Eur Respir J
1990, 3, 812–817

SHORT REVIEW

Devices for low flow O_2 administration

A.G. Stewart, P. Howard

Devices for low flow O_2 administration. A. Stewart, P. Howard.
ABSTRACT: Long-term oxygen therapy requires a practical regulated oxygen delivery system which works in the home. Although face-masks are cheap and efficient, they are awkward and need removal for talking and eating. Few patients would comply with this for 15 h per day. Nasal prongs are reliable, cheap, safe and well tolerated but are wasteful of oxygen. This waste is important both practically and financially when oxygen is supplied from portable or large cylinders or from a liquid source. The Oxymizer pendants and moustache or inspiration phased delivery devices improve nasal prong efficiency. Nasopharyngeal catheters are an alternative but more invasive means of oxygen conservation. Percutaneous transtracheal catheterization is both oxygen efficient and cosmetically acceptable. As it requires an invasive surgical procedure with some serious potential complications its use should probably be reserved for those patients in whom adequate oxygenation is not achieved by standard nasal prongs. Its use is rarely justified on merely cosmetic grounds. Permanent tracheostomy is not indicated in most cases of hypoxic chronic obstructive airways disease (COAD). Nasal prongs would seem the most reasonable method of oxygen delivery. Their use with oxygen concentrators lessens the need for oxygen conservation.
Eur Respir J., 1990, 3, 812–817.

Dept of Medicine, Royal Hallamshire Hospital, Sheffield, UK.

Correspondence: A.G. Stewart, Dept of Medicine, Royal Hallamshire Hospital, Sheffield, S10 2JF, UK.

Keywords: Low flow oxygen; nasal cannulae; nasopharyngeal cannula; oxygen conserving devices; oxygen masks; tracheostomy; transtracheal catheter; Venturi mask.

Received: February 1, 1990; accepted for publication February 28, 1990.

Oxygen is a dangerous drug, its delivery needs to be controlled. Haldane [1] in 1917, noting the risks of intermittent oxygen, felt that when it was safe it was unnecessary and when required its use was dangerous.

Long-term domiciliary oxygen therapy (LTOT) given for at least 15 h·day^{-1} reduces mortality and improves morbidity in patients with hypoxic cor pulmonale secondary to chronic obstructive airways disease (COAD) [2, 3]. The treatment requires a practical, regulated oxygen delivery system which will work in the home.

Diverse techniques and apparatus have evolved [4] since Campbell [5, 6] first described controlled oxygen therapy in 1960. Face masks, nasal prongs, transtracheal catheters, nasopharyngeal catheters and tracheostomy have all been tried. Oxygen tents, headboxes and cots are now rarely used in adult practice but are an important part of neonatal care. One hundred percent O_2 is seldom required and lower concentrations of around 30% are produced by dilution with air using a fixed or variable performance device.

Face-masks

Face-masks fall into two broad categories:

Fixed performance masks

These masks deliver a constant pre-determined O_2 concentration to the patient's mouth unaffected by tidal volume or pattern of breathing. Most fixed performance masks operate under conditions of high air flow, exceeding the peak inspiratory flow rate, thus the previously set concentration of oxygen is delivered to the face. Low flow delivery is only possible providing dilution of the oxygen mixture by room air can be prevented. Various anaesthetic circuits work on such principles, but in day to day LTOT this would be nearly impossible and certainly very uncomfortable for the patient due to the tightness of mask fit. Their need for a large reservoir would cause a degree of CO_2 rebreathing in patients who are already hypercapnic.

Ventimasks. These work on the venturi principle [7]. The jet of oxygen sucks in a fixed proportion of room air, usually 40 $l \cdot min^{-1}$. Normally this flow rate exceeds the peak inspiratory flow rate of 20–30 $l \cdot min^{-1}$, thus preventing further dilution by room air. The excess gas escape through ports in the mask. Mouth or nose breathing does not alter the delivered concentration. The mask is light and loose fitting around the lower face but fits snugly around the nose to prevent draughts into the eyes. The volume of this mask makes mask position less critical.

