Survey on domiciliary oxygen by concentrator in England and Wales

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ABSTRACT: Long-term oxygen therapy is initiated in England and Wales by the patient's family doctor, sometimes at the request of a hospital consultant. Guidelines for therapy exist but are not mandatory. We wished to investigate the numbers and types of patients being treated under this regimen, the method of treatment and how they responded to their oxygen dose.

We therefore interviewed and tested patients at the inception of therapy in six of the nine prescribing areas of the whole country, during August 1990 and February 1991. Main outcome measures were diagnoses, daily duration and flow prescribed, arterial oxygen saturation (SaO2) breathing air and improvement in arterial oxygen saturation on prescribed oxygen.

Most patients both in summer and winter reported diagnoses of chronic bronchitis (45%) or emphysema (50%), in addition to other conditions. Most were male (58%), and most (72%) were over retirement age. Roughly half (45%) were house-bound, but only 28 (6%) were totally bedridden. Three quarters (77%) reported that a hospital consultant had told them how much oxygen to use, and in all diagnostic groups mean prescriptions exceeded 15 h·day⁻¹ and 2 l·min⁻¹. However, only half (54%) of the patients with complete measurements had basal arterial oxygen saturation of 90% or less at the start of treatment, together with a satisfactory improvement in arterial oxygen saturation on the prescribed flow of oxygen.

In conclusion, patients are usually prescribed adequate regimens but little attempt is made to ensure that prescription is appropriate or response satisfactory. Resources continue to be used for treating patients without ensuring that they benefit. Supervision of patients after concentrator installation should be centrally funded.

Long-term domiciliary oxygen therapy (LTOT) was introduced in England and Wales in 1985. It was intended to provide low flow oxygen supplementation throughout the night and substantial parts of the day to hypoxaemic patients with chronic obstructive pulmonary disease (COPD). As the service was provided in the domiciliary situation, the patient's family doctor was given the responsibility for prescription. Physiological parameters requiring consultant referral were included in guidelines for prescription, but these were not mandatory. Arterial oxygen tension (PaO2) breathing air at rest had to be consistently below 7.3 kPa (55 mmHg) in the presence of defined airways obstruction to qualify for treatment [1]. In such patients, an improvement in survival was observed in two large studies [2, 3].

It was perhaps foreseeable that, despite the very limited diagnostic categories shown to benefit from LTOT, once the service became generally available, all categories of hypoxaemic patients, whether of respiratory or cardiac origin, would be treated. The provision of oxygen now costs more than £18 million annually [4] in the UK, with provision of cylinders by community pharmacy responsible for the bulk of the costs.

The purpose of the present study was to assess the appropriateness of LTOT prescription in terms of known benefits, and to establish the types of patients being prescribed LTOT.

Methods

In six of the nine prescription areas of England and Wales, as defined by the Department of Health (DoH) in 1985, each prescription for an oxygen concentrator to be installed during the months of August 1990 and February 1991 triggered a letter to the patient's general practitioner (GP) enclosing a short questionnaire asking for the patient's blood gas values, if known, and a clinical diagnosis. If more than one diagnosis was given, a primary diagnosis was allocated. This was taken to be respiratory failure (cor pulmonale) (if mentioned at all), then fibrosis (so long as respiratory failure was not
mentioned) or emphysema (so long as neither respiratory failure nor fibrosis was mentioned), or COPD (none of the other three mentioned), or "other". If only blood gas data were recorded, then a PaO₂ of ≤7.3 kPa together with an arterial carbon dioxide tension (PaCO₂) of ≥6.1 kPa was taken as suggestive of respiratory failure, and a PaO₂ of >9 kPa and a PaCO₂ of <4.8 kPa in patients over the age of 50 yrs was categorized with emphysema.

A home visit was made by a nurse from the concentrator company within 7 days of equipment installation, or within 7 days of the patient arriving home from hospital. The nurse measured oxygen saturation by pulse oximetry, where possible both on air and on the prescribed flow rate of oxygen. The patient breathed room air or the appropriate oxygen enrichment for at least 30 min before the measurement was made. The patient was also asked to complete a short, verbally-administered questionnaire about symptoms, therapy and knowledge of the oxygen prescription. The patient was shown a list of 13 diagnoses and asked whether he/she believed any applied to him/her. These patient-reported diagnoses have been categorized in the same way as those reported by the GP.

To report response to oxygen as prescribed, we derived a formula to compare actual response to "ideal" response (i.e. an SaO₂ of 97%).

