NASAL POSITIVE PRESSURE VENTILATION IN THE TREATMENT OF CHRONIC HYPERCAPNIC RESPIRATORY FAILURE : A CASE REPORT

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ABSTRACT

This paper describes the use of a nasal mask to deliver intermittent positive pressure ventilation to treat chronic respiratory failure in one patient with severe kyphoscoliosis. After two months of overnight nasal ventilation at home the patient achieved normal blood gases, showed improved inspiratory muscle strength, effort tolerance and was able to return to work. Intermittent nasal ventilation is a safe and effective ventilatory support modality for some patients with hypercapnic respiratory failure.

Keywords: *Hypercapnia, respiratory failure, ventilatory support, muscle fatigue, nasal mask.*

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INTRODUCTION

Hypercapnic respiratory failure may occur because of failure and fatigue of the inspiratory muscles of breathing. This is the case in patients with intrinsic neuro-muscular diseases such as polio, Gullian-Barre syndrome and myasthenia gravis[1,2]. Abnormal respiratory muscle function may also contribute to the carbon dioxide retention in patients with respiratory failure from structural changes of the chestwall such as kyphoscoliosis or diseases of the lungs and airways such as chronic obstructive pulmonary disease[2-4].

Resting chronically fatigued inspiratory muscles by mechanical ventilatory support may restore muscle function, increase strength and endurance and reduce the $PaCO_2$[5]. Intermittent mechanical ventilation during sleep has been used with remarkable effect in patients with diverse causes of hypercapnic respiratory failure[6]. Various negative and positive pressure ventilators may be used to provide intermittent ventilatory support [7].

In this paper I describe the treatment of hypercapnic respiratory failure in a patient with severe chronic hypercapnia by positive pressure ventilation via a nasal mask. This is a novel method of instituting positive pressure mechanical ventilation which avoids the problems associated with artificial airways [8-10].

CASE REPORT

The patient is a 40 year-old man with severe kyphoscoliosis from poliomyelitis in childhood with a Cobb angle of above 120 degrees. He had progressive effort dyspnoea, cyanosis, polycythemia and mild right heart failure. At presentation he had been on medical leave for over two years and was limited to a wheel chair. There had been no recent exacerbation of his symptoms. He was cyanosed, had lower rib cage paradox during inspiration (Fig 1), mild ankle edema and daytime somnolence. Pulmonary function testing showed severe restrictive disease with weak inspiratory muscles and baseline arterial blood gas showed severe chronic hypercapnic respiratory failure (Tables I & II). Overnight oximetric recording showed prolonged periods of severe desaturation to below 60% oxygen saturation.

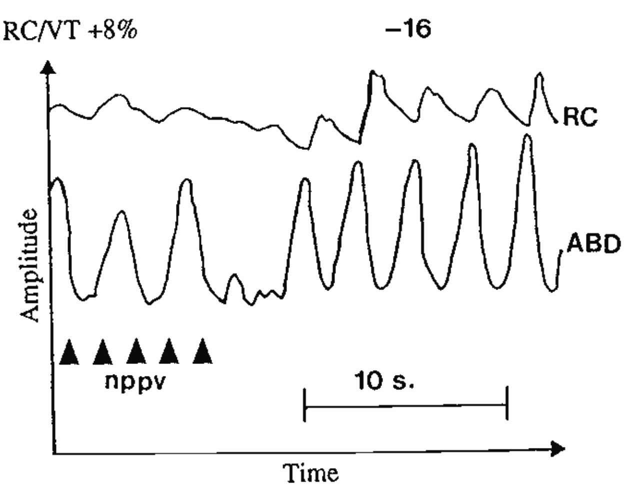
Mechanical Ventilation

Positive pressure ventilation was first instituted in the hospital during a period of clinical stability and applied via a tight fitting nasal mask (Respironics, Inc) as previously described[11,12]. A Servo 900C volume preset ventilator was used. He was ventilated in the "synchronized" intermittent mandatory ventilation mode at 20 breaths per minute, tidal volume of 600 ml and a trigger sensitivity of -2cm H_2O. The peak airway pressures during ventilation were between 15 to 20 cm H_2O. Inspiratory pressure support of +8cm H_2O was also provided.

His pulmonary function was reassessed after 5 full days of nasal positive pressure ventilation (NPPV) with 1-2 hour periods of rest for meals and cleaning (Table II).

The breathing pattern was measured by inductance plethysmography (Respitrace, Inc) with and without NPPV (Fig 1, Table III). Inductance coils were placed round the chestwall and abdominal cavities and set for isovolumic gains. The breathing pattern was recorded during quiet breathing in the supine position.

Fig 1 - This is a time tracing of ribcage (RC) and abdominal (ABD) excursions during tidal breathing when the patient was on NPPV (first 3 breaths) and after the nose mask was removed (last 5 breaths). The RC/VT ratio is the percentage contribution of RC to total RC plus ABD (VT or tidal volume) excursion during tidal inspiration (insp.). A negative value - as in this case when he was breathing on his own - confirms the presence of inspiratory RC paradox.



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Subsequently, the patient received home NPPV delivered by the Respironics BiPAP ventilatory support system at a positive inspiratory pressure level of +20 cm H_2O and minimal respiratory rate of 20 breaths per minute. He used the NPPV for at least 8 hours daily during sleep. His employer paid for the Respironics BiPAP ventilator on the recommendation of the author.

