Artigo Original

Influence of the oxygen delivery system on the quality of life of patients with chronic hypoxemia*

Influência do sistema de fornecimento de oxigênio na qualidade de vida de pacientes com hipoxemia crônica

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Abstract

Objective: To evaluate the health-related quality of life of patients with chronic obstructive pulmonary disease receiving long-term oxygen therapy (LTOT) at home through oxygen cylinders and compare these results with those obtained six months after the transition from oxygen cylinders to oxygen concentrators. **Methods:** A total of 45 patients were evaluated. Of those, 24 had chronic hypoxemia and 21 presented no evidence of hypoxemia. The patients with chronic hypoxemia had been regularly receiving LTOT for at least the last six months and were evaluated at baseline, while using cylinders, and six months after the transition from cylinders to concentrators. The non-hypoxemic patients were evaluated at the same time points as were the hypoxemic patients. In order to evaluate quality of life, a version of the Saint George's Respiratory Questionnaire (SGRQ), translated and validated for use in Brazil, was administered. **Results:** At baseline, quality of life, as evaluated using the total score and the symptom and impact domain scores of the SGRQ, was more impaired in the hypoxemic patients than in the non-hypoxemic patients. After six months of using the concentrators, the hypoxemic patients presented a significant improvement in the quality of life, and, at that time, no difference was found between the patients with and without hypoxemia. **Conclusion:** Our findings show that quality of life is impaired in patients with chronic obstructive pulmonary disease and chronic hypoxemia, that their quality of life can be improved through regular use of LTOT, and that the oxygen delivery system has an influence on this improvement.

Keywords: Pulmonary disease, Chronic obstructive; Anoxemia; Oxygen inhalation therapy; Quality of life.

Resumo

Objetivo: Avaliar a qualidade de vida relacionada à saúde de pacientes com doença obstrutiva crônica das vias aéreas recebendo oxigenoretapia domiciliar prolongada (ODP) por meio de cilindros de oxigênio e comparar estes resultados com os obtidos após seis meses de modificação do sistema de fornecimento para concentradores de oxigênio. **Métodos:** Um total de 45 pacientes, 24 com hipoxemia crônica e 21 sem evidências de hipoxemia, foram avaliados. Os pacientes com hipoxemia crônica estavam recebendo ODP regularmente durante pelo menos os últimos seis meses e foram avaliados no momento basal, em uso de cilindro, e após seis meses de transição para concentradores. Os pacientes não hipoxêmicos foram avaliados no mesmo intervalo de tempo que os pacientes hipoxêmicos. Para avaliar a qualidade de vida foi utilizada a versão validada para língua portuguesa (Brasil) do Questionário Respiratório Saint George (Saint George's Respiratory Questionnaire - SGRQ). **Resultados:** No momento inicial, os pacientes hipoxêmicos apresentaram maior comprometimento da qualidade de vida, avaliada pelo escore total e pelos escores dos domínios sintomas e impacto do SGRQ, que os pacientes não hipoxêmicos. Após seis meses, houve melhora significativa da qualidade de vida dos pacientes hipoxêmicos e, neste momento, não foi encontrada diferença entre os pacientes com e sem hipoxemia. **Conclusão:** Nossos achados mostraram que os pacientes com doença obstrutiva crônica das vias aéreas e hipoxemia crônica apresentam prejuízo da qualidade de vida, que essa qualidade de vida pode ser melhorada com o uso regular de ODP e que o sistema de fornecimento de oxigênio tem influência nessa melhora.

Descritores: Doença pulmonar obstrutiva crônica; Anoxemia; Oxigenoterapia; Qualidade de vida.

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Introduction

Long-term oxygen therapy (LTOT) is well established for treating chronic respiratory failure and persistent hypoxemia due to advanced chronic obstructive pulmonary disease (COPD).[1] The use of LTOT for more than 15 h/day increases survival, has a beneficial impact on hemodynamics, enhances neuropsychological function, and improves exercise performance as well as the performance of activities of daily living.[2-4]

The association between health-related quality of life (HRQoL) and arterial oxygen tension (PaO_2) has been shown; however, the effect of LTOT on HRQoL remains unclear.[5-9] In addition to decreasing patient mobility and damaging social relationships, LTOT can cause disturbing noise, as well as nasal/ear discomfort associated with the use of nasal tubes. It has also been associated with financial problems related to electricity consumption when concentrators are used.[9,10] Few studies have evaluated the impact of oxygen delivery systems on HRQoL in patients with chronic obstructive pulmonary disease.[11,12] Andersson *et al.*[11] showed that HRQoL improved in patients receiving liquid oxygen treatment and deteriorated in those receiving concentrator treatment through small portable oxygen cylinders. A cross-sectional study[12] showed that, in terms of HRQoL, there was no difference among patients receiving oxygen treatment through cylinders, those using small portable cylinders, and those using concentrators.

