Spinal Cord (1998) 36, 481–484

http://www.stockton-press.co.uk/sc

The use of the BiPAP® biphasic positive airway pressure system in acute spinal cord injury

AM Tromans[1], M Mecci[1,2], FH Barrett[1], TA Ward[1] and DJ Grundy[1]

[1]*The Duke of Cornwall Spinal Treatment Centre, Salisbury District Hospital, Wiltshire SP2 8BJ, UK*

In recent years there has been increasing demand on our Intensive Care Unit (ICU) facilities, mainly due to improved resuscitation techniques in the pre-hospital management of spinal cord injury (SCI). This has resulted in an increasing number of high tetraplegic and paraplegic patients with respiratory problems who have survived the initial injury, but have subsequently required ventilatory support, often for several weeks. In view of the continuing pressure on ICU beds and a consequent need for alternative means of providing ventilatory support within the spinal centre rather than within the ICU setting, there was a requirement to provide a simple means of ventilatory support suitable for use within the ward setting. Ventilatory assistance using BiPAP appeared to fulfil these criteria, enabling patients to be managed at reduced cost. We present our experience using this system in 28 acute SCI patients over a 4 year period.

Keywords: biphasic positive airway pressure system (BiPAP); respiratory support; spinal cord injury

Introduction

Biphasic positive airway pressure system (BiPAP) is a simple mechanical system designed for non-invasive respiratory pressure support via a nasal mask with or without supplemental oxygen. Unlike continuous positive airway pressure (CPAP) BiPAP provides the facility to separately pre-set different levels of inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP). The latter will also provide a degree of positive end-expiratory pressure (PEEP). The range of pressure support available is from 2–22 cm H_2O. Its main use has previously been in the treatment of sleep apnoea.[1] Its use in providing ventilatory support in acute SCI patients has not previously been described.

When we first started to use the BiPAP system, we envisaged that it might:

1. Benefit acute SCI patients who, although not requiring formal ventilation, were experiencing some degree of respiratory embarrassment. It was hoped that the provision of pressure support using BiPAP would avoid the need for full ventilation. However, it must be emphasised that the BiPAP is not intended to provide the total ventilatory requirements of the patient and must not be used as a life support ventilator.
2. Assist in the ward environment in the weaning of patients from full ventilation, thus reducing the length of stay in the intensive care unit.

Correspondence: AM Tromans
[2]Current address: Regional Spinal Injuries Centre, Southport, Merseyside, PR8 6PN, UK

Description of BiPAP

The BiPAP system is available in several models, but our experience is principally with the basic BiPAP, together with a free-standing airway pressure monitor (Figure 1). The settings at the back of the machine (Figure 2) enable the system to be used in one of three modes:

1. To deliver IPAP only; this is similar to continuous positive airway pressure (CPAP).
2. To deliver EPAP only; this is similar to positive end expiratory pressure (PEEP).
3. Spontaneous mode, to assist respiration with biphasic positive airway pressure support ie using both IPAP and EPAP.

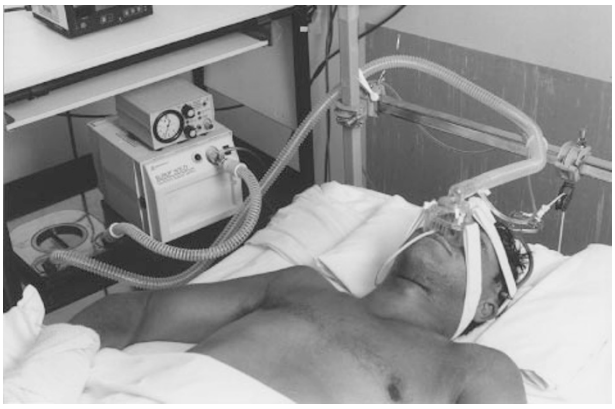

Figure 1 BiPAP in use, showing the system together with humidification unit and airway pressure monitor

Figure 2 IPAP and EPAP settings at rear of BiPAP system

Our experience is with the spontaneous mode, there being no apparent benefit in using the other two modes in spinal cord-injured patients. Whilst using this machine the patient is in full control of the rate and depth of respiration.

The BiPAP cycles spontaneously between pre-set levels of IPAP and EPAP in response to the patient's own respiratory flow.