A series of Ventimasks are stamped and colour coded with their required O_2 flow rate and nominal output concentration (24, 28, 35, 40%). The correct mask at the correct flow rate must always be selected.

The Hudson mask. This works on similar principles but here one mask provides a range of O_2 concentrations from 24–50% by adjustments to the size of the oxygen jet and the O_2 flow rates. Recent versions have a smaller internal volume and large ports opposite the nares. Although patient comfort is improved the mask is less likely to provide a predicted O_2 concentration and the mask position is critical [8–10].

All fixed performance masks "fail" in the very breathless patient where high inspiratory flow rates exceed the delivery system. For the average stable cor pulmonale patient this is unusual. Venturi devices are sensitive to back pressure. The resistance to flow in the tubes and humidifier should be kept low by using short length tubing. Although they are wasteful of O_2 at high O_2 flow rates these losses are acceptable when lower concentrations are used. Despite the high flow rates humidification is not required as moist room air is entrained.

Variable performance masks

These do not deliver a known, fixed oxygen concentration. Oxygen is delivered at a continuous rate, insufficient to supply all the inspired volume, room air supplies the remainder. Altering the oxygen flow rate varies the inspired O_2 concentration [11]. Variations in mask position, size of leaks, pattern and depth of breathing [10] produce large variations in the inspired oxygen concentration [12]. Various device factors such as size of reservoir and position of air holes in the mask further affect the inspired oxygen concentration.

These masks are cheap and disposable and are made of semi-rigid plastic. Patients are relatively comfortable as there is no need for a tight fit or high flow rates. The MC mask volume of 100–200 ml creates a small reservoir - this coupled with low flow rates may lead to CO_2 rebreathing. Flow rates greater than 4 $l \cdot min^{-1}$ avoid this, but this may be too much for the oxygen sensitive chronic bronchitic. In practice, the lower flow rates needed for controlled oxygen therapy rarely lead to carbon dioxide retention because of the loose fitting nature of the mask.

Any depression of respiration is dangerous; as the minute volume falls, the inspired O_2 concentration rises and may further depress the hypoxic ventilatory drive. A study of the Edinburgh mask at a flow rate of 1 $l \cdot min^{-1}$ shows an inspired O_2 concentration of 24% at a minute volume of 10 $l \cdot min^{-1}$; this rises to 29% at a minute volume of 4 $l \cdot min^{-1}$ and 38% at 2 $l \cdot min^{-1}$.

Arterial blood gas estimation is mandatory whenever controlled O_2 is given. This is particularly so with variable performance devices. From the information gained either the inspired O_2 concentration, or the flow (variable performance devices) should be adjusted to give the optimum arterial oxygen tension (Pa_{O_2}) without producing an excessive rise in arterial carbon dioxide tension (Pa_{CO_2}), (*i.e.* less than 1.3 kPa). Ideally a Pa_{O_2} of about 8 kPa should be targeted whilst keeping Pa_{CO_2} less than 8 kPa.

Masks are an efficient method of O_2 delivery, but are irritating, awkward and cumbersome and have to be removed for eating, drinking, expectorating and talking. Few people would comply with this for 15 h every day.

Nasal prongs

Nasal prongs overcome the difficulties of face masks [13] and are now the most commonly used system for prolonged O_2 delivery. They are simple, cheap, relatively comfortable, and require no invasive or time-consuming procedures. Over the years they have proved reliable and well-tolerated. Patients can eat, sleep, talk and expectorate without discontinuing therapy. The development of more powerful O_2 concentrators allows the use of longer tubing and gives some mobility around the house whilst taking oxygen. Their relatively unobtrusive nature coupled to portable oxygen cylinders allows travel away from the home.

The O_2 concentration delivered is independent of mouth or nose breathing [14]. Furthermore the O_2 can be given to one or both anterior nares with equal efficiency [15]. Oxygen at flow rates 1–3 $l \cdot min^{-1}$ produces comparable arterial oxygen saturations to that achieved by Ventimasks 24–35%. Oxygen flow rates up to 3 $l \cdot min^{-1}$ are well tolerated [16] and do not require humidification. A lowish humidity is unimportant when the patient is breathing through the nose or mouth as the upper respiratory tract can heat and humidify the inspired gas, keeping alveolar conditions constant. At greater flows humidification may be needed to avoid nasal mucosal drying, irritation and patient discomfort.