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\text{[SaO₂ improvement ÷ (97% - SaO₂ on air)]} \times 100
\]

This is referred to as % improvement SaO₂. According to the oxygen dissociation curve, blood with a PaO₂ of 7.3 kPa and an [H⁺] of 30 nmol·l⁻¹ (pH 7.50) would have a SaO₂ of 83.5%, whereas if the [H⁺] is 50 nmol·l⁻¹ (pH 7.30) the SaO₂ should be 90.5%. An SaO₂ on air of 90% or below was considered to be in accord with the prescription guideline that PaO₂ should be ≤7.3 kPa. In response to oxygen, we expected that the minimum benefit should be an improvement of 30% in SaO₂ (equivalent to an increase from 7.3 to 8.0 kPa.) We have, thus, used 90.5% at rest breathing air as the point above which a prescription for LTOT becomes inappropriate, and 30% as the point below which the change with treatment becomes unacceptably low.

Comparisons of categorical and grouped data were made using Chi-squared tests, and mean blood gas values compared using Student’s t-test or analyses of variance as appropriate. The values of the respective Chi-squared, Student’s t-test and analysis of variance (F) statistics and their associated degrees of freedom (df) are reported in the text, together with the associated p-value.

Results

Diagnostic conditions

During the two study months, 649 GP prescriptions were issued but only 477 LTOT installations were made, as some patients were still in hospital, had died, or had improved spontaneously before the end of the study month, and had, therefore, not required the installation.

All the patients were visited at home by a nurse. Their self-reported diagnoses were predominantly bronchitis and emphysema. These diagnoses were equally frequent in summer and winter, though others, such as lung fibrosis, were significantly more common in the summer (χ² = 7.7; p<0.01) (table 1).

The GPs of 353 of the 476 patients responded to our enquiry, but only 169 patients had at least one diagnosis reported by their GP, and these included "hospital says patient will benefit from oxygen" and "increasing cylinder use". A broad category diagnosis was derived for a further 51 patients from blood gas data supplied by the GP. The GP and patient derived diagnoses agree completely in 97 (48%) of the 202 patients for whom both were available. This agreement was as good as might have been expected, since there were differences between GP and consultant diagnoses, blood gas data were used to help derive the GP diagnoses, and there were multiple diagnoses for some patients. We have used the patients' own reported diagnoses in subsequent analyses.

The patients

Males (58%) were just in the majority, and most of the males (70%) and females (77%) were over the UK statutory ages for retirement from work (60 yrs for women and 65 yrs for men). There were 12 children in the sample under working age, with six of these under 1 year old. Of the 115 patients known to be of working age, only 10 (9%) were in work, though most of the remainder claimed that they were not housebound. In the whole sample, 45% were housebound. Most of these were able to get up and about for some part of the day, but 28 patients (6% of the whole sample) were bedridden.
at all times. A further 36% could not leave the house as often as they liked, nearly always citing a breathing problem as the reason. Transport and other disabilities were also mentioned. Sixty patients (13%) were current smokers, and 300 (64%) were former smokers at the time of their interview. Three quarters of all patients were severely disabled by breathlessness (breathless when walking a few metres on the level at their own pace). Two thirds of all patients reported ankle swelling; even 59% of the fibrotic patients experienced this symptom.

Prescriptions

Three quarters of the patients (77%) reported that a hospital consultant had told them how much oxygen they should be taking. The patients who had been informed by their GP were generally older, more often male, and more breathless; and, although the prescriptions were similar in terms of oxygen flow, there was some evidence that the GP-initiated prescriptions were for shorter daily durations (t=1.99; df=428; p=0.05) (table 2).

Most patients (89%) were supplied with nasal cannulae, and a few (7%) with a mask, or both (3%). Surprisingly, this was according to the patient's preference and not the prescription. Amongst 418 patients who answered questions about supplementary oxygen cylinder use, 60 patients responded positively; claiming a total use of 75 extra cylinders per week. Half of these were probably appropriate, being for use outside the home where the concentrator was installed or to fill a portable cylinder, but the remainder, which were used inside the home or for running a nebulizer, were of dubious value.

There were few differences between diagnostic groups in their prescriptions (table 3). The patients in the sample with fibrosis were prescribed oxygen for the longest period of each day, on average, but the differences between diagnostic groups were not significant (F=1.04; DOMICILIARY OXYGEN CONCENTRATORS IN UK 2023

Table 2. – Oxygen prescriptions and patient characteristics by source of information