In Brazil, three oxygen delivery systems can be prescribed: F-size steel oxygen cylinders with a capacity of 10 m^3, oxygen concentrators, and liquid oxygen. Since the implementation of the policy of reimbursement for LTOT to some institutions, the number of oxygen cylinders has been declining; however, they are still quite common.[5] The oxygen cylinders used in Brazil weigh 70-78 kg, and supplies of small portable cylinders are uncommon.

The hypothesis of this study was that LTOT using concentrators has more impact on HRQoL than does LTOT using F-size steel oxygen cylinders. Our aim was to evaluate the HRQoL of patients with chronic obstructive pulmonary disease receiving LTOT through F-size oxygen cylinders, excluding small portable cylinders, and compare these results with those obtained six months after the transition to oxygen concentrators.

Methods

Patients

This study was approved by the local Research Ethics Committee, and written informed consent was obtained from all subjects. Forty-five patients with chronic obstructive pulmonary disease were recruited from an outpatient chest clinic: twenty-four presenting chronic hypoxemia (PaO_2 < 55 mmHg), according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria,[4] and twenty-one without clinical or laboratory evidence of severe hypoxemia. Nineteen (79%) of the patients with chronic hypoxemia had COPD, two (8%) had bronchiectasis; one (4%) had cystic fibrosis, one (4%) had sleep apnea, and one (4%) had asthma. Of the patients with chronic obstructive pulmonary disease but without hypoxemia, seventeen (81%) had COPD, and four (19%) had asthma. All were clinically stable at the time of the study, and the hypoxemic patients were receiving LTOT according to the GOLD criteria.[4]

Study design

Clinically stable hypoxemic patients on optimal medical therapy were assessed at baseline while receiving LTOT through cylinders, excluding small portable cylinders, for at least 15 h/day over at least six months. They were reassessed six months later, after the transition to the oxygen concentrator delivery system. Compliance with LTOT was assessed through patient reporting. The patients in the control group were attending the outpatient chest clinic over the same period and were assessed at the same time points as were the patients in the hypoxemic group.

Spirometry, arterial blood gas analysis and peripheral oxygen saturation

Forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were calculated from the flow-volume curve using a spirometer (MedGraph 1070; Medical Graphics Corporation, St. Paul, MN, USA), according to the American Thoracic Society criteria.[13] FEV_1 was expressed in liters (l), in percentage of FVC, and as a percentage of reference values.[14] Blood was drawn from the brachial artery with the patient at rest and breathing room air. The

PaO_2 and arterial carbon dioxide tension ($PaCO_2$) were measured using a blood analyzer (Stat Profile 5 Plus - Nova Biomedical, Waltham, MA, USA). Peripheral oxygen saturation (SpO_2) was estimated by pulse oximetry (Biox 3700, Ohmeda; The BOC Group, Inc.; Louisville, CO, USA).

Body composition

Nutritional assessment consisted of determining height and body weight and estimating the percentage of ideal body weight (IBW) according to the Metropolitan Life Insurance Tables.[15] Body composition was estimated using single-frequency (50 kHz) bioelectrical impedance analysis (BIA 101, RJL Systems, Detroit, MI, USA). Resistance was measured in the supine position, on the right side of the body, as described by Lukaski *et al.*[16] Fat-free mass (FFM) was calculated using a group-specific regression equation developed by Schols *et al.*[17] Fat mass (FM) (kg) was calculated by subtracting FFM from body weight. The FFM index (FFMI) was calculated by dividing FFM by height in m^2.

Health- related quality of life

A version of the Saint George's Respiratory Questionnaire (SGRQ), translated to Portuguese and validated for use in Brazil, was used to evaluate health-related quality of life of patients.[18]

Statistical analysis

All parameters were checked for normal distribution. Analysis of variance (ANOVA) was used to assess to what extent hypoxemia and the oxygen delivery system affect HRQoL. In order to analyze relationships between variables, Pearson's or Spearman's correlation coefficients were calculated. Significance was determined at 5%.

