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## The effects of frequent nurse visits on patient's compliance with long-term oxygen therapy (LTOT). A 14-month follow-up

### Abstract

**Introduction:** Long-term oxygen therapy (LTOT) is the only treatment that improves prognosis in patients with chronic respiratory failure in the course of chronic obstructive pulmonary disease (COPD). This effect depends on the duration of oxygen use during the day and night. The aim of this study was to evaluate the daily use of oxygen concentrator and to analyze factors that promote patient compliance.

**Material and methods:** The study enrolled patients seen at the Long-Term Oxygen Therapy Center of the Department of Internal Medicine, Pneumology and Allergology, Medical University of Warsaw, Poland. Qualification for LTOT was in accordance with the guidelines of the Polish Respiratory Society and the European Respiratory Society (ERS). All patients were instructed to use oxygen therapy for at least 15 hours a day using a stationary oxygen concentrator. The duration of oxygen concentrator use was evaluated on the basis of the concentrator counter reading performed by visiting nurses. The visits were run on the monthly basis.

**Results:** The study group involved 30 subjects (77% of COPD patients). The mean age was  $67 \pm 9$  years, mean FEV<sub>1</sub> was  $46 \pm 18\%$  predicted, RV/TLC was  $64 \pm 16\%$  and PaO<sub>2</sub> was  $50 \pm 6$  mm Hg.

The mean duration of the daily oxygen therapy for the entire study group was  $12.5 \pm 4.6$  hours. Eleven (37%) patients complied with the treatment during the follow-up period with the mean duration of daily oxygen therapy  $17.4 \pm 2.6$  hours. The mean oxygen therapy use in the non-compliant group of patients averaged  $9.6 \pm 2.7$  hours.

We found that highest percentage of patients (48%) used oxygen for an appropriate period of time in the # first month of the treatment. The second month the number decreased to about 30% and remained at this level until the end of the follow-up period. The analysis of the COPD patients showed that in case of the compliant subjects the values of total lung capacity (TLC) ( $100 \pm 19\%$  predicted v.  $152 \pm 36\%$  predicted,  $p = 0.001$ ) and PaCO<sub>2</sub> ( $38 \pm 6$  mm Hg v.  $47 \pm 8$  mm Hg,  $p < 0.05$ ) were significantly lower in comparison to the group of patients who used the oxygen therapy for less than 15 hours a day. Fourteen (47%) patients reported a considerable increase in electricity consumption and seven (23%) patients complained about the noise of the oxygen concentrator. The daily oxygen use of this group was significantly lower in comparison to the patients who were not annoyed with the sound of the concentrator ( $9.0 \pm 3.7$  h/24 h v.  $13.5 \pm 4.4$  h/24 h,  $p = 0.02$ ).

**Conclusions:** Our study show that the patients' compliance was the highest during the first month of the treatment only, and that the monthly home visit did not influence the patients' self-discipline to use LTOT properly. The use of an alternative source of oxygen, such as liquid oxygen, which would not generate any noise or electricity consumption, may positively influence the patient's compliance.

**Key words:** respiratory failure, long-term oxygen therapy, compliance, home visits

**Pneumonol. Alergol. Pol. 2009; 77: 363–370**

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Received: 6.10.2008

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ISSN 0867-7077

## Introduction

Undisturbed functioning of all the cells in the body is depending on the delivery of appropriate amounts of oxygen. Patients with certain chronic respiratory diseases develop respiratory failure, characterized by permanently reduced partial pressure of oxygen in the arterial blood, leading to chronic tissue hypoxia. In the majority of chronic respiratory diseases causative treatment is not possible, and oxygen therapy is the only management option that provides the body tissues with the appropriate oxygenation. The oxygen therapy shows to be a highly effective method of treatment. It visibly improves the prognosis in patients with chronic obstructive pulmonary disease (COPD), and thus reduces the mortality factor by 50% per annum.

