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VIEWPOINT

Domiciliary oxygen - by liquid or concentrator?

Working Group on Oxygen Therapy of IUATLD
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Domiciliary oxygen - by liquid or concentrator? P. Howard, R. de Haller.
ABSTRACT: A few hypoxaemic and even less non-hypoxaemic patients with chronic obstructive pulmonary disease (COPD) benefit from portable oxygen. For these few, selected by double-blind tests against compressed air, liquid oxygen would seem more convenient and efficient. The extra cost of treating all hypoxaemic COPD patients with liquid oxygen by displacing the oxygen concentrator is not justified on the basis of current knowledge. The application of differing oxygen delivery systems to COPD patients requires more evaluation. The selection of patients for long-term oxygen therapy (LTOT) still presents major difficulties, which reflects on the numbers of patients likely to benefit from portable oxygen. No studies have yet shown the benefit of LTOT to chronic respiratory failure in other disorders such as lung fibrosis. As the pathophysiology is quite different, extension of the use of LTOT and portable oxygen to non-COPD patients must be treated with great caution.
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Long-term domiciliary oxygen therapy (LTOT) is now an accepted treatment for improving arterial blood gases in chronic respiratory failure associated with obstructive airways disease [1, 2]. There is less confidence about the application of LTOT to other forms of chronic respiratory failure, associated for example with lung fibrosis and neuromuscular disease. In the latter, assisted ventilation is usually also mandatory, at least in more advanced cases. LTOT requires the use of an oxygen flow rate administered to the patient usually through nasal cannulae at approximately 2 $l \cdot min^{-1}$ to improve arterial blood gases beyond an oxygen tension of 8.7 kPa 65 (mmHg). The treatment has to be given for at least 15 $h \cdot day^{-1}$ to achieve clinical benefit in terms of improved survival.

The oxygen is usually supplied through an oxygen concentrator, a device used for separating oxygen from ambient air. It is neat, easily positioned in the home and avoids the necessity to store large quantities of the gas in the domestic environment. It is relatively cheap to run and the equipment is reasonably reliable, readily serviced and easily transportable for holidays or weekends away. Oxygen concentrators suffer the disadvantage that portable oxygen therapy has to be provided separately.

Portable oxygen must be given at higher flow rates of 2–4 $l \cdot min^{-1}$ during walking with a view to reducing dyspnoea and improving exercise distance and has so far been aimed at patients with obstructive airways disease. A number of patients with advancing bronchitis derive genuine benefit from portable oxygen but whether all patients receiving domiciliary oxygen would increase perambulation outside the home if provided with portable oxygen is not certain. Liquid oxygen in small portable systems is ideally suited. The unit which is carried on the back or by shoulder strap weighs 2.5 kg when full and permits walking for up to 3 h before recharge, which can be extended further by the use of spacing devices or a transtracheal catheter. However, such units require a storage system of large quantities of oxygen within the home and a delivery service to periodically replenish these. They have to be installed in a space with free circulation as the refrigeration is maintained by venting continuously a small amount of the liquid source. A potential fire hazard exists as 25% of patients still smoke.

If liquid oxygen is to be considered, then it should probably be used as the source of long-term domiciliary oxygen as well. In most countries the cost of liquid oxygen is two to three times the cost of oxygen provided by an oxygen concentrator. This report addresses the issue of whether liquid oxygen should substantially replace the oxygen concentrator as the source for LTOT in the belief that liquid oxygen would so improve the quality of life, through increased survival and mobility of severely disabled hypoxic bronchitic patients, that the extra cost involved would be justified.

Portable oxygen can also be provided through compressed gas in a lightweight aluminium cylinder (2.5 kg), filled by the patient decanting from a domestic cylinder or by delivery of 6–12 reserve cylinders in some countries but not from the concentrator. Its duration of use, about 40 min, is less than that for

liquid sources but the time can be extended by the use of oxygen conserving devices, nasopharyngeal or intratracheal catheters. The decanting procedure has caused few problems but is potentially dangerous in unskilled hands. Larger cylinders could be wheeled in a shopping cart.

To justify the extra expense of liquid oxygen the efficacy of portable oxygen in chronic obstructive pulmonary disease (COPD) and the proportion of hypoxaemic patients likely to benefit must be clearly understood. It is appreciated that LTOT is given for hypoxaemia in disorders other than COPD but studies are too fragmentary to widen the discussion.

