A conservation device for oxygen therapy in COPD

T.W. Evans, J.C. Waterhouse, A.J. Suggett, P. Howard*


ABSTRACT: Patients with hypoxaeemia secondary to chronic obstructive pulmonary disease (COPD) are frequently prescribed oxygen therapy for short- and long-term domiciliary use. Oxygen administered via nasal cannulae incorporating a small collapsible reservoir ("Oxymlzer", Chad Therapeutics Inc., CA, USA) improves transcutaneous oxygen tensions in the short-term when compared to standard nasal cannulae. The effects of this device on arterial oxygen (Pao2) and carbon dioxide (Paco2) tensions was assessed over 60 min in twelve patients with severe hypoxaeemia (6.2±0.9 kPa, mean±SD) and hypercapnia (7.5±1.2 kPa). Following baseline measurements, oxygen was administered using standard nasal cannulae, and further measurements were made at 15 min intervals for at least 45 min. Patients were then changed to the "Oxymlzer" and measurements continued at 15 min intervals for a further 60 min. Mean Pao2 increased by 1.1±0.78 kPa (p<0.001), using the "Oxymlzer", but Pao2 was significantly greater after 15 min on the device than after 60 min (p<0.05). There was no change in Paco2 (p>0.05). The "Oxymlzer" increases Pao2 compared with standard cannulae, but the effect may not be sustained.

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Patients with hypoxaeemia secondary to chronic obstructive pulmonary disease (COPD) frequently require oxygen for domiciliary use [1, 2]. Short bursts of oxygen therapy administered from cylinders may be prescribed for the relief of exercise-induced breathlessness [3]. Long-term, low-flow oxygen administered from cylinders, liquid gas systems, or oxygen concentrators for at least 15 h per day is the only therapy known to reduce mortality in patients with hypoxic cor pulmonale secondary to COPD [4, 5]. In either case, oxygen is conventionally administered using nasal speculae (fig. 1A).

The use of nasal cannulae incorporating a small collapsible reservoir ("Oxymlzer", Chad Therapeutics Inc., CA, USA; fig. 1B), has been shown to increase transcutaneous oxygen tension or saturation during short study periods, suggesting that considerable savings in oxygen consumption may be made [6, 7]. No comparison of these devices has been made over longer study periods assessing the effects on both arterial oxygen (Pao2) and carbon dioxide (Paco2) tensions. We therefore compared the effects of the "Oxymlzer" with standard cannulae on arterial gas tensions over a 60 min period in twelve patients with severe COPD.

Methods

In order that the device could be assessed in patients fully accustomed to the long-term use of nasal cannulae, subjects were taken from our domiciliary oxygen programme in which they had been involved for a minimum of twelve months. Entry criteria therefore included clinical and physiological evidence of severe, irreversible COPD and either chronic hypoxaeemia (Pao2 less than 7 kPa on repeated measurements) requiring the provision of domiciliary oxygen therapy for at least 15 h per day [4]; or the use of short bursts of oxygen for at least 1 h per day for the relief of breathlessness [3]. Consequently, twelve patients (eight males, four females; mean age 64 yrs, range 55–74 yrs) with COPD, forced expiratory volume in one second (FEV1) 0.63±0.19 l, mean±SD; forced vital capacity (FVC) 1.50±0.45 l, entered the trial. All had severe hypoxaeemia (Pao2 on air 6.1±0.9 kPa, mean±SD) and variable hypercapnia (7.5±1.2 kPa). Ten were taking domiciliary oxygen therapy via standard nasal cannulae for at least 15 h per day and two short burst therapy.

On the day of the trial spirometry was checked (Micro Medical Instruments, UK). A radial artery cannula was inserted under local anaesthetic. All blood samples were drawn into heparinized glass syringes and analysed immediately (Corning 170 instrument, Corning Medical and Scientific Inc., Mass., USA). Following baseline measurements, oxygen (1 l/min) was administered using standard cannulae for at least 45 min. No instructions were given to subjects regarding ventilation in order that they should adopt their customary breathing pattern. Furthermore, the investigation was always carried out in the morning, and reading or the watching of television was encouraged to avoid somnolence. Further measurements

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of arterial gas tensions were made every 15 min until two successive results for PaO₂ and PaCO₂ were obtained within limits of 0.5 kPa. Patients were then changed to the conservation device at identical oxygen flow and arterial gas analysis was carried out every 15 min for at least a further 60 min (until successive gas tensions were within 0.5 kPa).

Using Wilcoxon’s signed rank procedure, statistical comparisons were made between mean results for PaO₂ and PaCO₂ at oxygen flow rates of 1 l·min⁻¹ using standard cannulae, 1 l·min⁻¹ using the conservation device for 15 min, and the final measurement using the conservation device. Values of p less than 0.05 were considered significant.