The efficacy of oxygen therapy depends on the daily number of hours it is used. It has been demonstrated that the survival of patients on 12-hours-daily oxygen therapy does not differ from the survival of patients receiving no oxygen therapy at all. A significant improvement in survival has been observed in case of patients receiving at least 15 hours of oxygen therapy daily, with still higher survival rates reported in patients on oxygen therapy for about 18 hours daily [1, 2]. The results of these studies have made it possible to formulate recommendations on long-term oxygen therapy, in accordance with it should be used for at least 15 hours daily [3]. These recommendations have been adopted by the Polish Respiratory Society [4].

In spite of the similarities in therapeutic recommendations, the methods, and organisation of LTOT in Western Europe, and North America differ considerably from those in Poland, where the stationary oxygen concentrator is the only source of oxygen in the home setting. The fact that it is impossible for Polish patients to receive oxygen therapy outside their homes may significantly affect the daily duration of oxygen therapy, and may trigger its limitation. In addition, the reimbursement of LTOT does not include the costs of electricity consumption, amounting to more than 100 PLN per month, which is more or less the same as the monthly payment for the oxygen concentrator (monthly electricity consumption:  $0.75 \text{ kWh} \times 15 \text{ hours a day} \times 30 \text{ days} = 338 \text{ kWh}$ ;  $338 \text{ kWh} \times 0.36 \text{ PLN} = 122 \text{ PLN}$ ). Given the fact that most of the patients who qualify for LTOT are pensioners or disabled, this cost may be a considerable burden to the household budget. At the Long-Term Oxygen Therapy Center of our Department, we

decided to address the above factors that may adversely influence the daily duration of oxygen therapy by providing frequent home nurse visits. During visits nurses' task was to motivate patients to breathe with the supplementary oxygen for an appropriate number of hours daily.

We decided to examine the compliance with LTOT among patients of our LTOT Center during a 14-month long follow-up and to find out whether there is any correlation between pulmonary functional status, and the daily duration of oxygen therapy, and also among socio-economic factors, and the daily duration of oxygen therapy.

## Material and methods

The enrollment of the patients that, according to our LTOT Department, qualified for long-term oxygen therapy, was held between 2004–2006.

The criteria of qualification for LTOT were consistent with those of the Polish Respiratory Society's: the qualified patients suffered from chronic non-malignant lung diseases with resting partial oxygen pressure below 55 mm Hg when stable, or between 55, and 59 mm Hg when radiological or electrocardiographical signs of pulmonary hypertension and/or secondary polycythemia (haematocrit exceeding 55%) were present. Qualification for LTOT was carried out during two to three days' of hospitalization at our Department involving medical history, physical examination, spirometry, plethysmography, chest X-ray, ECG, blood cell counts, and arterial blood gas analysis while breathing room air.

After having confirmed the indications for LTOT, we established the optimal oxygen flow using the oxygen concentrator. Optimal oxygen flow as a flow was defined at which the arterial blood oxygen saturation ( $\text{SaO}_2$ ) measured by pulse oximetry was 90–93%. The effectiveness of oxygen delivery at a given flow was confirmed by arterial blood gas analysis. During hospitalization each patient (and his or her family) was thoroughly informed about the principles of operation, and use of the oxygen concentrator. After completion of the qualification procedure, the patient was given, free of charge (the cost of hiring the concentrator is paid for by the National Health Fund), the oxygen concentrator, and advised to breathe with oxygen for at least 15 hours daily, including overnight. During the first home visit, the patient completed a questionnaire regarding his or her educational background, housing conditions (standard, area, number of rooms, and