Results

Thirty-eight patients completed the second evaluation, four patients with hypoxemia died within the six-month period, and three patients without hypoxemia refused to perform the second evaluation; results from these seven patients were not considered in the follow-up analysis. Table 1

Table 1 - Characteristics of study subjects.

	Hypoxemic	Non-hypoxemic
n	24	21
Age (years)	66.9 ± 17.5	65.5 ± 8.4
Gender (M/F)	13/11	15/6
Tobacco use (pack-years)	32.7 ± 6.6	50.4 ± 7.4
Current tobacco use (yes/no)	0/24	1/20
FVC (%)	85.1 ± 2.61	98.2 ± 6.62
FEV_1 (%)	51.6 ± 21.4	56.7 ± 20.7
FEV_1/FVC	48.1 ± 1.81	47 ± 1.61
PaO_2 (mmHg)*	53.4 ± 13.1	70.4 ± 8.0
$PaCO_2$ (mmHg)*	45.7 ± 8.2	37.8 ± 4.7
SpO_2 (%)*	84.4 ± 8.7	94.1 ± 1.8
Ht (%)*	46.2 ± 7.6	41.9 ± 3.5
IBW (%)	106.5 ± 24.0	113.9 ± 25.7
FFM (%)	71.5 ± 11.3	72.7 ± 8.9
FM (%)	28.2 ± 11.7	27.3 ± 8.9
BMI (kg/m^2)	25.5 ± 6.5	27.3 ± 5.7
FFMI (kg/m^2)	17.5 (16.0-21.0)	19.0 (17.0-21.3)

Data presented as mean ± SD or median (quartile 1- quartile 3). FVC: forced vital capacity, expressed as % of reference values. FEV_1: forced expiratory volume in one second, expressed as % of reference values. FEV_1 / FVC: ratio between forced expiratory volume in one second and forced vital capacity. PaO_2: arterial oxygen tension; $PaCO_2$: arterial carbon dioxide tension; SpO_2: peripheral oxygen saturation; Ht: hematocrit; IBW (%): ideal body-weight (%); FFM (%): fat-free mass (%); FM (%): fat mass (%); BMI: body mass index; FFMI: fat-free mass index. *$p < 0.05$.

summarizes the baseline characteristics and physiological variables for the study and control groups.

Hypoxemic and non-hypoxemic patients were matched for age, gender, FEV_1, and for past and current tobacco use. The hypoxemic patients had significantly lower PaO_2 and SpO_2 and significantly higher $PaCO_2$ and hematocrit values than did the non-hypoxemic patients. No statistically significant differences were seen for body composition attributes between the two groups. However, 21% of the patients in the hypoxemic group and 12.5% of the patients in the control group were classified as malnourished, defined as body weight less than 90% of the ideal. Correlation analysis revealed significantly negative correlations between FEV_1 (L) and SpO_2 and all of the SGRQ domains; however, PaO_2 and body composition parameters were not correlated with the SGRQ domains (Table 2).

Mean SGRQ domains and total scores are presented in Figure 1. At baseline, the hypoxemic patients showed poorer scores for the symptoms (70.9 ± 25.8 *vs.* 48.3 ± 23.1) and the impact (55.0 ± 22.8 *vs.* 36.9 ± 23.5) domains and for total score (58.0 ± 21.7 *vs.* 42.8 ± 18.4) than did the non-hypoxemic patients.

Six months after the transition from oxygen cylinders to concentrators, blood gas levels, hemoglobin levels, and hematocrit levels did not change significantly in either group (Table 3). Oxygen flow rate in L/min, SpO_2 using the prescribed oxygen flow rate and daily treatment time did not change in the patients using oxygen supplementation. The hypoxemic patients under LTOT showed statistically significant increases in body weight and body mass index (Table 3).

There was a statistically significant improvement in the HRQoL of the hypoxemic patients, as demonstrated by improved symptoms (70.9 ± 25.8 *vs.* 47.8 ± 16.5) and impact (55.0 ± 22.8 *vs.* 45.6 ± 23.0), and total score (58.0 ± 21.7 *vs.* 47.8 ± 18.8). The HRQoL of the non-hypoxemic patients did not change significantly after six months and, at that time, there were no statistically significant differences between the hypoxemic and the non-hypoxemic patients for any SGRQ domains or total score (Figure 1).

