Intermittent Positive Pressure Ventilation via Nasal Access in the Management of Respiratory Insufficiency*

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These are preliminary observations of the introduction of a new technique of noninvasive positive pressure respiratory support for patients with subacute or chronic respiratory failure. Clinical situations where intubation or tracheostomy have been performed were managed by intermittent positive pressure ventilation via nasal access (NIPPV) with a CPAP mask, or a custom constructed Vel-Foam nose piece. Four patients were managed at home with the use of portable volume ventilators. One patient employed the technique while hospitalized with subacute respiratory failure. Two patients, otherwise dependent on mouth intermittent positive pressure ventilation (MIPPV) 24 hours a day, received necessary dental care with NIPPV support. In a large population with a decade or more follow-up, MIPPV was shown to be an effective noninvasive technique to support respiration in patients with the most severe paralytic respiratory failure. Preliminary observations suggest that NIPPV may compare favorably with MIPPV and deserves more widespread study and application.

Since the early 1960s, many patients with severe respiratory insufficiency due to a restrictive pulmonary syndrome from respiratory muscle weakness and thoracic deformity have been managed at home. The rocking bed and iron lung were commonly employed by patients with respiratory insufficiency due to poliomyelitis. The advent of the cuirass or chest shell negative pressure system was for many patients an effective alternative to tracheostomy. It was not, however, effective in the presence of significant scoliosis, and since its use required recumbency, those patients without significant time off the respirator had no mobility. With the arrival of portable positive pressure ventilators in 1957, many such patients were tracheostomized and mobilized using tracheostomy intermittent positive pressure ventilation (TIPPV) with their ventilators mounted onto standard or motorized wheelchairs.¹

To avoid the inconvenience, complications and poor cosmesis of tracheostomy and long-term TIPPV, other clinicians employed mouth intermittent positive pressure ventilation (MIPPV).²³ The MIPPV is used throughout the day with the patient in his wheelchair and overnight with a Bennett lip seal to hold the mouth piece securely in place while the patient sleeps. The MIPPV has been shown to safely and reliably provide up to 24 hours a day of total ventilation for patients, many of whom with vital capacities (VC) at or close to 0 ml.²³ Overnight use of the Bennett lip seal can, however, make speaking and clearing of secretions inconvenient and there is always a risk of aspiration of vomitus in an acutely ill patient. Long-term use of MIPPV can cause bite deformities and aerophagia can be a source of discomfort.⁴ For these reasons, the nasal access for assisted ventilation was attempted.

The intranasal route for the administration of oxygen, and CPAP has become a standard approach to the management of neonatal respiratory distress. It has been noted that when CPAP is employed by sleep apnea patients, "the soft palate and the tongue are held together and pushed away from the posterior pharyngeal wall, providing a hermetic seal of the oral cavity." This same sealing of the oral cavity occurs with the delivery of nasal IPPV (NIPPV).

In 1982, Delaubier⁵ and Rideau⁶ introduced NIPPV in the management of French muscular dystrophy patients. In their studies, NIPPV was employed by 30 patients overnight and for short periods daily. It was felt that those patients with paralytic respiratory failure might be able to receive life-sustaining ventilation by this technique, thus avoiding the inconvenience of MIPPV and possibly eventual tracheostomy. Rideau and Delaubier discovered that the use of individually cut-out and fitted foam rubber nose pieces similar to that seen in Figure 1, has several advantages over delivering NIPPV via a CPAP mask (Fig 2). Adult

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CPAP masks are available in three sizes which do not adequately fit all patients. Inadequate fit permits unacceptable leak of insufflated air, usually into the patient's eyes. The individually cut-out piece is more comfortable, requires much less strap pressure due to its smaller surface area, and may permit less leak. These, however, may require periodic refabrication as the cut out nasal holes widen and no longer hold the inserted tubing firmly.

These are the first patients in the United States to employ NIPPV to our knowledge.

**Patients and Methods**

Any patient with paralytic respiratory insufficiency without significant intrinsic lung disease or other severe complicating medical conditions is a candidate for a trial of NIPPV. Oropharyngeal musculature should be sufficiently intact to clear the upper airway of secretions and allow speech. Each patient requiring aid on the basis of symptomatic and progressive nocturnal hypoventilation (periods of sleep $P_{CO_2}>50$ mm Hg as determined by overnight capnograph monitoring, $O_2$ saturation $<90$ percent as determined by pulsed oximeter monitoring) has a trial of NIPPV via a CPAP mask. If inadequate fit causes excessive leak, an individually cut nose piece is constructed. Two inch width Vel-Foam is cut sufficiently long to encircle the patient's head, as seen in Figure 1. It is narrowed in front to fit comfortably sealing the nostrils and is mildly creased in the nasolabial fold. Medial to the ear the Vel-Foam is divided into two strips of 1 inch width to course posteriorly one above and one below the ear. The strips are joined with the corresponding contralateral strip by Velcro closure. The fit should be secure enough to seal the nostrils. To complete the nasal piece, an infant nasal cannula CPAP assembly is obtained. The T-piece with nipple adapter, nasal prongs, and Velcro attachments are discarded. Each blue corrugated small bore tubing is advanced several millimeters into each nostril through holes that are pierced through the Vel-Foam overlying the nostrils. The fit of the tubing across the Vel-Foam should be tight. The other ends of the tubing are joined by a Y-adapter to enter the respirator tubing. A regenerative or cascade humidifier may be added to the circuit; however, most patients on NIPPV do not require this additional humidification.