Nasal prongs are visible, this may have cosmetic and psychological effects in the occasional self conscious patient [17]. Hiding the delivery tubes into the frame of a pair of spectacles may minimize this problem [18].

Compared to masks, nasal prongs have no problems of CO_2 rebreathing. The problem of prong displacement during sleep is difficult to prevent, but seems not to be a major problem.

Nasal prongs have poor efficiency, their reservoir is limited to the nasal cavities and much O_2 is wasted from continuous delivery throughout the respiratory cycle. Various O_2 conserving devices which work with nasal prongs are discussed later.

Nasopharyngeal catheters

Nasopharyngeal catheters are an alternative way of maintaining a raised inspired oxygen concentration when nasal prongs or masks have proved inadequate [19, 20]. For maximum efficiency the catheter should be inserted nasally, such that the tip lies behind and just beneath the soft palate. This distance is similar to that between the nostril and the ear lobe. The nasopharynx acts as the expiratory limb of a "T-piece" breathing apparatus and this eliminates rebreathing. If anything, the anatomical deadspace is further reduced as the nasopharynx is partially cleared of CO_2 by oxygen flow during the expiratory pause.

Firm strapping reduces the risk of catheter displacement. Even so a blow off valve is needed in case it slips into the oesophagus. Most catheters need to be changed every 6 h to the opposite nostril. Once changed, it is relatively comfortable and the problem of air leaks around a mask do not occur. A flow rate of 1 $l \cdot min^{-1}$ O_2 gives an inspired concentration of 25–30% and at 2 $l \cdot min^{-1}$ gives a concentration of 30–35% oxygen.

Oxygen conserving devices

Oxymizer

The Oxymizer (moustache) [10, 21–23] and Oxymizer-pendant [10, 19, 24] (Chad Therapeutics Inc.) store oxygen in a 20 ml collapsible reservoir, which is filled from the O_2 source during expiration. This conserved oxygen is then inhaled as a bolus dose in the first part of inspiration. During the rest of inspiration the reservoir remains collapsed and the device functions like conventional nasal prongs delivering O_2 at the set flow rate. When compared to standard nasal prongs, they improve oxygen saturation over the flow rates range 0.5–3 $l \cdot min^{-1}$. An equivalent O_2 saturation is produced at a 33–50% lower O_2 flow rate.

Unfortunately efficiency varies between patients. Some people show no improvement. The reason is not clear but may be due to their breathing pattern. The response of every individual has to be assessed. Efficiency is lost at high flow rates (>3 $l \cdot min^{-1}$) where the reservoir only supplies a small fraction of the total O_2 delivered and at low flow rates (<0.5 $l \cdot min^{-1}$) where the reservoir fails to fill during expiration.

The article by Collard *et al.* [19] compared nasopharyngeal catheters with standard nasal prongs and Oxymizer pendant. The Oxymizer pendant was slightly more efficient than the nasopharyngeal catheter but both were significantly better than the nasal prongs in terms of the Pa_{O_2} reached on oxygen supplementation at 2 $l \cdot min^{-1}$. Interestingly, of the 20 patients who failed to reach a target 8.6 kPa with nasal prongs, nine subsequently reached it when using the Oxymizer pendant. As oxygen flow rates from concentrators cannot be reliably increased above 3 $l \cdot min^{-1}$, reservoir devices may allow optimum oxygenation of those patients refractory to oxygenation by standard nasal prongs or masks.

Concern about the long-term efficiency of the Oxymizer has been raised. Evans *et al.* [22] confirmed an improvement in Pa_{O_2} after use of the Oxymizer compared to standard nasal prongs but found a significantly greater Pa_{O_2} at 15 min compared to 60 min without any change in Pa_{CO_2}. This suggests that loss of efficiency is not due to a reduced minute volume secondary to the improved Pa_{O_2}. Although the relative bulk of the Oxymizer moustache may convert nose breathing to mouth breathing this has not been shown to affect oxygen saturation [14]. It is possible that the bolus of oxygen to the alveoli may impair ventilation/perfusion balance by relieving hypoxic vasoconstriction and allowing under-ventilated parts of the lung to become perfused. Long-term studies of these devices need to be carried out in the domiciliary situation before their widespread use can be accepted.