In order to provide adequate ventilatory assistance, our experience has suggested that a pressure difference between IPAP and EPAP of at least 8 cm H_2O is required, as the tidal volume is proportional to IPAP – EPAP and the patient's own respiratory effort.

Materials and methods

We have reviewed our experience with the BiPAP on 32 occasions involving 28 acute spinal cord injured patients admitted over a period of 4 years from 1992–1995. There were 21 males and seven females with an age range from 22–70 and a mean age of 40 years. Eighteen of the 28 patients were admitted within 24 h of injury. BiPAP was used either as a means of preventing ventilatory failure or as a method of weaning from full ventilation. Twenty-two tetraplegic and six paraplegic patients were treated with BiPAP and four of these patients used BiPAP in both situations.

Results

Patients using BiPAP as a means of preventing ventilatory failure (Table 1)

Of the 17 patients in this group, (Table 1) ten used the BiPAP successfully, the BiPAP augmenting the patient's own respiratory efforts and thus avoiding the need for full ventilation. In this group of ten the mean initial vital capacity on admission was 1.1 L (range 0.7–1.8 L) and this fell to a mean of 0.9 L (range 0.5–1.7) immediately before commencing BiPAP. In seven patients the BiPAP did not prevent ventilatory failure, the patients requiring full ventilation. In this group the mean initial vital capacity was 1.25 L (range 0.5–2.1 L) but this fell to 0.6 L (range 0.5–0.8 L) before BiPAP was commenced. Two of these patients were subsequently weaned from full ventilation using BiPAP.

Indications for commencing ventilatory support with BiPAP were as follows:

1. Respiratory fatigue and exhaustion, characterised by a pattern of falling oxygen saturation, despite oxygen therapy, and decreasing vital capacity.

Table 1 Result of prophylactic use of BiPAP to avoid full ventilation (17 patients)

Neuro. level	*Initial Frankel grade*	*Frankel grade on discharge*	*Age*	*Initial vital capacity (litres)*	*Vital capacity immediately before commencing BiPAP (litres)*	*Total days on BiPAP*	*Ventilation avoided*
C4	A	A	22	1.6	1.0	9	YES
C4	A	A	39	Not available	0.6	1	NO
C4	C	C	47	0.7	0.5	15	YES
C4	A	A	50	0.9	0.5	1	NO
C5	A	A	23	1.5	0.6	<1	NO
C5	A	A	23	1.9	0.8	1	NO
C5	A	A	23	0.7	0.7	6	YES
C5	C	D	33	0.7	0.7	12	YES
C5	B	C	34	0.5	0.5	2	NO
C6	A	A	23	1.1	0.8	8	YES
C6	A	A	48	2.1	0.5	1	NO
C6	B	C	57	0.9	0.9	4	YES
C6	A	A	66	1.8	1.7	6	YES
C8	A	A	47	1.4	0.7	4	YES
T2	A	A	29	0.8	0.9	4	YES
T3	A	A	70	1.2	0.8	3	YES
T5	A	A	47	0.6	0.6	1	NO

Table 2 The use of BiPAP in weaning from full ventilation (15 patients)

Neuro. level	*Initial Frankel grade*	*Frankel grade on discharge*	*Age*	*Total days on full ventilation*	*Total days on BiPAP*	*Successful weaning achieved*
C2	A	A	23	17	66	No
C4	A	A	22	14	19	Yes
C4	A	A	28	22	53	Yes
C4	A	A	35	13	32	Yes
C4	A	A	50	18	65	Yes
C4	A	A	60	7	51	Yes
C4	C	C	66	30	42	Yes
C5	A	A	23	4	6	No
C5	B	C	34	16	41	Yes
C5	C	C	42	27	33	Yes
C6	C	D	23	17	19	Yes
C6	A	A	27	15	25	Yes
T3	A	A	37	9	15	Yes
T6	A	A	43	5	19	Yes
T7	A	A	59	10	4	Yes

2. Heavy smokers or patients with known previous chest problems such as chronic obstructive airway disease.
3. Older patients who have a potentially increased morbidity and mortality from respiratory problems.
4. The presence of chest injuries, such as haemothorax, fractured ribs and lung contusion. BiPAP was not used in the presence of a pneumothorax, as the positive pressure would risk the development of a tension pneumothorax.
5. Increased secretions, particularly if associated with atelectasis.