Table I - Arterial Blood Gas on room air

	Baseline	2 Months	12 Months
pH	7.33	7.46	7.45
pCO_2 (mmHg)	64	39	41
pO_2 (mmHg)	67	71	68
O_2 Sat (%)	84-90	95	95

O_2 Sat - percent oxygen saturation recorded on Biox II ear oximeter.
Two & 12 Months - after two & 12 months of NPPV.

Table II - Pulmonary Function

	Baseline	After NPPV		
		5 days	2 Months	12 Months
FVC (% pred)	23	23	35	38
FEV_1 (% pred)	25	26	30	34
FEV_1/FVC (%)	86	84	85	84
TLC (% pred)	25	24	-	-
PE, m, max (cmH_2O)	+44	+48	+44	+42
PI. m, max (cmH_2O)	-28	-36	-45	-44

FVC : forced vital capacity
FEV_1 : 1-second forced expiratory volume
TLC : total lung capacity
% pred : percent predicted
PE & PI, m, max : maximal expiratory & inspiratory pressures generated at the mouth repectively.

Table III - Breathing Pattern (Respitrace)

	Baseline	During NPPV
Breaths/min	34	30
Ti (sec.)	0.8	1.1
Ti/Ttot. (%)	0.4	0.5
RC/VT (%)	-12	+37

Ti/Ttot : inspiratory duty circle.
RC/VT : Percentage contribution by rib-cage (RC) to total rib-cage plus abdominal wall (VT) excursion during total inspiration.

RESULTS

Nasal PPV was well tolerated both in the short term (5 days) in the hospital and in the longer term (12 months) at home. Inspiration was felt to be lighter during NPPV and he was able to sleep well during overnight nasal ventilation.

The hypercapnia was reduced and oxygen saturation increased during NPPV. Nocturnal falls in oxygen saturation were however not completely obliterated. The paradoxical rib cage motion during the inspiratory phase was corrected when NPPV was applied (Fig 1). This was indirect evidence for cessation of inspiratory muscle activity during NPPV.

He experienced a marked increase in inspiratory muscle strength after 2 months of NPPV (from -28 cm H_2O to 45 cm H_2O : Table II). There was a small increase in the vital capacity which accompanied the increased inspiratory muscle strength at 2 months (Table II). The hypercapnia was also corrected after 2 months of nasal ventilation at home (Table I). This was sustained for up to 12 months of follow-up and was associated with a dramatic improvement in exercise tolerance. From being bound to the wheelchair he was able to walk about and return full time to his previous employment as a factory supervisor. He no longer complains of daytime somnolence.

DISCUSSION

The positive result of NPPV in this case is consistent with recent reports on the efficacy of intermittent mechanical ventilation in the supportive treatment of respiratory failure [6,7]. In the last decade there have been numerous reports which describe improvement in respiratory muscle strength, blood gases, daily function and even employability in patients with hypercapnic respiratory failure who had received intermittent (usually nocturnal) mechanical ventilation[6,7]. These studies lend strong support to the concept that chronic inspiratory muscle fatigue is a major component of hypercapnic respiratory failure and the corollary that muscle rest (by the artificial support of breathing) will result in clinical improvement [1,2,4]. The optimal timing and duration of ventilatory support need to be defined by further research. Furthermore, we need to be reminded that treating the respiratory muscles alone may at best be a sort of rearguard maneuver in the face of irreversible lung or chestwall disease. Nevertheless there is an established role for intermittent ventilatory support in the treatment of some patients with hypercapnic respiratory failure who might otherwise die from progressive disease or become totally dependent on artificial ventilation. The ability of NPPV to reverse insidious hypercarbia in this patient is an impressive demonstration of the powers of the respiratory muscles to recover from chronic overload.

Application of positive pressure via the nose mask is a non-invasive method of securing the upper airway for mechanical support of ventilation, one which the patient may safely apply himself[8-10, 13,14]. This contrasts with the need for tracheostomy or endotracheal intubation during conventional delivery of positive pressure ventilation. The nasal mask seems to deliver both volume preset (Servo 900C) and pressure preset (Respironics BiPAP system) ventilation equally well. The favourable experience with the long term use of nasal continuous positive airway pressure in patients with obstructive sleep apnoea suggests that a similar favourable result with NPPV may be anticipated [12,15].

The role of NPPV in the long term treatment of patients with respiratory failure from a wide spectrum of disorders and with complex cardio-respiratory dysfunction remains to be determined by careful prospective studies. To improve the chances of success in the use of NPPV careful patient selection is essential. The best results will be achieved in patients with well established hypercapnic respiratory failure ($paCO_2$ around 60 mmHg) who nevertheless have enough reserve pulmonary function to look after their personal needs. They should only need the NPPV at night and be fully alert, cooperative and, most important of all, have adequate oropharyngeal muscle strength for swallowing, speaking and clearing oral secretions[13]. It might also be anticipated that patients without progressive underlying lung, airway or neuromuscular disease (as in the patient described in this report) would do better on NPPV.

This paper describes the favourable results from using nocturnal NPPV at home in one patient with severe hypercapnic respiratory failure from restrictive pulmonary disease. I conclude that it is a relatively simple, safe, and well tolerated method of securing the airway for positive pressure ventilation.

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