PCO_2: 41 - 51 mmHg - HCO_3 24 and 25 mmHg Legend2: $PO_2$1: Oxygen partial pressure collected with patient at rest; $PO_2$2: Oxygen partial pressure collected from pre-exercise patient; $PO_2$3: Oxygen partial pressure collected from a patient after physical exercise; $PCO_2$1: Partial Pressure of Carbon Gas taken with patient at rest; $PCO_2$2: Partial Pressure of Carbon Gas taken from pre-exercise patient; $PCO_2$3: Partial Pressure of Carbon Gas taken from a patient after physical exercise; $HCO_3$1: Sodium bicarbonate collected from a patient at rest; $HCO_3$2: Sodium bicarbonate harvested with pre-exercise; $HCO_3$2: Sodium bicarbonate collected from a patient after physical exercise.

Our study evaluated the similarities between the oxygen supplies available for home use: the cylinder, the concentrator, and the liquid O_2 reference through the cylinder and the portable concentrator in a patient with severe to very severe COPD, dependent on ODP, through O_2 titration and measurements of venous blood gases.

Home O_2 administration has been in existence for approximately 50 years [5]; however, data from the 1970s onwards showed that ODP improved quality and prolonged the life expectancy of patients with COPD with chronic hypoxemia. Although it is reasonable to assume that most of the benefits resulting from this therapeutic form can occur in chronic hypoxemia of other etiologies, this is not yet fully defined [10].

The Brazilian Society of Pulmonology and Tisiology (SBPT) highlights the benefits of oxygen therapy and indicates three sources. We did not find reports on the improvement of SpO_2 using a concentrator or cylinder in the literature; however, it is recommended to use the concentrator or portable O_2 source during physical activity in hypoxemic patients. Regarding the prevalence of the use of cylinders or concentrators in resting situations, we found equipment with different characteristics, such as the weight and the use of electricity and mobility, to be available.

A worrying point in the use of portable O_2 concentrators is based on authors who state that POCs do not always maintain adequate oxygenation during exercise, since the "evidence suggests that the maintenance of $SpO_2 \geq 90\%$ offers a survival advantage" [15]. Continuous oxygen therapy is one of the treatments indicated to avoid for chronic hypoxemia; factors such as the extensive airflow limitation and the restriction of the movements imposed by the use of oxygen, can interfere within the quality of life [18-23].

Conclusion

Our study demonstrated similarities in peripheral oxygen saturation during O_2 supply at rest and during submaximal effort with the use of supplemental oxygen offered by the cylinder compared to the portable oxygen concentrator in hypoxemic COPD patients.

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Conflict of Interest

Any conflict of interest not exists.

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