Table 2 - Correlation coefficients of the SGRQ domains with lung function and blood gas variables.

Domains	Measure					
	VEF_1 (L)	Pa O_2 (mmHg)	SpO_2 (%)	IBW (%)	BMI (kg/m²)	FFMI (kg/m²)
Symptoms	-0.33**	-0.23	-0.38**	0.02	0.19	-0.19
Activity	-0.38**	-0.11	-0.38*	0.09	0.16	-0.02
Impact	-0.37**	-0.12	- 0.41*	0.19	0.26	-0.10
Total	-0.38**	-0.14	-0.44*	0.17	0.23	-0.09

SGRQ: Saint George's Respiratory Questionnaire; FEV_1: forced expiratory volume in one second, expressed in liters; PaO_2: arterial oxygen tension; SpO_2: peripheral oxygen saturation; IBW: (%): ideal body weight (%); BMI: body mass index; and FFMI: fat-free mass index. **p < 0.05; *p < 0.01.

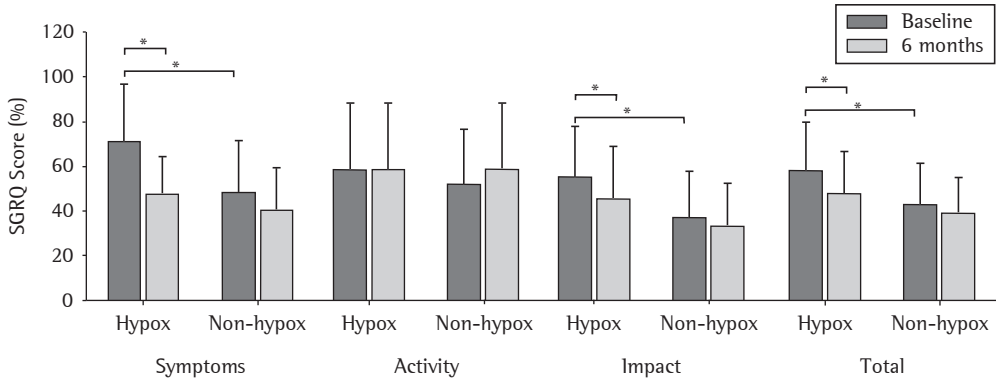

Figure 1 - Saint George's Respiratory Questionnaire (SGRQ) scores at baseline and after six months. Hypox: hypoxemic group; Non-hypox: non-hypoxemic group. *p < 0.05.

Table 3 - Blood gas levels, hematocrit levels and body composition at baseline and after six months for both groups.

	Hypoxemic		Non-hypoxemic	
	Baseline	6 months	Baseline	6 months
IBW (%)	105 ± 26	105 ± 26	111 ± 23	115 ± 25
BMI (kg/m^2)*	25.2 ± 6.9	25.8 ± 6.8	26.6 ± 5.1	27.4 ± 5.8
Body weight (kg)*	61.3 ± 20.8	62.6 ± 21.0	73.4 ± 16.0	74.9 ± 17.2
FFMI (kg/m^2)	18.2 ± 3.5	18.5 ± 2.9	19.3 ± 3.7	20.7 ± 5.3
FFM (%)	72.8 ± 12.1	72.9 ± 13.1	72.8 ± 7.8	75.6 ± 10.9
FM (%)	27.9 ± 12.2	28.8 ± 12.2	27.4 ± 8.9	23.6 ± 10.9
Hg (g%)	14.9 ± 2.5	14.6 ± 2.4	14.4 ± 1.5	14.7 ± 1.2
Ht (%)	46.9 ± 7.4	45.1 ± 7.2	40.9 ± 7.8	44.1 ± 3.5
PaO_2 (mmHg)	52.1 ± 9.9	57.6 ± 14.1	69.3 ± 10.9	69.2 ± 10.1
$PaCO_2$ (mmHg)	46.8 ± 7.4	45.9 ± 7.9	40.7 ± 13.4	41.0 ± 14.7
SpO_2 (%)	86.1 ± 7.7	86.1 ± 8.8	93.9 ± 1.7	93.3 ± 5.3
SpO_2F (%)	92.3 ± 7.2	90.5 ± 6.2	-	-
Oxygen flow rate (L/m)	1.4 ± 0.7	1.5 ± 0.8	-	-
Daily treatment time (h)	15.8 ± 4.7	13.3 ± 6.9	-	-

IBW: ideal body weight; BMI: body mass index; FFMI: fat-free mass index; FFM: fat-free mass; FM: fat mass; Hg: hemoglobin; Ht: hematocrit; PaO_2: arterial oxygen tension; $PaCO_2$: arterial carbon dioxyde tension; SpO_2F: peripheral oxygen saturation with the flow rate prescribed; SpO_2: peripheral oxygen saturation. *$p < 0.05$ for hypoxemic patients between baseline and 6 months.

