Eur Respir J
1989, 2, 280–282

TECHNICAL NOTE

Insufficient oxygen concentration obtained at domiciliary controls of eighteen concentrators

J.P. Bongard, C. Pahud, R. De Haller

Insufficient oxygen concentration obtained at domiciliary controls of eighteen concentrators. J.P. Bongard, C. Pahud, R. De Haller.

ABSTRACT: The oxygen concentration (O_2%) produced by 12 type A concentrators, with a working time of 28–18,099 h, and 6 type B concentrators, with a working time of 0–3,033 h, was measured over a 12 month period in the user's home, at a flow rate of 2 $l \cdot min^{-1}$. One hundred and two measurements of O_2% (mean 82.9), made at least once monthly by a visiting nurse, showed that type A concentrators were usually delivering less than 92% expected O_2. Four concentrators were delivering less than 40% O_2 after a working time of only 4,000 h. Sixty two measurements made by the manufacturer confirmed these findings (mean 86.8). The 18 measurements performed by the nurse on the type B concentrators showed expected O_2% values (mean 93.1). Our study demonstrates the necessity of regular clinical and technical surveillance, at the user's home, during long-term domiciliary oxygen therapy and the need for the manufacturer to incorporate an alarm system monitoring the O_2% into oxygen concentrators.
Eur Respir J., 1989, 2, 280–282.

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Keywords: Oxygenotherapy; oxygen concentrators.

Accepted after revision October 14, 1988.

The benefits of long-term domiciliary oxygen therapy are well documented [1, 2]. Guidelines for indications and surveillance exist in several countries [3–5]. Oxygen should be given for at least 15 $h \cdot day^{-1}$ at a flow rate sufficient to ensure a saturation greater than 90%. Oxygen cylinders are costly and cumbersome and have been replaced by oxygen concentrators.

Our Centre is responsible for the supply and supervision of concentrators in the Canton of Geneva (pop. 300, 000), in collaboration with the family practitioners. We introduced domiciliary supervision of O_2 concentration in October 1985, following the discovery, by the manufacturer, of machines delivering severely deficient oxygen flows. This prospective study confirms the necessity for this type of domiciliary supervision.

Methods

The allocation of oxygen concentrators for long-term oxygen therapy, and their supervision at 1, 3 and every 6 months thereafter, according to the guidelines in force in Switzerland [5] are under the responsibility of our Centre. A nurse visits patients once or twice a month, checks the clinical state of the patient, the functioning of the concentrator and the time the concentrator has been in use. Since October, 1985, she has regularly measured the oxygen concentration (O_2%) delivered. Servicing is only performed at our request, by the respective manufacturers if less than 90% O_2 or another technical problem is noted.

Since April, 1983, 12 type A concentrators have been used, and have accumulated a working time ranging from 28–18,099 h. Since February, 1986, 6 type B concentrators have been used and have accumulated a working time of 0–3,033 h. The O_2% of all these machines was checked at least once a month from October, 1985, until October, 1986, using a Sedam D.001 mini O_2 analyser. The precision of 0.1% O_2 and the linearity of the response from 0–100% O_2 corresponds to that generally accepted [6]. It was recalibrated every 6 months and was always found to be stable. At the user's home, it was calibrated at 20.9%. All the measurements were taken at an altitude that varied by less than 100 m. The oximeter cell was changed every year. All measurements were performed at a flow rate of 2 $l \cdot min^{-1}$, after the concentrator had been working for at least 30 min. The oximeter was connected to the end of the machine tubing. The measurement of O_2% was taken after 10 min of stabilization. If the O_2% was less than 90%, a service was carried out by the manufacturer. The oximeter used by the manufacturer is identical to the one we used. On several occasions, O_2% was measured simultaneously by the manufacturer and ourselves. The results were always identical.

Statistics

The mean (M), the median, the minimum (min) and frequencies were calculated for all the O_2% measurements made on type A concentrators by our Centre (AC) and by the manufacturer. Similar values were computed for the type B concentrators.

Results

The mean O_2% measured on type A concentrators by our Centre (M 82.9; median 86; min 21; n=102) as well as those measured by the manufacturer (M 86.8; median 90.55; min 23; n=62) were significantly lower than the 92% generally required of this type of concentrator [6, 7].

Ninety five percent of the measurements were under this value. Less than 40% O_2 was found in four machines after working times of less than 4,000 h. Insufficient O_2% was measured several times on each of the 18 type A concentrators, at a working time from 28–18,099 h (fig. 1).

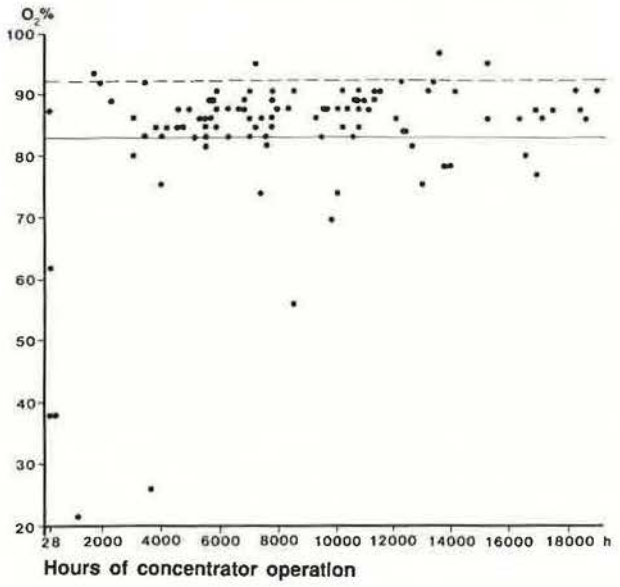

Fig. 1. – Oxygen concentration (O_2%) measured by our Centre on 102 type A concentrators (AC), working times from 28–18,099 h. The mean (full line) is 82.9%. The value from other studies (dotted line) is 92%.