The moustache is highly visible and may be cosmetically unacceptable to many patients, the pendant device on the other hand can be hidden under clothing and may therefore be more acceptable. These devices certainly save O_2, but this must be weighed against their frequent replacement cost. The manufacturers of Oxymizer recommend replacement every 10–14 days. No trials have yet investigated their safe life span.

Inspiration phased O_2 delivery

Many attempts have been made to conserve O_2 by using intermittent, inspiration phased O_2 delivery. Early devices relied upon voluntary hand activation [25] or chest wall movements for activation [26]. They were obtrusive and unacceptable to patients. Most devices activated by temperature or pressure changes require specially modified nasal prongs which are expensive [27, 28].

Winter *et al.* [29] demonstrated O_2 conservation during high flow rates by using a regulator valve and microprocessor switch which sensed pressure change during the respiratory cycle. O_2 flowed only during inspiration. Standard nasal prongs are used. Unfortunately rapid respiration, as may occur in the breathless COAD patients, causes an almost continuous flow of O_2 and little O_2 conservation [30]. The device requires a power source, is less portable and there are restrictions to the length of tubing over which the sensor can detect pressure changes, thus reducing patient mobility.

A similar demand oxygen controller is incorporated into the portable liquid O_2 system Pulsair 1 which is commercially available in the USA [29]. This reduces O_2 usage by 40% while maintaining comparable arterial oxygen saturation (Sa_{O_2}) to that produced by continuous flow nasal prongs. Puriton Bennet have the "Companion 6" for use with hospital wall outlets or stationary high pressure cylinders and the "Companion 5" for stationary and portable liquid O_2 systems. A further device Optimax is also available. It should be possible for similar devices to be modified for use with O_2 concentrators. Although the initial costs are higher the follow-on costs may be lower than the Oxymizer.

The potential for electromechanical failure is an obvious worry. So far, there is little reported long-term experience with these devices. Many devices do not have a fail safe mechanism to deliver oxygen if no inspiration is sensed. This is of particular necessity in those patients with sleep apnoea. The effect of mouth breathing on the function of these devices is not known. Once again this may be very important during sleep.

As with the Oxymizer devices there is little saving in the tachypnoeic mouth breathing patient. They should not be prescribed simply for the relief of breathlessness. The use of either electromechanical or reservoir devices must be carefully considered in LTOT. Halving the number of O_2 cylinders, or quantity of liquid O_2, required per week reduces costs and improves the practical problems of supply and storage. The cost savings are less clear with O_2 concentrators, halving the flow rate may lead to concentrators which are smaller, cheaper and more economical to run. The use of portable oxygen cylinders is limited by their small capacity. Conserving devices enable extended walking times particularly with liquid oxygen source.

Transtracheal catheter

Worries have been expressed that highly visible masks and nasal prongs may affect personal self-image, cause social isolation and affect patient compliance. Transtracheal oxygenation (TTO$_2$), first introduced by Heimlich [31] in 1982 overcomes this cosmetic problem. Although many hundreds of patients have been operated on worldwide there are wide variations in its use between countries and chest physicians are divided as to its need and place in the treatment of severe COAD.

The technique involves the insertion of an 8–16 Fr gauge cannula by percutaneous needle puncture or operative intervention under local anaesthesia at an appropriate position for the cannula's stabilization by a necklace. Commonly this is between the second and third cartilage rings. The cricothyroid membrane should be avoided. The necklace and cannula are then hidden under clothing.

Indeed some centres have taken this cosmetic principle one stage further. The tubing is tunnelled subcutaneously from the neck to exit on the chest wall, so avoiding visible tracheal puncture. (This may have the added advantage of reducing infections at the point of tracheal puncture.)

The mini tracheostomy tract becomes epithelialized in about 8 wks. By this stage, the patient has been taught to remove, clean and replace the cannula twice daily without the need for guide wires [32]. During this "maturation" period frequent visits to hospitals are required to exchange the in-dwelling cannula.

