OXYGEN SAVINGS WITH A NEW NASAL CANNULA

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SYNOPSIS

A new reservoir nasal cannula (RNC) (Oxymizer Chad Therapeutics Inc) which is claimed to deliver oxygen more efficiently than the standard nasal cannula (SNC) has recently been introduced. We evaluated the RNC in 11 patients (9 males) with hypoxaemic chronic lung disease (mean arterial oxygen saturation, SaO2, 82%; mean forced expired volume in the first second 0.52 L). SaO2 was measured noninvasively with a Biox III oximeter. Oxygen was delivered via the SNC at flow rates of 0.5, 1, 2, 2.5, 3 and 4 L/min and the RNC at flow rates of 0.5, 1, 2 and 2.5 L/min. Mean SaO2 values with the RNC were consistently higher when compared to the SNC at the corresponding flow rates: by 4.3%, 3.6%, 3.2% and 2.4% at flow rates of 0.5, 1, 2 and 2.5 L/min respectively. With the RNC, lower oxygen flow rates achieved equivalent SaO2 values to the SNC at the corresponding flow rates such that flow rates of 0.5, 1 and 2 L/min on the RNC were approximately equivalent to flow rates of 2, 3 and 4 L/min on the SNC. In a patient on long term domiciliary oxygen, this could mean a 50 to 80% reduction in his monthly oxygen bill.

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Two hallmark studies (1,2) have shown that long-term oxygen therapy improves survival and quality of life in patients with hypoxaemic chronic obstructive pulmonary disease. Despite these proven benefits, widespread use of domiciliary oxygen therapy is curbed by its expense. In Singapore, domiciliary use of oxygen from compressed gas in tanks costs a patient approximately $400 per month. A new reservoir oxygen cannula (RNC) (Oxymizer Chad Therapeutics) (see Figure 1) which is claimed to deliver oxygen more efficiently than the standard nasal cannula (SNC) has recently been introduced. At flow rates of 0.5 to 2 L/min using the RNC, the oxygen delivery was generally equivalent to using the SNC at 1 to 4 L/min (3, 4, 5) enabling considerable savings in oxygen usage. In another study however, the RNC did not appear to have any advantage over the SNC in 7 of the 12 patients assessed (6). We therefore evaluated the RNC in 11 patients with hypoxaemic chronic lung disease.

PATIENTS AND METHODS

We studied 11 patients (9 males) with hypoxaemia at rest (mean arterial oxygen saturation, SaO2, 82%). Ten had chronic obstructive lung disease and 1 had pulmonary fibrosis. All were clinically stable at the time of the study. Their mean age was 61±9.2 years, the mean FEV, 0.52±0.15 L,BTPS, and the mean VC a.38±0.51L,BTPS.

Fig. 1 The reservoir nasal cannula.

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TABLE 1
PATIENTS' DATA

No.	Race	Sex	Age	FEV[1]	VC
1.	CHI	M	74	0.55	1.31
2.	MAL	M	68	0.51	1.54
3.	CHI	F	57	0.52	1.20
4.	CHI	M	50	0.55	2.08
5.	CHI	M	55	0.60	2.20
6.	CHI	M	69	0.25	0.60
7.	CHI	F	77	0.44	0.82
8.	CHI	M	63	0.56	1.34
9.	CHI	M	60	0.84	0.85
10.	MAL	M	55	0.34	1.52
11.	CHI	M	51	0.55	1.73

Age is given in years.
FEV[1] — forced expired volume in the first second, L,BTPS.
VC — vital capacity L,BTPS.
CHI = Chinese, MAL = Malay, M = male, F = female

All studies were performed in the afternoon. The subjects assumed a comfortable position of their own choice, either seated or supine, but maintained that position throughout the study. SaO2 was measured noninvasively using a Biox III oximeter. After a minimum period of 30 minutes of air breathing, a baseline reading of SaO2 was recorded. Oxygen was then delivered via either the SNC at flow rates of 0.5, 1, 2, 2.5, 3 and 4 L/min, or the RNC at flow rates of 0.5, 1, 2 and 2.5 1/min. Each flow rate was maintained for 6 to 8 minutes to allow the SaO2 reading to stabilise before it was recorded. The patient then breathed air for at least 30 minutes for the SaO2 to return to the baseline level. The study was then repeated with the other nasal cannula. Statistical comparisons were made using the Wilcoxon's signed rank sum test for paired data. Differences were considered significant when the p value was less than 0.05.

We also compared the pendant cannula, another reservoir-type nasal cannula (see Figure 2), with the SNC on three of the patients (patient numbers 1, 4 and 10, Table 1) using the protocol described above.