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>GP (n=100)</th>
<th>Hospital doctor (n=340)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest disease</td>
<td>Other disease</td>
<td></td>
</tr>
<tr>
<td>n=83</td>
<td>n=17</td>
<td>n=259</td>
</tr>
<tr>
<td>Breathlessness on walking a few yards on the level at own pace %</td>
<td>84</td>
<td>87</td>
</tr>
<tr>
<td>Age ≥75 yrs %</td>
<td>39</td>
<td>50</td>
</tr>
<tr>
<td>Sex male %</td>
<td>65</td>
<td>71</td>
</tr>
<tr>
<td>Oxygen prescription</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow l·min⁻¹</td>
<td>2.3±0.91 (1.0–5.0)</td>
<td>2.2±0.49 (1.5–4.0)</td>
</tr>
<tr>
<td>Duration h·day⁻¹</td>
<td>15.4±4.83 (8–24)</td>
<td>13.8±5.28 (8–24)</td>
</tr>
</tbody>
</table>

Data for oxygen prescription are presented as mean±SD, and range in parenthesis. GP: general practitioner.

Table 3. – Oxygen prescription and response

<table>
<thead>
<tr>
<th>Respiratory failure (cor pulmonale)</th>
<th>Fibrosis</th>
<th>Emphysema</th>
<th>COPD</th>
<th>Other</th>
<th>No reported diagnosis</th>
<th>All groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescribed flow* l·min⁻¹</td>
<td>2.1 (0.6)</td>
<td>2.6 (1.3)</td>
<td>2.1 (0.7)</td>
<td>2.2 (0.8)</td>
<td>2.2 (1.0)</td>
<td>2.1 (0.6)</td>
</tr>
<tr>
<td>n</td>
<td>21</td>
<td>37</td>
<td>201</td>
<td>103</td>
<td>61</td>
<td>39</td>
</tr>
<tr>
<td>Prescribed duration* h</td>
<td>15.2 (3.7)</td>
<td>17.3 (6.0)</td>
<td>15.9 (3.9)</td>
<td>15.6 (3.9)</td>
<td>15.7 (5.3)</td>
<td>15.4 (3.8)</td>
</tr>
<tr>
<td>n</td>
<td>21</td>
<td>26</td>
<td>201</td>
<td>103</td>
<td>61</td>
<td>37</td>
</tr>
<tr>
<td>Extremely breathless† %</td>
<td>82</td>
<td>87</td>
<td>81</td>
<td>77</td>
<td>69</td>
<td>76</td>
</tr>
<tr>
<td>n</td>
<td>22</td>
<td>37</td>
<td>202</td>
<td>101</td>
<td>52</td>
<td>41</td>
</tr>
<tr>
<td>Some oedema %</td>
<td>77</td>
<td>59</td>
<td>73</td>
<td>69</td>
<td>53</td>
<td>72</td>
</tr>
<tr>
<td>n</td>
<td>22</td>
<td>37</td>
<td>203</td>
<td>106</td>
<td>60</td>
<td>42</td>
</tr>
<tr>
<td>SaO₂ off O₂* %</td>
<td>89.5 (5.4)</td>
<td>86.0 (5.6)</td>
<td>88.2 (7.2)</td>
<td>88.7 (6.0)</td>
<td>87.6 (7.9)</td>
<td>86.6 (6.3)</td>
</tr>
<tr>
<td>n</td>
<td>20</td>
<td>22</td>
<td>179</td>
<td>89</td>
<td>52</td>
<td>33</td>
</tr>
<tr>
<td>SaO₂ on O₂* %</td>
<td>91.2 (4.7)</td>
<td>92.0 (5.2)</td>
<td>92.9 (4.9)</td>
<td>93.1 (4.9)</td>
<td>91.2 (6.2)</td>
<td>92.2 (3.3)</td>
</tr>
<tr>
<td>n</td>
<td>13</td>
<td>27</td>
<td>130</td>
<td>64</td>
<td>40</td>
<td>29</td>
</tr>
</tbody>
</table>

*: data presented as mean and SD in parenthesis. †: breathless when walking on level at own pace. COPD: chronic obstructive pulmonary disease; SaO₂: arterial oxygen saturation.
Differences in the flow of oxygen prescribed were significant ($F=2.75; \ df=5,456; \ p=0.02$) and again showed the largest prescriptions in the fibrotic patients. There was considerable variation within groups, with many patients prescribed oxygen for an inadequate period each day and possibly at inappropriate flow rates.

A detailed analysis of individual patient response to oxygen is shown in figure 1, which compares basal SaO$_2$ breathing air with response to oxygen as prescribed. Of the patients having both measurements, only half (128 (54%)) fall in the top left quadrant, having a basal SaO$_2$ of 90% or less and an improvement of SaO$_2$ of more than 30% of the predicted maximal improvement on oxygen. In the lower left quadrant of the diagram there were 17 (7%) patients. These were desaturated and had inadequate response to the prescribed flow rate. Most patients in the right hand quadrants (92 (38%)) improved fully to an SaO$_2$ of 97% but were insufficiently desaturated at rest for current guidelines of therapy. These are surprising findings, considering that the measurements were made within only one week of concentrator installation.