**Table 1. Anthropometric characteristics and functional status of the study subjects**

Variable	Mean $\pm$ SD			P value
	Entire group n = 30	COPD patients n = 23	Other causes of respiratory failure n = 7	
Age (years)	67 $\pm$ 9	70 $\pm$ 8	58 $\pm$ 5	0.001
BMI [kg/m <sup>2</sup> ]	26 $\pm$ 5	25 $\pm$ 5	26 $\pm$ 6	NS
FEV <sub>1</sub> [l]	1.1 $\pm$ 0.6	0.97 $\pm$ 0.5	1.4 $\pm$ 0.7	NS
VC (% predicted)	64.8 $\pm$ 18.9	66.3 $\pm$ 18.7	50.9 $\pm$ 20.3	NS
FEV <sub>1</sub> (% predicted)	46 $\pm$ 18	44 $\pm$ 17	57 $\pm$ 19	NS
FEV <sub>1</sub> %VC max	57 $\pm$ 14	51 $\pm$ 9	78 $\pm$ 11	< 0.001
TLC (% predicted)	122 $\pm$ 44	133 $\pm$ 40	77 $\pm$ 29	0.003
RV/TLC	64 $\pm$ 16	66 $\pm$ 15	53 $\pm$ 16	NS
PaO <sub>2</sub> [mm Hg]	50 $\pm$ 6	52 $\pm$ 5	45 $\pm$ 7	0.008
PaCO <sub>2</sub> [mm Hg]	43 $\pm$ 8	44 $\pm$ 8	42 $\pm$ 11	NS
MRC dyspnoea severity score	2.8 $\pm$ 1.4	2.6 $\pm$ 1.3	3.6 $\pm$ 1.5	NS
Oxygen flow [lpm]	2.2 $\pm$ 1.0	1.9 $\pm$ 0.7	3.1 $\pm$ 1.3	0.002
Mean daily duration of oxygen therapy [h]	12.5 $\pm$ 4.6	12.4 $\pm$ 4.9	12.7 $\pm$ 4.0	NS

number of other members of the household), and performance status. Every four weeks each patient was visited by a trained nurse, who verified the correct usage of the oxygen concentrator, measured the patient's SaO<sub>2</sub>, estimated the daily duration of oxygen therapy based on the oxygen concentrator counter reading, and encouraged the patient's compliance. The nurse also asked questions about electricity consumption, and the sound produced by the oxygen concentrator. The information obtained during the visits was captured in a special questionnaire, and provided, on an ongoing basis, to the doctor. Every three months the patient was seen by his or her consulting doctor at our LTOT Center. During the visit, arterial blood gas analysis was performed in order to verify the ongoing presence of indications for LTOT, and incompliant patients were encouraged to extend the daily duration of oxygen use.

The oxygen concentrator counter readings were used to calculate the mean daily duration of oxygen therapy. Statistical calculations were performed with the use of Statistica Version 8 (StatSoft Inc.). Quantitative variables were summarized as means  $\pm$  standard deviations. The significance of intergroup differences was assessed, depending on the distribution of the variables, by t-Student test for unmatched samples or by the non-parametric Mann-Whitney U-test. The distribution of qualitative variables was assessed by the chi-square test. The differences were considered statistically significant at  $p < 0.05$ .

## Results

Thirty patients in the study (13 men, and 17 women) was enrolled. The most common cause of respiratory failure was COPD (23 patients), with the remaining causes being kyphoscoliosis (2 patients), idiopathic pulmonary fibrosis (2 patients), chronic thromboembolic pulmonary hypertension (2 patients), and obesity hypoventilation syndrome (1 patient). COPD patients were older, and less hypoxaemic. Table 1 summarises the study group characteristics.

The average daily duration of oxygen therapy in the entire group over 14 months of follow-up was 12.5  $\pm$  4.6 h/24 h. Eleven (37%) patients complied with the treatment. The average daily duration of oxygen therapy among these patients was 17.4  $\pm$  2.6 h/24 h. Nineteen (63%) patients did not comply with the treatment, and their average daily duration of oxygen concentrator use was 9.6  $\pm$  2.7 h/24 h. No significant differences in sex, age, educational background, housing conditions, BMI or the severity of dyspnoea on the MRC dyspnoea scale were observed between the two groups. The detailed results of the comparison of both groups are summarized in Table 2.

Only eight out of the 23 patients with COPD (35%) complied with the treatment, while 15 (65%) patients used oxygen for less than 15 hours a day. Compliant subjects had lower values of PaCO<sub>2</sub> (38  $\pm$  6 mm Hg v. 47  $\pm$  8 mm Hg,  $p < 0.05$ ), and less hyperinflation, as measured by total lung capa-