Efficacy of portable oxygen

Portable oxygen may be useful in hypoxaemic patients in three ways: 1) during daily life activities to improve exercise tolerance; 2) to decrease the sensation of breathlessness through decrease of the chemoreceptor output by correction of hypoxia; and 3) to extend daily hours of LTOT into the mobile period of the day.

Dyspnoea has an important subjective component not fully correlated with parameters of ventilatory dysfunction. Improvement in performance has been reported during compressed air breathing, through a placebo effect [3]. Objective assessment of the usefulness of portable oxygen during exercise requires double blind studies comparing portable systems of compressed air with similar systems of oxygen.

Early studies of this type using 5 $l \cdot min^{-1}$ supplementary oxygen given by nasal prongs, in 26 severe COPD patients during incremental treadmill exercise, variably reduced the decrease of arterial oxygen tension (Pao_2) during exercise at the expense of some increase in arterial carbon dioxide tension ($Paco_2$) or decrease in pH. No placebo effect was observed in trained patients [4].

LEGGETT and FLENLEY (1977) [5] observed in "blue bloaters" an increase of the distance walked during 12 min from 712 m to 764 m when the portable oxygen device was wheeled on a shopping cart but not when carried. The weight of the equipment obscured the benefits in the latter case.

WOODCOCK *et al.* (1981) [6] studied 10 "pink puffers" with severe fixed airways obstruction (forced expiratory volume in one second (FEV_1) 0.71 *l*) but without significant hypoxia (Pao_2 at rest, breathing air, 9.65 kPa). They noticed a decrease of breathlessness (expressed by visual analogue scale) and an increase in walking distance on a treadmill using 4 $l \cdot min^{-1}$ supplemental oxygen, whether the cylinder (2.5 kg) was carried by an assistant or by the patient. Much inter-patient variation was evident. In their experience, the advantage of supplemental oxygen is not abolished by the extra work attributable to the weight of the cylinder. Furthermore, breathing oxygen for 5 min before a short exercise resulted in a similar improvement in exercise tolerance. This finding was not confirmed, however, by the observations of MACKEON *et al.* (1988) [7].

The reproducibility of the favourable effects of supplemental oxygen given by nasal prongs in 20 severe obstructive COPD patients (mean FEV_1 0.92 *l*) with clear hypoxia (Pao_2, 8.9 kPa) was studied by WATERHOUSE and HOWARD (1983) [3] using a simple 6 min walking test. Breathlessness and walking ability were shown to respond independently to oxygen (3 $l \cdot min^{-1}$) breathing. The improvement of breathlessness during oxygen was measurable and associated with a relative fall in respiratory rate. Although the distance walked increased significantly more with supplemental oxygen than with air, believing it to be oxygen, only 25% of patients had substantial oxygen benefits (>10% improvement of baseline values). Repeat measurements of the breathlessness after an interval of up to three months were relatively close, suggesting that individual expression of the patients sensations was reproducible.

The identification of individual patients most likely to be helped by supplemental oxygen during exercise is difficult. Resting spirometric data and blood gas analysis are not predictive but the steepest drop in Pao_2 on maximal exercise may be so [8].

In conclusion, concerning efficacy in COPD, portable oxygen benefits are small in terms of the alleviation of breathlessness and improvement of exercise distance except in a minority (about 25%). Benefit must be demonstrated by double-blind tests of portable oxygen and portable compressed air before prescription. Oxygen conserving devices will extend equipment usage [9].

Portable oxygen as a means of extending LTOT

Among the two important studies [1, 2] which evaluated LTOT in the early 1980s the Nocturnal Oxygen Therapy Trial (NOTT) [2] compared continuous (average of about 19 h daily) oxygen supplementation with nocturnal only (12 h daily) therapy in 203 patients with hypoxaemic COPD. It showed improvement of survival and neuropsychological function to be proportional to the daily duration of oxygen therapy. Oxygen therapy, it was concluded, must be given for as long as possible during the day and that goal could be achieved through the use of portable sources of gas to extend the use of fixed oxygen sources. Treatment compliance seems to be more irregular with gaseous oxygen [10] and concentrators [11] than with liquid oxygen but in clinical practice would the use of portable devices on an ambulatory basis truly extend LTOT in and out of the home?