Discussion

The results of this investigation show that the patients with chronic obstructive pulmonary disease and hypoxemia receiving oxygen through cylinders had a poorer HRQoL than did the patients with less severe hypoxemia. Transition from oxygen cylinders to concentrators resulted in a significant improvement in HRQoL and there was no difference in SGRQ scores between the hypoxemic patients using concentrators and the non-hypoxemic patients.

As compared to previous reports, our results showed significantly higher SGRQ scores for the patients with severe hypoxemia and chronic obstructive pulmonary disease than for the patients without evidence of hypoxemia, as well as a correlation between SpO_2 and SGRQ scores.[7,8] However, the correlation between HRQoL and arterial oxygenation is controversial in the literature. Previous studies using general health questionnaires have shown no correlations between PaO_2 and quality-of-life measures.[19,20] A recent study, carried out in Brazil, comparing low-income patients with COPD and hypoxemia who received LTOT through cylinders with COPD patients with less severe hypoxemia showed no significant differences in SGRQ scores.[5]

Changing the oxygen delivery system from cylinders to concentrators improved the quality of life of the hypoxemic patients to the same level as that of the patients with less severe hypoxemia evaluated in this study. The effects of LTOT on HRQoL have not been clearly established. Andersson *et al.*[11] showed improved HRQoL in patients receiving liquid oxygen treatment and deterioration in those using concentrators with small oxygen portable cylinders. Applying a general health questionnaire, the Sickness Impact Profile, Heaton *et al.*[21] found no improvement in the quality of life of hypoxemic COPD patients after six months of LTOT delivered by either stationary or portable oxygen delivery systems. Okubadejo *et al.*,[8] using SGRQ, also detected no change in the quality of life of patients with severe COPD receiving oxygen therapy through oxygen concentrators for 6 months.

Restricted mobility and noise disturbance, as well as problems with sore noses and ears, from using nasal tubes can explain why LTOT can reduce the quality of life of hypoxemic patients.[10] In low-income countries, higher costs resulting from electricity consumption by concentrators can be an additional problem.[5] Our patients received oxygen delivered by heavy steel oxygen cylinders; small portable oxygen cylinders were not available. For this reason, problems with restricted mobility and personal isolation were probably more common and might have been one reason why the hypoxemic patients presented an improved HRQoL after the transition to oxygen concentrators. Although

concentrators are classified as stationary systems, they are lighter and easier to move than the 10 m^3 steel cylinders, thereby allowing greater patient mobility. In fact, a cross-sectional study showed that patients who underwent treatment with concentrators and stationary cylinders preferred the concentrators because they were safer and easier to handle, although there was no difference in HRQoL between the groups, as assessed using a general questionnaire.[12] The same study also showed an improved sense of well-being in most patients.[12]

Another reason for the improvement in HRQoL could be the adherence to prescribed oxygen therapy. However, in our hypoxemic patients, no change was seen in oxygen flow rate (l/min), SpO_2 using the prescribed oxygen flow rate, or daily treatment time (Table 3).

A relationship between the SGRQ total score and FEV_1, which is in agreement with several other studies,[5,19-22] was observed in this study. Our results did not show a relationship between body composition attributes and HRQoL. Shoup *et al.*[23] showed that the weight variable was not significantly related to the SGRQ symptom score; however, underweight patients had significantly greater impairment in activity, impact, and total scores than did normal weight patients. In the same study, overweight patients had more impairment in the SGRQ impact and total scores than did normal weight patients. In a recent study, COPD patients with depleted FFM, irrespective of body weight, had more impaired SGRQ activity and impact scores.[24] As the sample size evaluated in this study was small, we did not consider it appropriate to analyze sub-groups of patients.

In summary, our findings showed that the HRQoL of patients with chronic obstructive airway disease and hypoxemia is lower than that of patients with less severe hypoxemia, that their HRQoL can be improved through regular use of LTOT, and that this improvement in their HRQoL is influenced by the oxygen delivery system.

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