**Table 2. Comparison of selected anthropometric and functional variables in compliant versus non-compliant patients**

Variable	Patients using oxygen therapy for more than 15 hours a day (compliant patients)	Patients using oxygen therapy for less than 15 hours a day (non-compliant patients)	P value
Number of subjects, n (%)	11 (37)	19 (63)	
Age (years)	66 ± 10	68 ± 4	NS
Sex (F/M)	5/6	12/7	NS
BMI [kg/m <sup>2</sup> ]	23 ± 5	27 ± 4	NS
MRC dyspnoea severity score	2.8 ± 1.4	2.8 ± 1.4	NS
Oxygen flow [lpm]	2.5 ± 1.4	2 ± 0.7	NS
Mean daily duration of oxygen therapy [h]	17.4 ± 2.6	9.6 ± 2.7	< 0.001

**Table 3. Comparison of selected anthropometric and functional variables in compliant versus non-compliant COPD patients**

Variable	Patients using oxygen therapy for more than 15 hours a day (compliant patients)	Patients using oxygen therapy for less than 15 hours a day (non-compliant patients)	P value
Number of subjects, n (%)	8 (35)	15 (65)	
Age (years)	67 ± 11	71 ± 6	NS
Sex (F/M)	3/5	11/4	NS
BMI [kg/m <sup>2</sup> ]	24 ± 5	26 ± 4	NS
VC (% predicted)	67.1 ± 20.6	65.9 ± 20.6	
FEV <sub>1</sub> (% predicted)	45 ± 16	43 ± 18	NS
FEV1%VC	52 ± 8	51 ± 9	NS
TLC (% predicted)	100 ± 19	152 ± 36	0.001
RV/TLC	58 ± 13	71 ± 15	NS
PaO <sub>2</sub> [mm Hg]	51 ± 4	52 ± 5	NS
PaCO <sub>2</sub> [mm Hg]	38 ± 6	47 ± 8	< 0.05
MRC dyspnoea severity score	2.3 ± 1.2	2.7 ± 1.4	NS
Oxygen flow [lpm]	2.0 ± 0.8	1.8 ± 0.6	NS
Mean daily duration of oxygen therapy [h]	18.5 ± 2.8	9.4 ± 2.4	< 0.001

city (TLC) ( $100 \pm 19\%$  predicted v.  $152 \pm 36\%$  predicted,  $p = 0.001$ ) (Table 3). In the majority of cases (18 patients) the subjects were qualified for LTOT according to the first criterion of severe hypoxaemia, and only five patients had moderate hypoxaemia, and pulmonary heart disease. These groups did not differ significantly in terms of the basic pulmonary function parameters, and the daily duration of oxygen concentrator use.

The greatest percentage of compliant patients was observed in the first month of treatment (48% of patients). The second month, the number of patients using their oxygen concentrators for at least 15 hours daily decreased, and remained stable at 25–33% until the end of follow-up (Fig. 1).

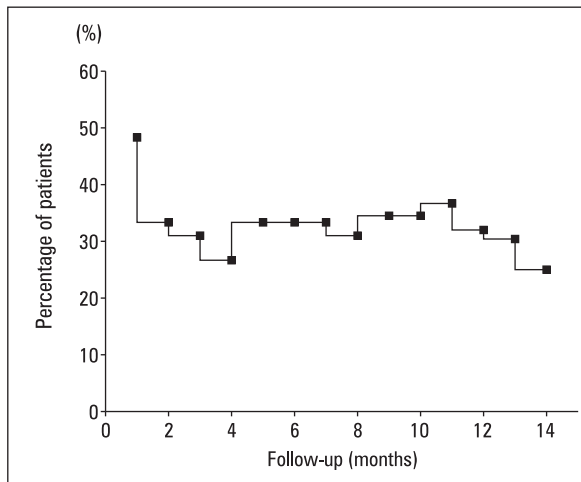
The highest percentage of patients (40%) used oxygen for 6–12 hours daily. The second most nume-

rous group (30%) consisted of patients using oxygen therapy for 15–18 hours daily. The distribution of the study population, with respect to the daily number of hours using oxygen, is shown in Figure 2.