O_2 flow rate is titrated to give an O_2 saturation of at least 90% (Pa_{O_2} 8.0 kPa). Flow rates of 1 $l \cdot min^{-1}$ are common, adjustments being made in 0.25 l steps to a maximum of 4 $l \cdot min^{-1}$. These flows are generally sufficient to adequately oxygenate those patients refractory to oral or nasal oxygen.

Oxygen requirements may be reduced by 55% at rest and 30% on exercise. An improvement in walking distance and a reduction in subjective dyspnoea at low flow rates have been shown. Theoretically, by bypassing the nasopharyngeal deadspace the respiratory effort may be lessened. The clinical significance of this is questionable, as long-term tracheostomy does not improve respiratory failure in these patients. Furthermore, the reduction in deadspace is only a small fraction of the increased deadspace seen in COAD.

The breathing circuit requires a pressure determined safety valve in case the catheter tip becomes blocked. As the heat and moisture exchanging areas of the upper respiratory tract are bypassed, some form of humidification is often required, particularly at the higher flow rates.

Although patient satisfaction and acceptability are high, there are serious complications. Patients undoubtedly fare better with better oxygenation and lower complication rates in those units who specialize in this technique. Physicians caring for small numbers of LTOT patients should not attempt this technique. The larger series reported have the lower complication rates [32, 33], the learning curve seems critical. In one small series of 10 patients [34], 3 withdrew with catheter site sepsis, 2 patients preferred nasal cannulae, one died from an infective exacerbation of his COAD and only 4 patients continued use beyond 6 months. The 20 patient series of Banner and Govan [35] had 12 patients remaining on TTO$_2$ at 13 months (3 patients died, 2 failed to comply, 2 had major complications and 1 felt there was no benefit). The larger series (100 patients each) of Heimlich and Carr [32] and Christopher *et al.* [33] had a lower failure rate of 8–12% and a higher patient acceptance of 90–96%. The procedure causes an initial increase in cough with production of blood streaked sputum and some puncture site discomfort. Combining the four series (230 patients) immediate procedure related complications include subcutaneous emphysema in 15 (a period of catheter stenting rather than immediate O_2 administration may reduce this), significant skin puncture site bleeding in 2 and bronchospasm in 2. Later sequelae include haemoptysis in 5, skin infections in 7 (this can be reduced by the use of prophylactic antibiotics during the initial procedure). Mucous plugging of the catheter occurred in 15 patients. Mucous balls are a potentially serious complication. They develop during tract maturation, due to the drying effect of the oxygen, increased sputum production and poor adherence to catheter change schedules. The mucous balls initially cause troublesome coughs but may lead to catheter blockage and even tracheal obstruction. Daily catheter cleaning prevents their development. Nine catheters failed, and 2 fractured cannulae required bronchoscopic extraction. In 29 cases the patient inadvertently removed or dislodged the catheter, in 8 of these cases reinsertion failed. Other attributable complications include iatrogenic pneumonia, pneumomediastinum, cardiac arrhythmias, keloid, dermatitis, hoarseness (following cricothyroid puncture), tracheal stricture and abscess formation. Happily, there have been no procedure-related deaths but similar techniques for tracheal aspiration or detergent instillation have caused at least 7 deaths. The debate continues as to whether such an invasive procedure is justified largely on cosmetic grounds.

Long-term tracheostomy

Permanent tracheostomy has little role in most cases of hypoxic COAD. The reduction in physiological deadspace is small and following tracheostomy the patients tend to hypoventilate, such that the $Paco_2$ remains at pre-tracheostomy levels. An obvious exception applies to those patients with severe kyphoscoliosis who do gain considerable benefit.

Conclusions

Nasal prongs would seem to be the most reasonable method of O_2 application due to their simplicity, safety and cheapness. Their use with oxygen concentrators lessens the need for oxygen conservation. Alternative devices should only be used when inadequate oxygenation on standard nasal prongs has been proved. This potential benefit must be weighed against the greater complication rate. The cosmetic drawbacks to nasal prongs affects only a small number of patients and some of their doctors.