Two practical problems arose, the main one being nasal mask discomfort. This was usually alleviated by the use of a light protective dressing over the bridge of the nose, or by using a nose mask different from the one supplied, such as a full face mask as for CPAP, or a snorkel mouth-piece. The other problem was that of a blocked nose, which usually responded well to ephedrine nasal drops.

The reasons for failure of BiPAP would seem to be as follows:

1. Inadequate ventilatory support provided, with increasing ventilatory failure.
2. The inability to tolerate the BiPAP.

Of the seven patients in whom BiPAP failed to prevent ventilatory failure, two experienced rises in their neurological level (from C5 to C2, and from C6 to C3) and another patient had pre-existing severe chronic obstructive airways disease, with excessive sputum retention.

Patients using BiPAP as a means of weaning from full ventilation (Table 2)

This group of 15 patients (Table 2), with ages ranging from 22–66 years and neurological levels from C2 to T7, required full ventilation in the intensive care unit for 7–30 days with a mean of 15 days. They were then managed on BiPAP alone for times ranging from 4–66 days, with a mean of 33 days. BiPAP was successful in 13 of the 15 patients, who were weaned in a mean of 32 days. The reasons for failure to wean the two patients from full ventilatory support using the BiPAP were as follows:

1. Neurological deterioration, resulting in diaphragmatic paralysis and requiring long-term ventilation.
2. Inability to tolerate the BiPAP – this patient was weaned on CPAP.

Prerequisites to the use of BiPAP as a method of weaning from full ventilation are

1. Formal ventilation must have been uncomplicated.
2. Ventilation must be via a pressure support cycle.
3. Pressure support required must be within the BiPAP range (2–22 cm H_2O).
4. The patient must be able to tolerate and be adequately ventilated on the BiPAP.

There would appear to be little point in switching to the BiPAP, unless the weaning process is anticipated to be longer than 48 h.

The method we have found useful in weaning patients from the BiPAP can be summarised as follows:

1. The patient must be stable with the current level of support from the BiPAP.
2. The assisted and unassisted vital capacity are measured on and off the BiPAP.
3. The pressure support (IPAP) is reduced by 2 cm H_2O for increasing periods.
4. The IPAP is also reduced by 6–8 cm H_2O for ten breaths several times daily.

5. When the IPAP has been reduced by 2 cm H_2O for 24 h, the cycle begins again and is repeated until the patient is fully weaned.
6. The EPAP requirements are minimal during the weaning process, and do not exceed in our experience 4 cm H_2O pressure (the minimum EPAP attainable is 2 cm H_2O).

Discussion

The use of BiPAP is already established in the treatment of obstructive sleep apnoea.[1] Its use has also been described by Pennock *et al* in an ICU setting in patients in whom intubation and mechanical ventilation was being strongly considered, the ventilatory support providing improved patient comfort, a slower respiratory rate and improved oxygenation.[2] In this study, 22 of 28 patients (79%) recovered from their episode of ventilatory failure and avoided alternative mechanical ventilatory support.

Our initial interest in using BiPAP in acute spinal cord injury was similarly as a means of preventing ventilatory failure. We thought that some patients, who previously would have required full ventilation, might be spared this by judicious early use of BiPAP, and this was realised in ten of 17 of our patients (59%).

Although we intend to continue using BiPAP in this way, it has become evident that its principal virtue is as an effective method of weaning from full ventilatory support. This has had the effect of dramatically decreasing the length of time these (mainly) high lesion patients have required full ventilation and therefore the facilities of an intensive care unit, with the psychological advantages of being nursed in the spinal unit ward situation, as well as providing a significant reduction in costs.

The BiPAP system is an easily understood method of ventilatory assistance in a general spinal ward setting, and has enhanced our management of spinal cord-injured patients requiring temporary ventilatory assistance.

Footnote

BiPAP® is a registered trademark of Respironics Inc, 1001 Murry Ridge Drive, Murrysville, Pennsylvania 15668. No financial incentive was supplied by the company for the study or for the preparation of this paper.

References

1 Sanders MH, Kern N. Obstructive sleep apnoea treated by independently adjusted inspiratory and expiratory positive airway pressures via nasal mask. *Chest* 1990; **98:** 317–324.
2 Pennock BE *et al*. Pressure support ventilation with a simplified ventilatory support system administered with a nasal mask in patients with respiratory failure. *Chest* 1991; **100:** 1371–1376.