Results

Arterial gas tensions for each patient on oxygen using standard cannulae (mean of four measurements for each patient) and using the “Oxymizer” (all values) are shown.
Clinic Hypercapnia during oxygen therapy in air and the conservation device have little effect on gas changing to mouth breathing in longer term with a device, a significant rise in $P_{aco_2}$ (p<0.05). The changes in $P_{aco_2}$ were not significant.

Table 1. - $P_{ao_2}$ and $P_{aco_2}$ (kPa, mean±SD) for twelve subjects given oxygen via standard cannulae and the conservation device.

<table>
<thead>
<tr>
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<th>$P_{ao_2}$ kPa</th>
<th>$P_{aco_2}$ kPa</th>
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<tbody>
<tr>
<td>Standard cannulae</td>
<td>7.80±1.66</td>
<td>7.83±1.24</td>
</tr>
<tr>
<td>Conservation device</td>
<td>9.25±1.64</td>
<td>7.74±1.53</td>
</tr>
<tr>
<td>Conservation device for 15 min</td>
<td>8.65±1.64</td>
<td>7.87±1.47</td>
</tr>
</tbody>
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*: p<0.05; **: p<0.01. Values for $P_{aco_2}$ were not significantly different.

Discussion

In agreement with previous short-term studies [6, 7] the conservation device significantly increased $P_{ao_2}$ for the group as a whole compared with standard nasal cannulae. The oxygen reservoir incorporated in the "Oxymizer" fills with gas from the source during expiration and empties at the onset of inspiration, delivering the stored oxygen as a bolus. At low oxygen flow rates the reservoir may not fill. At high flow rates only a small fraction of the total gas delivered forms of the oxygen bolus and the device may be less efficient. Previous studies have shown variation in the efficiency of the device between patients but no correlation studies have shown variation in the efficiency of the spirometry [6]. Mechanical interference with basal breathing due to the bulk of the oxymizer might have resulted in patients changing to mouth breathing in the longer term with a consequent reduction in $P_{ao_2}$, but other studies have indicated that altered patterns of ventilation in the form of mouth or nasal breathing using both nasal cannulae and the conservation device have little effect on gas analysis [9]. It might be expected that the additional bolus of oxygen delivered would cause a deterioration in ventilation/perfusion (V/Q) matching, as hypoxic vaso-constriction is relieved and areas of unventilated lung become perfused. In these circumstances $P_{ao_2}$ would rise temporarily and then fall as seen in our study. In a recent review of the subject, STRADLING concluded that patients with COPD given oxygen therapy fail to show an effect of raising inspired oxygen concentration that is large enough to adversely effect $P_{aco_2}$; this further supports our findings [8]. Whatever the explanation, it seems that longer term studies, using these devices in domiciliary circumstances, need to be undertaken. Clearly their role in conserving gas will be most significant in patients using oxygen cylinders or liquid gas systems, although their use in combination with oxygen concentrators could facilitate oxygen delivery at lower flow rates.

References


Un appareil de conservation pour oxygénothérapie aux BPCO. T.W. Evans, J.C. Waterhouse, A.J. Suggett, P. Howard. RÉSUME : Une oxygénothérapie est fréquemment prescrite pour des patients dont l'hypoxémie est secondaire aux BPCO, que ce soit pour des traitements brefs ou prolongés au domicile. L'oxygène administré par des canules nasales incorporant un petit réservoir collabore ("Oxymizer", Chad Therapeutics Inc., CA, USA), améliore les pressions d'oxygène transcutantes dans l'intégralité quand on les compare aux canules standards. Les effets de cet appareil sur la $P_{ao_2}$ et la $P_{aco_2}$ ont été étudiés pendant une période de 60 minutes chez 12 patients atteints d'hypoxémie sévère ($6,2±0,9$ kPa). Après les mesures initiales de la $P_{ao_2}$ et de la $P_{aco_2}$, l'oxygène a été administré par une canule nasale standard, et des mesures ultérieures ont été réalisées à des intervalles de 15 minutes pendant au moins 45 minutes. Les patients ont été placés ensuite sous "Oxymizer", et les mesures ont été poursuivies pendant 60 minutes de plus à des intervalles de 15 minutes. La $P_{ao_2}$ moyenne a augmenté sous l'effet de l'"Oxymizer" de 1.1±0.78 kPa (p<0.01), mais la $P_{aco_2}$ mesurée après 15 minutes s'avérait significativement plus élevée que celle mesurée après 60 minutes (p<0.05). On n'a pas noté de modification de la $P_{aco_2}$ (p>0.05). L'"Oxymizer" augmente donc la $P_{ao_2}$ par comparaison avec les canules standards chez les patients nécessitant de l'oxygène pour la correction d'une hypoxémie sévère, mais son effet peut être peu persistent.