RESULTS

The mean SaO2 baselines were 82.9±8.9% and 83±9.1% for the SNC and RNC respectively. At flow rates of 0.5, 1, 2, 2.5, 3 and 4 L/min using the SNC, the mean SaO2 values were 88.7±5.2, 90.5±5.2, 92.3±4.4, 93.8±3.7, 94.6±3.1 and 95.8±2.4 respectively. At flow rates of 0.5, 1, 2 and 2.5 L/min via the RNC, mean SaO2 values were 93±4.7($p=0.002$), 94.1 ± 3.8($p = 0.002$), 95.5 ± 3.4($p = 0.002$) and 96.2 ± 3.1 ($p = 0.002$) (see Table 2) (p values when compared with the SNC readings at the equivalent oxygen flow rates). Mean SaO2 values with the RNC were consistently higher when compared to the SNC at the corresponding flow rates: by 4.3%, 3.6%, 3.2% and 2.4% at flow rates of 0.5, 1, 2 and 2.5 L/min respectively. The mean SNC and RNC baseline respiratory rates were 25.3±8.1 and 25.2±8.6 per min respectively. The mean SNC and RNC baseline pulse rates were 99.7±14.6 and 98.6±14.6 respectively. The mean respiratory rates at oxygen flow rates of 0.5, 1, 2 and 2.5 L/min using the SNC were 21±8.6, 21.8±8.3, 21.4±12.3 and 22±8.3 per min respectively, and were not significantly different from the respiratory rates at the corresponding flow rates using the RNC: 22.2±8.2, 21.3±8.4, 20.6±9.4 and 20.9±6.5 per min at the flow rates of 0.5, 1, 2 and 2.5 L/min respectively. The mean pulse rates at the oxygen flow rates of 0.5, 1, 2 and 2.5 L/min were 94.8±15.2, 95.5±16.2, 93.8±16.2 and 94.2±15 per min respectively, and were not significantly different from the mean pulse rates at the corresponding flow rates using the RNC: 93.6±16.4, 92.3±14.9, 92.7±16.2 and 91.4±14.7 at the flow rates of 0.5, 1, 2 and 2.5 L/min respectively. To achieve a mean SaO2 of 90% in our patients, the oxygen flow rate required was <0.5 L/min with the RNC but 1 L/min using the SNC. Comparison of the SaO2-flow rate curves for the SNC and RNC allowed the estimation of equivalent flow rates (see Figure 3). Flow rates of 0.5, 1, 2 and 2.5 L/min on the RNC were equivalent to flow rates of 2.2, 2.7, 3.8 and > 4 L/min with the SNC (or: flow rates of 2, 3 and 4 L/min on the SNC were approximately equivalent to flow rates of 0.5, 1 and 2 L/min using the RNC). The pendant also showed similar savings in oxygen consumption so that a flow rate of 1 L/min with the pendant cannula was equivalent to 2 L/min with the SNC (see Figure 4).

TABLE 2
MEAN OXYGEN SATURATIONS AT VARIOUS OXYGEN FLOW RATES THROUGH EITHER THE SNC OR THE RNC

Flow Rate	SAO2 (SNC)	SAO2 (RNC)	P Value
0	82.9 ± 8.9	83 ± 9.1	NS
0.5	88.7 ± 5.2	93 ± 4.7	0.002
1	90.5 ± 5.2	94.1 ± 3.8	0.002
2	92.3 ± 4.4	95.5 ± 3.4	0.002
2.5	93.8 ± 3.7	96.2 ± 3.1	0.002
3	94.6 ± 3.1		
4	95.8 ± 2.4		

Oxygen flow rate in L/min.
SAO2 (SNC) = Oxygen saturation using the standard nasal cannula.
SAO2 (RNC) oxygen saturation using the reservoir nasal cannula.
NS = not significant.
P value from Wilcoxon's signed rank sum test for paired data.

DISCUSSION

Oxygen flow through the SNC continues during the expiratory phase and is therefore partly wasted. The RNC consists of a highly compliant collapsible sac, about 20 mls in volume. attached close to the nasal outflow prongs (see Figure 5). The sac is placed within a vented plastic casing to protect the sac from overexpansion. During the expiratory phase, positive nasal pressure stops 02 flow at the cannula tips and 02 collects in the sac. Depending on the expiratory time and the 02 flow rate, oxygen may fill up the 20 ml reservoir before overflowing out through the cannula tips. Expiratory phase 02 wastage is thus minimised. With the next inspiration, this 20 ml bolus of 02, being close to the outlet, will form part of the initial inspirate, and thus have better access to the alveolar space. The efficiency of the RNC is dependent on the patient's pattern of breathing, dead space and the 02 flow rate.