Essentially, any portable pressure or volume ventilator may be used; however, the more even flow characteristics of the volume ventilators are usually preferred by most patients. In addition, with the use of volume ventilators, the delivered volumes are not affected by transient airway flow conditions, both low and high pressure alarms may be used, and since electricity consumption is one third that of pressure ventilators, one may have up to 24 hours of ventilator use on one fully charged external 12-volt battery. These volume ventilators contain an additional internal battery which gives an hour of use when external battery and wall current are not available. Our patients have neither required positive end-expiratory pressure nor additional oxygen, although these ventilators are compatible with delivery of both, if needed.

**Case 1**

A 30-year-old man had sporadic Duchenne muscular dystrophy and severe scoliosis. His VC was less than 50 ml. He had no time free of respiratory assistance and had been dependent on MIPPV 24 hours a day since age 18 years. He required extensive dental work. He was placed on NIPPV via a nasal CPAP mask. Oral insufflation leak was eliminated by the seal of the soft palate against the tongue. Thus, NIPPV freed his mouth to allow three dental extractions on Jan 14, 1986. Following the two hours of dental care, he resumed 24 hour MIPPV.

**Case 2**

A 36-year-old woman had a 19-year history of multiple sclerosis and base line VC of 1,500 ml. On Feb 24, 1986, complaining of three days of sleeplessness due to shortness of breath and progressive quadriparesis, her VC was measured at 250 ml sitting (6 percent of predicted normal) and 180 ml supine (4.5 percent of predicted normal) with an arterial blood gas (ABG) $pH$ 7.38, $P_0_2$ 86 mm Hg, $P_{CO_2}$ 46 mm Hg. Treatment with adrenocorticotropic hormone was begun and NIPPV delivered (Fig 2) at a rate of 14/min, IMV 900 ml, with inspiratory pressures at 24 cm H$_2$O. Expiratory volumes were consistently 730 ml while awake or asleep and whether the patient's mouth was closed or opened as in Figure 2. On direct observation, the mechanical effect of the ventilation was effective in sealing the soft palate against the posterior aspect of the tongue with each breath, thereby preventing significant oral leak. A repeat ABG on NIPPV was $pH$ 7.44, $P_0_2$ 85 mm Hg, $P_{CO_2}$ 29 mm Hg. More importantly, her respiratory rate and depth normalized, her dyspnea was entirely relieved, and she slept well that night. Continuous CO$_2$ metabolic analyzer monitoring at no time indicated $P_{CO_2}$ over 36 mm Hg and the low pressure alarm set at 20 cm H$_2$O never sounded during her sleep. Her VC dropped to 100 ml and she became dependent on NIPPV around the clock for the next 24 days at which point her VC began to rebound. On March 1, she no longer required aid.

Thus far, one other patient dependent on MIPPV 24 hours a day has successfully employed NIPPV to allow extensive dental work. Four patients with progressive neuromuscular disease and symptomatic nocturnal hypoventilation employ NIPPV overnight. In each case, significant sleep blood gas alterations were ameliorated by
NIPPV. The patient in Figure 1, for example, has a congenital myopathy. Her VC was 310 ml supine (9 percent of predicted normal). Her sleep Pco\textsubscript{2} off aid varied from 75 to 90 mm Hg, O\textsubscript{2} saturations 50 to 85 percent. On NIPPV, Pco\textsubscript{2} remained between 40 and 45 mm Hg, and O\textsubscript{2} saturation returned to normal during sleep.

DISCUSSION

Although negative pressure assistive devices such as the chest shell ventilator may be helpful in providing overnight respiratory assistance,\textsuperscript{4,5} they are generally not effective in the presence of scoliosis and are not practical for use during the day. For patients with progressive neuromuscular respiratory insufficiency, 24 hour dependence is likely to develop. For these patients, we offer both MIPPV and NIPPV and allow the patient to choose the technique with which he is most comfortable. The MIPPV is very effective and practical for use during the daytime. However, NIPPV has advantages over MIPPV for nighttime aid as noted earlier. Two of our patients use both techniques.

Of the six patients who have thus far been offered NIPPV-MIPPV for long-term aid, two chose MIPPV. Three of the other four continue to benefit from NIPPV. None of these patients has refused respirator dependence, and none has thus far undergone placement of a tracheostomy. This is consistent with our experience with over 140 patients in respiratory failure who were previously offered noninvasive respiratory aids including MIPPV. Only a few refused respirator dependence. The others benefited from MIPPV for many years with the majority not yet requiring a tracheostomy. Of the 75 postpolio respirator dependent patients on MIPPV\textsuperscript{3} for an average of over 14 years and on noninvasive aids for as much as 36 years, only six have eventually had a tracheostomy after an average of 30 years of respirator dependence. Noninvasive aids appear to be less likely to be rejected than tracheostomy with TIPPV.

From our experience with MIPPV, patients with poor pulmonary compliance due to severe intrinsic lung disease or cardiac failure may not normalize blood gas values. Excessive insufflation leak is often a factor, particularly overnight. The same might be expected to occur with patients on NIPPV. Thus far, none of our patients offered NIPPV has had significant obstructive lung disease, diffusion abnormalities, and none has had a tracheostomy. We have not observed any complications with use of NIPPV.

The MIPPV is an effective, time-tested technique of noninvasive respiratory support. Now, wider clinical evaluation of NIPPV should be undertaken to determine if it can be an effective alternative, and like MIPPV, postpone or eliminate tracheostomy for some patients.

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REFERENCES