Table 1. – Values of oxygen concentration

		Mean	SD	t-test
AC	(n=102)	82.91	12.27	NS
AM	(n=62)	86.79	12.97	
BC	(n=18)	93.11	2.64	p=0.04
AC3033	(n=10)	68.36	27.05	
BC	(n=18)	93.11	2.64	p=0.001
AM3033	(n=14)	81.09	23.14	
AC		82.91	12.27	p=0.001
BC		93.11	2.64	
AM		86.79	12.97	p=0.04
BC		93.11	2.64	

O_2%: oxygen concentration; AC, AM: O_2% measured by our Centre and manufacturer, respectively, type A concentrator working times from 0–18,099 h; BC: O_2% measured by our Centre, type B concentrator working times from 0–3,033 h; AC3033, AM3033: O_2% measured by our Centre and manufacturer, respectively, type A concentrator working times from 0–3,033 h; NS: Student's t-test not significant.

The mean O_2% of the type B concentrators was in the expected range (M 93.1; median 93.5; min 90.7; n=18). Seventeen percent of the measurements were under 92% O_2. These machines had working times of less than 3,033 h (table 1). Other measurements made on the type B concentrators after this study confirmed these values.

Discussion

This study shows that the type A concentrators in our hands were unreliable. Four machines delivered less than 40% O_2. The small difference between the O_2% measured by ourselves and that measured by the manufacturer is probably explained by the fact that the manufacturer made several of his measurements following technical servicing of the machines.

The type B concentrators produced an O_2% comparable to that generally obtained with this type of machine. No unsatisfactory equipment was discovered, but the working times of these machines were quite short. A longer term control is therefore required.

Knowing that other teams in other countries have experienced the same difficulties with other types of concentrators than the ones we used, the names of the apparatus tested here are not given. The results of this study obviously stress a general problem.

Several studies have investigated the function of molecular-sieve type oxygen concentrators similar to those we used. Fourteen concentrators were tested every 3 months for 1 yr, by a medical technician in a study by EVANS *et al.* [8]. After seventeen of 56 visits a machine had to be withdrawn to undergo servicing. Three machines were not producing an O_2% greater than 90% and in two of them the O_2% was less than 50%. JOHNS *et al.* [6] and GOULD *et al.* [7] tested 4 and 6 machines, respectively, in the laboratory. At a flow rate of 2 $l \cdot min^{-1}$, all the O_2% measured were higher than 92%. With these flow rates and O_2%, the mean O_2 saturation measured at the patients' ear was always greater than 90% [7]. In these three studies, the effective working times of the machines are not mentioned.

In the reference studies [1, 2], long-term oxygenotherapy was achieved with systems assumed to produce near 100% O_2. The flow rate administered by nasal prongs was chosen so as to increase the arterial oxygen tension (Pao_2) by more than 60 mmHg. It is difficult to estimate for each patient what the consequence of reducing O_2% will be on the Pao_2, as this depends on parameters susceptible to change as well as ventilation rate (VE), arterial carbon dioxide tension ($Paco_2$), cardiac output, arterial-alveolar oxygen tension difference ($P(A\text{-}a)o_2$). Clearly, the patients needing the higher flow rate will suffer greater decrease of Pao_2 on reducing the O_2%. With less than 40% O_2, it will be almost impossible to achieve an increase of 1 kPa (7.5 mmHg) of Pao_2.

Our patients did not notice any difference when their concentrators were insufficient. We have not noted any repercussions on their medical status at the routine checks, but we have not obtained gasometric controls at home when they received oxygenotherapy from their defective concentrators. Checking the O_2% at least monthly, the

O_2% will enable us to avoid a long-term effect of low O_2%.

If we measured less than 90% O_2, we asked the manufacturer to carry out a technical servicing. No constant technical failure was mentioned by the manufacturer.

In our study, measurements were made by the nurse in the user's home during routine visits. Measuring O_2% by non-technical personnel is thus possible. Our results prove that it is imperative that an alarm system monitoring O_2% should be incorporated into oxygen concentrators. Without an alarm, regular checks of O_2% are obviously necessary. The patients' confidence is more readily acquired when the gas checks are made by the health-care team, rather than being left to the manufacturer.

Acknowledgements: We are grateful to Dr P. Howard, Department of Medicine, University of Sheffield, Sheffield, UK, for revision of the manuscript.

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Concentration d'oxygène insuffisante obtenue lors de contrôles à domicile de dixhuit concentrateurs. J.P. Bongard, C. Pahud, R. De Haller.

RÉSUMÉ: La concentration d'oxygène (O_2%) produite par 12 concentrateurs de type A, après une utilisation de 28 à 18099 heures, et 6 concentrateurs de type B, après une utilisation de 0 à 3033 heures, a été mesurée à domicile à un débit de 2 $l \cdot min^{-1}$, sur une période de 12 mois. 102 mesures de O_2% (M=82,9) réalisées au moins une fois par mois par l'infirmière à domicile démontrent que les concentrateurs de type A produisent une concentration d'oxygène inférieure aux 92% attendus. Quatre concentrateurs produisaient moins de 40% O_2 après une utilisation de moins de 4000 heures. 62 mesures pratiquées par la firme elle-même confirment ces valeurs (M=86,8). Les 18 mesures pratiquées par l'infirmière à domicile sur les concentrateurs de type B montrent un O_2% conforme aux valeurs attendues (M=93,1). Notre étude montre la nécessité d'un contrôle clinique et technique régulier à domicile pendant l'oxygénothérapie au long cours et le besoin d'incorporer un système d'alarme contrôlant la concentration d'oxygène dans les concentrateurs.

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