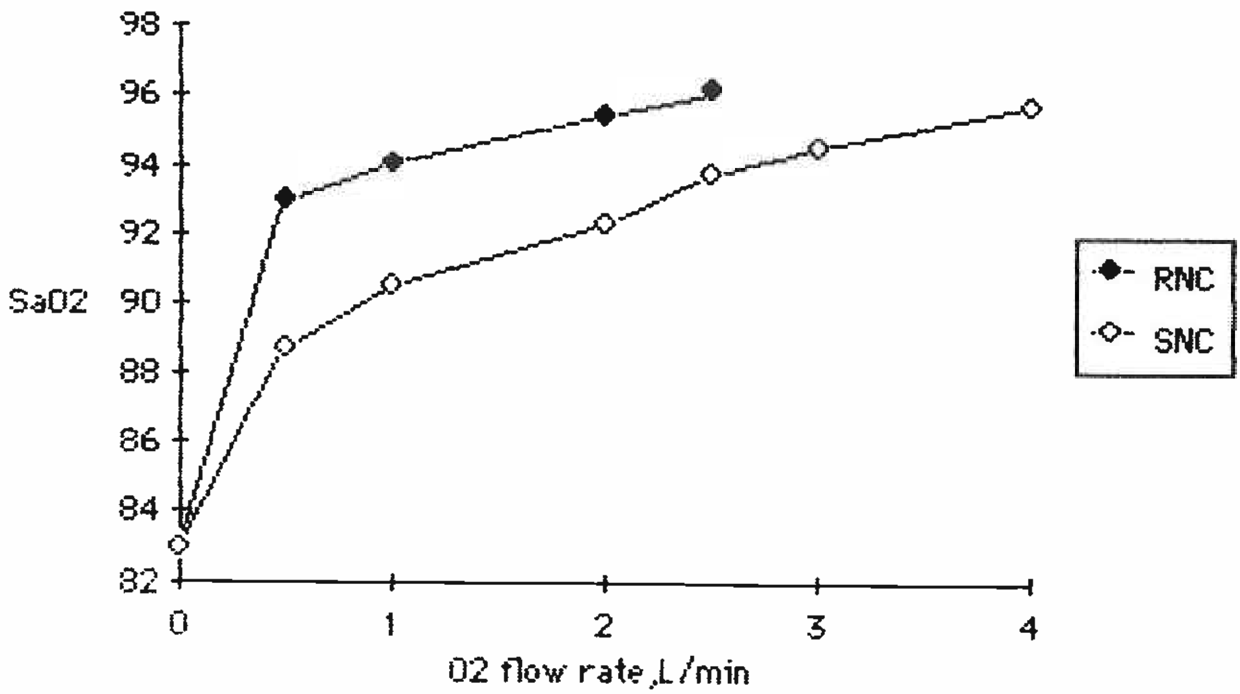

Fig. 3 Mean oxygen saturation values, SaO2, of the 11 patients at various oxygen flow rates through the standard nasal cannula (SNC) and reservoir nasal cannula (RNC). Mean SaO2 was always higher with the RNC than the SNC at all the equivalent flow rates.