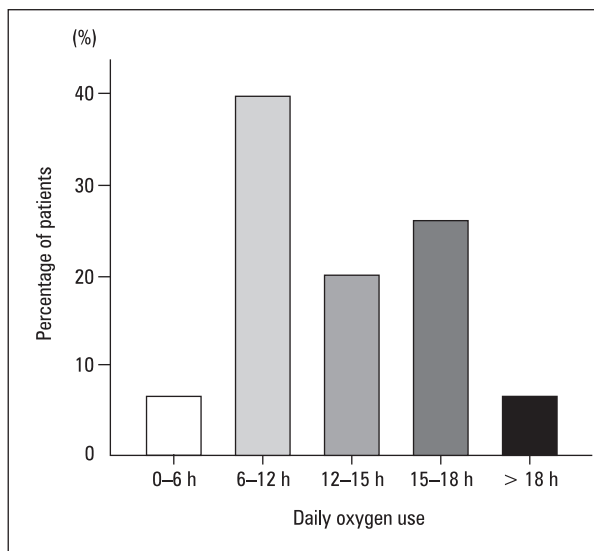
Ten patients experienced at least one COPD exacerbation requiring hospitalization during the follow-up period, which gives a mean of  $0.5 \pm 0.9$  exacerbations for the entire group. The occurrence of exacerbations did not affect the daily duration of oxygen therapy.

Fourteen (46%) patients reported increase in their electricity bills. However, statistical analysis did not show any significant difference in oxygen use between this group, and the group that did not report this problem.

Seven (23%) patients complained about the noise produced by the oxygen concentrator. The-



**Figure 1.** Percentage of compliant patients during the 14 months of follow-up



**Figure 2.** Distribution of the daily duration of oxygen therapy

se patients breathed oxygen for significantly shorter periods a day ( $9 \pm 3.7$  h/24 h v.  $13.5 \pm 4.4$  h/24 h,  $p = 0.02$ ), and were older ( $74 \pm 5$  years v.  $65 \pm 9$  years,  $p = 0.03$ ).

## Discussion

The benefits of LTOT in patients with respiratory failure in the course of COPD have been demonstrated in numerous studies, with improved survival being the most important one, as shown by two independent randomized studies in the early 1980s [1, 2]. These studies made it possible to formulate the principle that oxygen therapy should be used for at least 15 hours daily.

The other benefits of oxygen therapy include: improved quality of life [5], improved exercise capacity [6], improved intellectual function, and mental status [1], reduced secondary polycythemia [1, 2], and stabilised pulmonary artery pressure [7]. Despite the considerable number of benefits of oxygen therapy, the results of quality of life studies are inconsistent [8]. Oxygen therapy is inconvenient, and embarrasses patients, forcing them to change their lifestyles. Having to use an oxygen-supplying device is often perceived by patients as a limitation of their freedom. This effect may be particularly frequent in Poland, where (for economic, and logistic reasons) the stationary oxygen concentrator is the only source of oxygen. Another element that hinders the use of LTOT is the increased electricity consumption, which is often the main factor discouraging the patient from using oxygen for the recommended minimum 15 hours daily.

We decided to examine compliance with LTOT among patients looked after at our LTOT Facility, and analyze the factors that increase, and decrease the daily number of hours receiving oxygen therapy. In order to balance the factors that might limit the daily duration of oxygen therapy, we introduced monthly home visits by nurses specializing in the care of patients with respiratory failure. During the visits the nurses assessed the efficacy of oxygen therapy by measuring arterial blood oxygen saturation with a pulse oximeter, and recording the duration of oxygen concentrator use. They also reminded patients about the necessity of breathing oxygen for an appropriate number of hours daily. In spite of this, results were unsatisfactory: the average daily duration of oxygen therapy was 12.5 hours daily. Only about 30% of the patients used their oxygen concentrators for at least 15 hours a day.

Patient's compliance with oxygen therapy as a significant factor determining the efficacy of treatment has been addressed in numerous publications. Polish data from the early 1990s indicates that the percentage of patients receiving oxygen therapy for a sufficient period of time is unsatisfactory, and comprises about a third of all the patients on oxygen therapy [9]. A French study of around 1000 patients demonstrated that nearly half (45%) used oxygen for more than 15 hours a day [10]. An even higher percentage (54%) has been observed in a Scottish study [11]. In Turkey, on the other hand, a mere 28% of 1100 patients has been found to comply with oxygen therapy [12]. Similar results, albeit on a smaller group of patients (249), have been obtained in a Greek study [13].