Although the Medical Research Council (MRC) and Nocturnal Oxygen Therapy Trial Group (NOTT) studies [2, 3] demonstrated the need for at least 15 h oxygen treatment daily, there is still a need to examine the consistency of the arterial oxygen response to these various devices throughout the oxygen therapy period and to relate this response to therapeutic benefit. The role of supplementary oxygen in conditions other than COAD, such as lung fibrosis, is not yet proven.

References

1. Haldane JS. – The therapeutic administration of oxygen. *Br Med J*, 19171, 181–183.
2. Medical Research Council Working Party. – Long-term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema. *Lancet*, 1981, i, 681–685.
3. Nocturnal Oxygen Therapy Trial Group. – Continuous or nocturnal therapy in hypoxaemic chronic obstructive lung disease, a clinical trial. *Ann Intern Med*, 1980, 93, 391–398.
4. Recommendations for long-term oxygen therapy: a task force report *Eur Respir J*, 1989, 2, 160–164.
5. Campbell EJ. – Respiratory failure. The relation between oxygen concentration of inspired air and arterial blood. *Lancet*, 1960, ii, 10–11.
6. Campbell EJ. – A method of controlled oxygen administration which reduces the risk of carbon dioxide retention. *Lancet*, 1960, ii, 12–14.
7. Fracchia G, Torda TA. – Performance of Venturi oxygen delivery devices. *Anaesth Intensive Care*, 1980, 8, 426–430.
8. Hunter J, Olson LG. – Performance of the Hudson Multi-Vent oxygen mask. *Med J Austr*, 1988, 148, 444–447.
9. Campbell EJM. – How to use the Venturi mask. *Lancet*, 1982, ii, 1206.
10. Goldstein RS, Young J, Rebuck AJ. – Effects of breathing pattern on oxygen concentration received from standard face masks. *Lancet*, 1982, ii, 1188–90.
11. Flenley DC, Hutchinson DCS, Donald KW. – Behaviour of apparatus for oxygen administration. *Br Med J*, 1963, 2, 1081–1087.
12. Leigh JM. – Variation in performance of oxygen therapy devices. *Anaesthesia*, 1970, 25, 210–222.
13. Williams AB, Jones PL, Mapleson WW. – A comparison of oxygen therapy devices used in the post-operative recovery period. *Anaesthesia*, 1988, 43, 131–135.
14. Gould GA, Forsyth IS, Flenley DC. – Comparison of two oxygen conserving nasal prong systems and the effect of nose and mouth breathing. *Thorax*, 1986, 41, 808–809.
15. Petty TL, Nett CM, Lakshminarayan S. – A single nasal prong for continuous oxygen therapy. *Respir Care*, 1973, 18, 421–423.
16. Evans TW, Waterhouse J, Howard P. – Clinical experience with the oxygen concentrator. *Br Med J*, 1983, 287, 459–461.
17. Heaton RK *et al*. – Psychological effects of continuous and nocturnal oxygen therapy in hypoxaemic chronic obstructive pulmonary disease. *Arch Intern Med*, 1981, 143, 1941–1947.
18. Petty TL. – Pulmonary rehabilitation - better living with new techniques. *Respir Care*, 1985, 30, 98–107.
19. Collard P, Wautelet F, Delwiche JP, Prignot J, Dubois P. – Improvement of oxygen delivery in severe hypoxaemia by a reservoir cannula. *Eur Respir J*, 1989, 2, 778–781.
20. Green ID. – Choice of method for administration of oxygen. *Br Med J*, 1967, 3, 593
21. Tiep BL, Nicotra B, Carter R, Bleman MJ, Mittman C. – Evaluation of a low flow oxygen conserving nasal cannula. *Am Rev Respir Dis*, 1984, 130, 500–502.
22. Evans TW, Waterhouse JC, Suggett AJ, Howard P. – A conservation device for oxygen therapy in COPD. *Eur Respir J*, 1988, 1, 959–961
23. Moore Gillon JC, George RJD, Geddes DM. – An oxygen conserving nasal cannula. *Thorax*, 1985, 40, 820–824.
24. Tiep BL, Belman MJ, Mittman C, Phillips R, Otsap B. – A new pendant storage oxygen conserving nasal cannula. *Chest*, 1985, 87, 381–383.
25. Cotes JE, Matthews CR, Tasker PM. – Continuous *versus* intermittent administration of oxygen during exercise to patients with chronic lung disease. *Lancet*, 1963, i, 1075–1077.
26. Pflug AE, Cheney FW, Butler J. – Evaluation of an intermittent oxygen flow system. *Am Rev Respir Dis*, 1972, 105, 449–52.
27. Mecikaslki M, Shigeoka JW. – A demand valve conserves oxygen in subjects with chronic obstructive pulmonary disease. *Chest*, 1984, 86, 667–670.
28. Auerbach DUM, Flick MR, Block AJ. – A new oxygen cannula system using intermittent demand nasal flow. *Chest*, 1978, 74, 39–44.
29. Winter RJD, George RJD, Moore-Gillon JC, Geddes DM. – Inspiration phased oxygen delivery. *Lancet*, 1984, ii, 1371–1372.
30. Gould GA, Hayhurst MD, Scott W, Flenley DC. – Clinical assessment of oxygen conserving devices in chronic