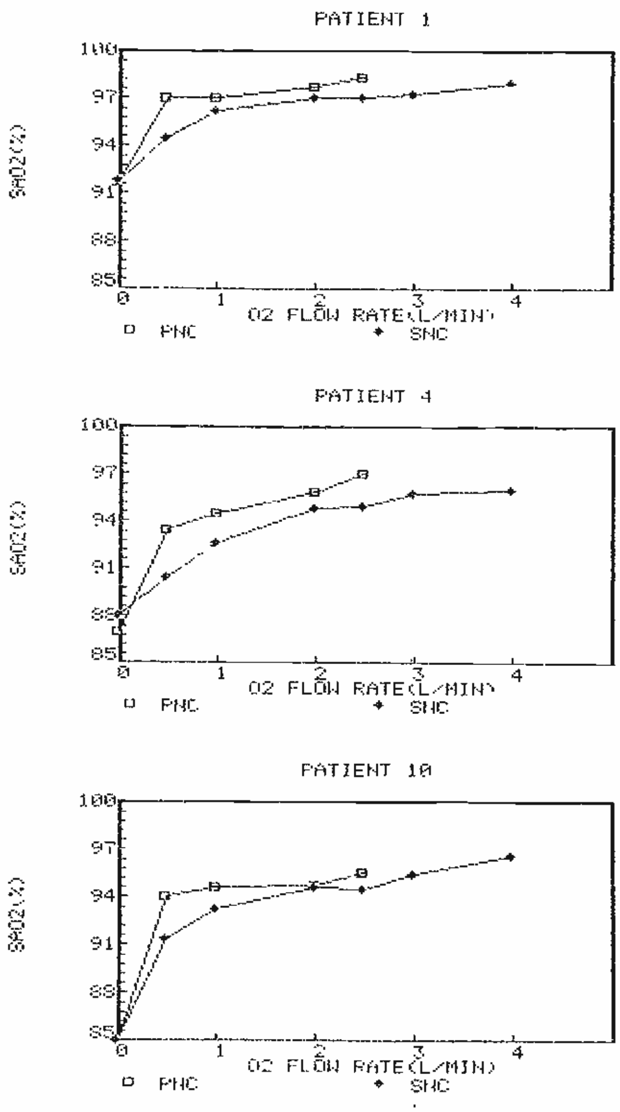

Fig. 4 Oxygen saturation values, SaO2, of 3 patients at different oxygen flow rates through the standard nasal cannula (SNC) and the pendant nasal cannula (PNC). In all three patients, the SaO2 was higher with the PNC than the SNC at equivalent oxygen flow rates.

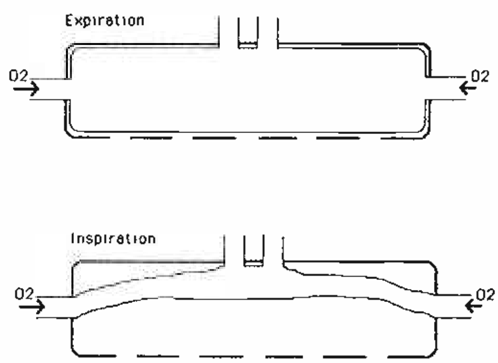

Fig. 5 Diagrammatic representation of the reservoir nasal cannula. During expiration (top), positive nasal pressure prevents oxygen overflow through the cannula tips and oxygen accumulates in the sac. The sac is housed within a vented plastic casing to protect it from overdistension. During inspiration (bottom), the 20 ml bolus of oxygen is inhaled and the sac collapses and thereafter functions as a conduit.

A prolonged expiratory time allows the reservoir to fill and 02 to overflow during expiration. With a shallow tidal volume and an increased dead space, part of the 02 bolus may not gain access to the alveolar space. At higher flow rates (2–2.5 L/min), the reservoir fills up rapidly during expiration and overflow is more likely to occur. At even higher flow rates (> 3 L/min), the reservoir may not afford any advantage and may in fact function just as a conduit. Indeed, in one patient the reservoir remained distended even during inspiration when the oxygen flow rate was transiently increased to 4 L/min.

We have shown that in our patients, the RNC was more efficient than the SNC in delivering oxygen. The results were similar with the pendant cannula, although only three patients were studied. The savings could be as much as 70–80% at the low flow rates and about 50% at the higher rates. In an individual patient, this could mean a reduction in the monthly oxygen bill to $150–200 per month. This will be slightly offset by the cost of the RNC which the manufacturers advise should be changed every two weeks. With the reduced cost, more patients could then benefit from long-term domiciliary oxygen therapy. Despite its bulky appearance, most of the patients did not mind using the RNC and four actually preferred it. Those who find the RNC uncomfortably large may opt for the pendant nasal cannula instead. Using the RNC at half the SNC flow rates will enable portable oxygen cylinders to last twice as long. This may encourage these usually home-bound patients to go outdoors more often.

Our study was confined to stable patients so that any differences in 02 delivery between the RNC and SNC would less likely be attributed to changes in the gas exchange status of the patients. The similar baseline respiratory and pulse rates for both the SNC and RNC studies indirectly confirms that our patients were clinically stable. As we did not monitor the arterial CO2 tension nor the ventilation, we cannot exclude the possibility that a different ventilatory pattern may account for the better oxygenation with the RNC. However, the respiratory rates (and the pulse rates) were not significantly different at the equivalent oxygen flow rates on the SNC and RNC. It would seem likely that the better oxygenation of the patients was due to the use of the RNC itself.

Fig. 2 The pendant nasal cannula.

REFERENCES

1. Medical Research Council Working Party. Long term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema. Lancet 1981; 1:681–6.
2. Nocturnal Oxygen Therapy Trial Group. Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease; a clinical trial. Ann Intern Med 1980; 93:391–8.
3. Soffer M, Tashkin DP, Shapiro BJ, Littner M, Harvey E, Farr S. Conservation of oxygen supply using a reservoir nasal cannula in hypoxemic patients at rest and during exercise. Chest 1985; 88:663–8.
4. Moore-Gillon JC, George RJD, Geddes DM. An oxygen conserving cannula. Thorax 1985; 40:817–9.
5. Tiep BL, Nicotra B, Carter R, Belman MJ, Mittman C. Evaluation of a low-flow oxygen-conserving cannula. Am Rev Respir Dis 1984; 130:500–2.
6. Gould GA, Hayhurst MD, Scott W, Flenley DC. Clinical assessment of oxygen conserving devices in chronic bronchitis and emphysema. Thorax 1985; 40:820–4.