Several studies have shown that daily oxygen use increases with the duration of treatment [10, 14]. This phenomenon is explained by the gradual deterioration of the patient's condition that leads to prolonged daily duration of oxygen therapy, and by the educational effects of home visits by the staff looking after the patients. Our study does not demonstrate such relationship. The greatest percentage of patients (nearly 50%) used oxygen for a sufficient number of hours in the first month of treatment. As early as in the second month of the treatment we noticed a reduction in the number of compliant patients to about 30%. This percentage was maintained at a stable level until the end of the follow-up. The lack of perceived effects of treatment (in the patients' opinion) might be the reason for the decreased duration of oxygen therapy after the first month of treatment. Doctors looking after patients on LTOT could often hear: "I breathe oxygen, but see no improvement". Patients frequently expect a rapid effect of oxygen therapy demonstrated by the improved exercise tolerance. As the patients do not experience that, they feel disappointed, and less keen on continuing the treatment. It is very important to make patients aware of the fact that oxygen will not provide them with a dramatic, and rapid improvement of health, but its effectiveness will become evident in the long term.

The patients treated with LTOT should stay monitored. The optimal frequency of the nurses' home visits has not been established, and it varies from country to country. In France the recommended frequency of visits is every 2–4 months [15], while the British Thoracic Society recommends visits every six months [16]. The National Health Fund in Poland recommends visits every three months, which seems appropriate. Cottrell et al. carried out a randomized study to compare the effects of visits paid every two months versus every six months in a group of 50 subjects with COPD receiving oxygen therapy. After one year of follow-up, no significant differences were found in the number of outpatient interventions, number of hospitalizations, duration of hospitalizations or survival. Unfortunately the study did not monitor the duration of oxygen therapy [17].

For economic reasons, the stationary oxygen concentrator is the only source of oxygen available in the home setting in Poland. The lack of access to portable sources of oxygen may negatively affect the daily duration of oxygen therapy. Katsenos et al. compared oxygen use between patients using oxygen concentrators, and patients using liquid oxygen systems [18]. Only 13% of patients

using the concentrator breathed oxygen for more than 15 hours daily with the mean daily duration of oxygen therapy amounting to 7.6 hours. In the group of patients using portable liquid oxygen devices the values were 43%, and 12.8 hours respectively. Other studies also demonstrated increased duration of oxygen therapy when portable oxygen sources were used [19]. The additional advantages of liquid oxygen include the lack of dependence on electricity, and noiseless operation. Nearly half of our patients found the increase in electricity bills quite considerable. No significant relationship has however been found between the increased electricity bills, and the duration of oxygen therapy. A significant decrease in the daily duration of oxygen has been observed in the group of patients who found the noise produced by the concentrator a serious problem. They were elderly patients, what might explain the lower tolerance of monotonous sounds.

Numerous authors emphasize that patient's education is an essential factor improving compliance with oxygen therapy [10, 20]. Home visits by nurses asking patients, and their families about the duration of concentrator use, and emphasizing the necessity of using oxygen for an appropriate number of hours, may be regarded as a form of patient's education. In spite of this intervention, however, we did not observe any increase in the daily duration of oxygen therapy for the 14 months of the follow-up. It should however be noted that the lack of an appropriately selected control group is a certain limitation of our study.

Pepin et al. found that the severity of the disease as evidenced by a more marked hypoxaemia, hypercapnia, and airway obstruction contributes to the prolongation of oxygen therapy duration [10]. We found no such relationship in our study, although we did demonstrate a significantly lower TLC, and PaCO<sub>2</sub> in the group of patients using LTOT for more than 15 hours daily. This relationship, however, seems to be of a random nature, and results from the small size of the study group.

## Conclusions

Our results indicate that the nurses' frequent home visits do not increase patient's compliance with LTOT. The compliance might be improved by reimbursing the cost of electricity consumed by the working oxygen concentrator, introducing an alternative source of oxygen in the form of liquid oxygen, and providing patients who are active outside their homes with a portable sources of oxygen.

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