Few studies are available on this topic. In a multicentre study including 159 COPD patients [10] the effects of portable oxygen both on the daily duration of oxygen therapy and on daily activities were evaluated. The patients were randomly allocated to either oxygen concentrators only, small oxygen cylinders plus oxygen concentrators or liquid oxygen (LO). In the group with a portable system, the daily use of

oxygen appeared significantly longer compared to the use of the oxygen concentrator alone but no difference appeared between the two subgroups having or not having liquid oxygen. Outdoor walking activities were no different between groups with fixed or portable oxygen sources, at least in those patients using oxygen more than 18 $h \cdot day^{-1}$. Only 60% of patients in the group with portable sources used their ambulatory system outdoors and for walking without statistical difference between gaseous and liquid oxygen. Twenty five percent of patients never used their portable oxygen (19 out of 51 with gaseous oxygen, only 2 out of 33 with liquid oxygen) because of fear of lack of oxygen and difficulties of delivery. Fifteen percent of patients used portable oxygen only at home, these were essentially patients with liquid oxygen (9 out of 33) as opposed to patients with gaseous oxygen (4 out of 51). The convenience and comfort of liquid oxygen, particularly refiil upon demand, explained this difference. Among the 60% of patients who used portable oxygen outside the home (50 out of 84) the use of the two types of oxygen was almost the same; 67% used liquid oxygen and 55% gaseous oxygen.

In this study one patient out of two with portable gaseous oxygen and two out of three with liquid oxygen considered that they gained an improvement of their quality of life with portable oxygen. A preference was expressed for the use of liquid sources for practical reasons. One of the major causes of the restricted use of portable sources outside the home (40% non-compliant patients) was the weight of the apparatus [9] even though the supplemental oxygen compensates for the extra oxygen uptake required for carrying the apparatus [7]. The cosmetic appearance posed difficulties for some patients but intratracheal catheters offer a solution.

Early studies in the UK suggested that LTOT would confer up to 5 yrs added survival in hypoxic COPD. Current usage of the oxygen concentrator suggests a mean installation time of only 10 months with deinstallation within three months in the winter time through death of 20% of patients. The reasons for such short-term application are not clear but suggest that treatment is being applied in the main to very advanced disease. In such instances, portable oxygen would hardly be relevant.

Thus, portable oxygen seems capable of extending LTOT from fixed supply with some objective and subjective preferences for liquid over compressed gas. The existence of other benefits, either objective, subjective or both, from the use of portable oxygen despite its extra cost are yet to be demonstrated in COPD and other diseases. Non-compliance and the use of LTOT in immobile patients with advanced disease further complicate the issue.

Recommendations

The following recommendations are believed to be reasonable at the present time:

1. Good laboratory double-blind tests of walking ability and dyspnoea are essential to select patients who benefit from portable oxygen.
2. A system should be devised for replacement of liquid or gaseous portable units (full for empty) perhaps through O_2 contracting companies or chemists for the few patients who benefit substantially and will use the equipment.
3. Long-term domiciliary oxygen (LTOT) should be delivered for hypoxaemic COPD patients by concentrators, being the most convenient and economical method.

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Traitement par l'oxygène à domicile: oxygène liquide ou concentrateur? P. Howard, R. de Haller.

RÉSUMÉ: Un petit nombre de sujets hypoxémiques, et encore moins de sujets non hypoxémiques, atteints de maladie pulmonaire chronique obstructive, bénéficient de l'oxygène de dèambulation. Pour ce petit nombre de sujets, sélectés par des tests en double aveugle avec l'air comprimé, l'oxygène liquide pourrait sembler plus pratique et plus efficace. Le coût supplémentaire du traitement de tous les sujets COPD hypoxémiques au moyen d'oxygène liquide, en remplacement du concentrateur d'oxygène, n'est pas justifié sur la base de nos connaissances actuelles.

L'application des différents systèmes d'administration

de l'oxygène aux patients BPCO exige plus d'evaluation. La sélection des patients pour le traitement au long cours à l'oxygène représente toujours de difficultés majeures, qui se reflètent sur le nombre de patients susceptibles de bénéficier d'oxygène portable. Aucune étude n'a encore démontré les avantages du traitement au long cours par l'oxygène chez les sujets en insuffisance respiratoire atteints de maladies autres que les BPCO, comme par exemple la fibrose pulmonaire. Puisque la physiopathologie est tout à fait différente, l'élargissement de l'utilisation de l'oxygénothérapie au long cours et de l'oxygène portable à des patients non atteints de BPCO doit être abordé avec une grande prudence.

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