Over 80% of patients in each of the diagnostic groups responded satisfactorily to oxygen therapy (table 4). All the patients with fibrosis responded appropriately, in line with the higher flow rates given to this group. Many patients, particularly those with self-reported obstructive airways disease, had basal SaO$_2$ values over 90%. There was a significant positive correlation (Spearman's rank correlation, $rs=0.264; \ p<0.001$) between flow rate and improvement in SaO$_2$ over the whole group.

**Discussion**

Long-term domiciliary oxygen therapy improves survival in hypoaemic COPD [2, 3]. No data are available for other hypoaemic chest diseases. The oxygen concentrator scheme is being used for all hypoaemic and, in some instances, normoaemic patients with chronic chest disease. There are significant numbers of patients with "other" conditions, presumably falling into the category of preterminal respiratory failure due to any cause. The patient profile in this study was quite different from those studied in the Medical Research Council oxygen studies [2] on which prescription guidelines were written. The cost-effectiveness of LTOT needs to be re-evaluated in longer term studies in a wider group of patients.

The majority of patients studied were limited by their disease, many were totally housebound and a small
proportion was bedridden. Patients who cite only breathing problems as the reason for not leaving the house might be expected to benefit from portable oxygen. In our experience of testing this type of patient, only a small percentage achieve benefit [5].

General practitioners and consultants appear to be using the service diagnostically and therapeutically in much the same way. This probably reflects better consultation, and is clearly an improvement on earlier findings [6, 7]. It is interesting that so many patients with fibrosis report ankle swelling, suggesting that it may have been used as a selection criterion for therapy. The mean oxygen flow rates and hours of oxygen prescribed are now in broad agreement with the guidelines. However, standard deviations are wide, indicating that many patients remain inadequately treated.

It is surprising to find a small number of patients use both an oxygen concentrator and a cylinder supply over and above the single cylinder that is sometimes prescribed for emergency back-up for the concentrator. In the country as a whole, the prescription of oxygen cylinders continues to rise, and there is no evidence to suggest that concentrators have substituted for cylinders [4].

Previous studies have suggested that occasional cylinders are prescribed more to treat breathlessness than hypoxaemia [8, 9], but benefits need to be carefully measured before prescription of oxygen [9].

One third of the patients were not sufficiently hypoxaemic according to the prescription guidelines, when assessed in the daytime by pulse oximetry within one week of prescription. Resting PaO₂ is seen to be a highly variable physiological parameter. It has been shown that after an acute exacerbation of hypoxaemic COPD, improvement of PaO₂ can occur for up to four months [10]. There is no information as to whether patients with mild fluctuating hypoxaemia would eventually become permanently seriously hypoxaemic, or whether oxygen therapy could prevent such progression. Until such studies are performed, the benefits of treatment in such patients are doubtful. The data suggest that prescriptions are often written with the patients in a highly unstable phase of their disease. Concentrators should probably be removed after 3 months if PaO₂ remains consistently above 8.6 kPa (65 mmHg).

Despite the incidence of significant disability which we observed, there was no organized home support from the family doctors, the hospital or the social services. These were only provided on an ad hoc basis, with no specific funding. The only specific support for the patients studied was through the concentrator company nurses, who are not funded within the terms of the contract.

The oxygen concentrator service has developed without proper home care support, and this situation needs to be remedied. No attempt is being made to monitor the suitability or progress of patients on their equipment at home. The Department of Health currently funds the service in four ways: 1) installation of the equipment; 2) three monthly planned preventative maintenance and electricity cost reimbursements; 3) machine removal; and 4) oxygen back-up for those patients considered by doctors to be in need. Patient supervision should be included in section (2).

It is predicted that home monitoring to include pulse oximetry will yield the following benefits: a) removal of machines from normoxaemic individuals inadvertently prescribed; b) early removal of machines from patients temporarily hypoxaemic who recover to normoxaemia; c) better oxygenation on long-term treatment for those who need it; and d) clearer assessment of the need and use of portable oxygen. The savings from closer home monitoring are predicted to at least pay for themselves by avoidance of useless therapy. However, any removal of machines must be accompanied by close follow-up.

England and Wales is one of the remaining areas of Europe not to be setting up a register of home oxygen patients to facilitate proper monitoring. A register is recommended. The contracting company system is generally working well. The suppliers should now be financed to provide a complete service, to include at least pulse oximetry and, possibly, other simple physiological measurements, with formal reporting to general practitioner and respiratory consultant.

References