bronchitis and emphysema. *Thorax*, 1985, 40, 820–824.
31. Heimlich HJ. – Respiratory rehabilitation with a transtracheal oxygen system. *Ann Otol Rhinol Laryngol*, 1982, 91, 643–647.
32. Heimlich HJ, Carr GC. – Transtracheal catheter technique for pulmonary rehabilitation. *Ann Otol Rhinol Laryngol*, 1985, 94, 502–504.
33. Christopher KL, Spofford BT, Petrun MD, McCarthy DC, Goodman, JR, Petty TL. – A program for transtracheal oxygen delivery. *Ann Intern Med*, 1987, 107, 80–808.
34. Hoffman LA, Dauber JH, Ferson PF, Openbrier DR, Zullo TG. – Patient response to transtracheal oxygen delivery. *Am Rev Respir Dis*, 1987, 135, 153–156.
35. Banner NR, Govan JR. – Long-term transtracheal oxygen delivery through microcatheter in patients with hypoxaemia due to chronic obstructive airways disease. *Br Med J*, 1986, 293, 111–114.

Revue brève. Appareils pour l'administration d'oxygène à bas débit. A. Stewart, P. Howard.

RÉSUMÉ: Une oxygénothérapie au long cours exige un système pratique de régulation de l'administration d'oxygène, capable de fonctionner au domicile. Quoique les masques faciaux soient bon marché et efficaces, ils sont désagréables et doivent être retirés pour parler et manger. Peu de patients accepteraient cette modalité pendant 15 heures par jour. Les embouts nasaux sont valables, bon marché, sûrs et bien tolérés, mais dispendieux en oxygène. Cette perte est importante, à la fois pour des raisons pratiques et financières, lorsque l'oxygène est administré à partir de cylindres portables ou de grande dimension, ou à partir d'une source d'oxygène liquide. Les systèmes Oxymiser pendants et moustache ou les appareils d'administration rythmée sur l'inspiration, améliorent l'efficience des embouts nasaux. Les cathéters naso-pharyngés sont un moyen d'épargne d'oxygène alternatif, mais plus invasifs. La cathétérisation transtrachéale percutanée est efficace du point de vue de l' oxygène, et acceptable sur le plan cosmétique. Comme elle exige une technique chirurgicale invasive, avec quelques complications sérieuses potentielles, son utilisation devrait probablement être limitée aux patients chez qui une oxygénation adéquate n'est pas obtenue par les embouts nasaux standard. Son utilisation n'est que rarement justifiée sur la base d'arguments surtout cosmétiques. La trachéostomie permanente n'est pas indiquée dans la plupart des cas do BPCO hypoxiques. Les embouts nasaux sont donc la méthode la plus raisonnable d'administration d'oxygène. Leur utilisation avec les oxyconcentrateurs diminue le besoin d'épargne d'oxygène.
Eur Respir J., 1990, 3, 812–817.