Questions and Answers.

BIPAP*, BiPAP®, APRV – A breadth of explanations.

Introduction

Mechanical Ventilation in Intensive Care has an inherent tendency to generate nomenclature whose origins might be clinical, technical or device oriented. The origins might be self explanatory or may have a clear therapy philosophy in the background or may have proprietary rights as their basis. The list of therapies in all fields is expanding rapidly posing many familiarisation issues for clinical staff. We are frequently asked at scientific meetings to explain the differences in modalities of ventilation and adjunct therapies with similar sounding names. In response to this we set out in the course of this article to highlight the differences and similarities of commonly used terms in modern ventilatory support namely Biphasic Positive Airway PressureVentilation (BIPAP), BiPAP® and APRV.

We must also bear in mind that with the advance of newer technologies and therapies the difference between a mode of ventilation and a form of breathing support is often very narrow. To assist us with this clarification when faced with new modalities there is one question we could perhaps ask, does this function assist with lung gaseous exchange if the patient has no spontaneous breathing ability? In most cases, an answer in the positive would indicate a mode of controlled ventilation whilst a negative reponse would indicate a form of breathing support, the SIMV mode and CPAP therapy are good illustrations.

As we review the many interpretations of the new therapies we need to be mindful of current opinion with respect to ventilatory therapy. We know much more about ventilator induced lung injury, the effect of high pressures and associated barotrauma, the lack of synchrony between patient and ventilator. From the above, lung protective strategies have evolved where the avoidance of high pressures and shear forces are common goals. The positive contribution of spontaneous breathing interfaced with mechanical ventilation is no longer a question of doubt. Conventional modes of ventilation are often limited in their ability to facilitate the spontaneous breathing patient and sedative drugs and muscle relaxants are used instead to suppress respiratory drive and adapt the patient to the ventilator - currently this is considered by many as completely the wrong approach.

THE AUTHOR

Joseph Fitzgerald,
Marketing Manager

The author previously worked in Dräger UK in Sales and Product Management. Since 1992 he has worked on customer oriented Product Development and internationally on Ventilator Therapy Applications. Since 1995 he has worked in Dräger Lübeck in Marketing Intensive Care Systems.

Historical origins:

Biphasic Positive Airway Pressure (BIPAP) mode of ventilation was first presented in 1988 by Professor Benzer and his group (Innsbruck), his theory consisted of alternating PEEP levels (1). This was the first time the acronym BIPAP was used and was followed in 1989 with the publication of a new approach to ventilatory technique (2) by Baum & Benzer which was also the first full year of commercial introduction of Biphasic Positive Airway Pressure as an integrated mode of ventilation on the Evita ventilator. This new approach took patient-ventilator interaction a major step forward, now there was the possibility if so desired for spontaneous breathing to continue through all mandatory phases. This concept was introduced as a positive adjunct to weaning.

Airway Pressure Release Ventilation (APRV) as a new concept in ventilatory support was developed independently by Professor Downs et al (3) (Florida) and in common with the European group that developed BIPAP, used in their

*Trademark used under license

earlier studies a high continuous flow CPAP device and PEEP/CPAP was switched between two values.The concept of APRV is rather to reduce than to increase the airway pressure to achieve mechanical support (4) hence the term 'release'.

Therapeutic aims of the two research groups was different (5), the USA group focused on patients who needed high levels of PEEP/CPAP to maintain sufficient PAO_2 and who were able to breathe spontaneously. Assistance with CO_2 removal was provided by short releases to a lower pressure level.

The European group's intention in contrast was the ability to facilitate spontaneous breathing during every ventilatory phase allowing the reduction in sedation and muscle relaxants.

The BiPAP® S/T-D Ventilatory Support System was also introduced in 1989 by Respironics Inc. for home care application. It was the first commercially available pressure support ventilation (PSV) home care device (6). It was designed as a non-invasive alternative to traditional management in non life support applications. It is intended to augment patient ventilation and is filed with the FDA in the category of non continuous ventilator (7).

Biphasic Positive Airway Pressure Definition:

Biphasic Positive Airway Pressure is spontaneous breathing superimposed on standard pressure controlled ventilation (PCV). As in time cycled PCV the duration of time and pressure at the upper and lower pressure levels can be independently set. When there is no spontaneous breathing this can replicate a CMV/IPPV mandatory ventilation format. Extending the time at the lower pressure value (PEEP) creates an SIMV type phasing and extending the time at the upper pressure level (inverse timing) invokes the APRV mode of ventilation. Original CPAP is achieved by adjusting both pressures to the same level. All these modes are achieved within the scope of operation of this one mode and no switching between modes is required.

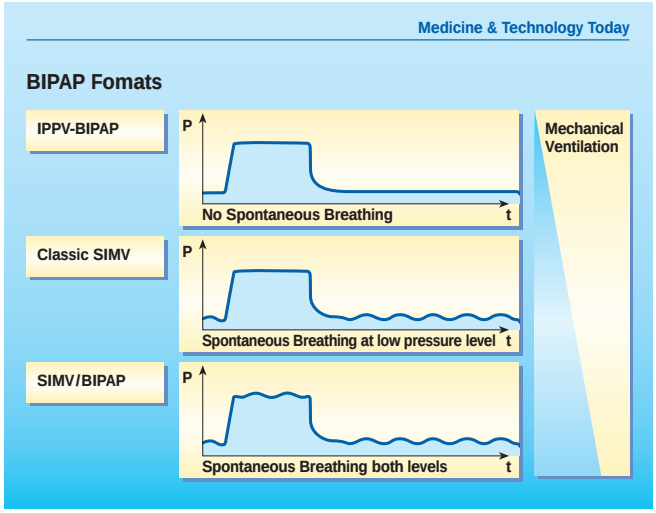

Figure 1

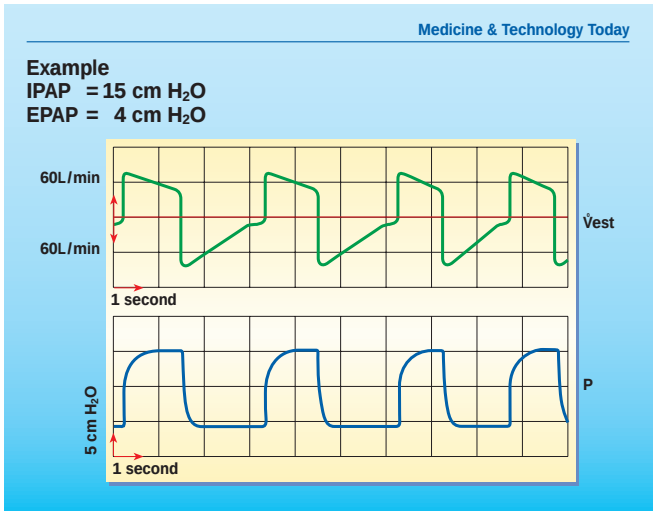

Figure 2

Comparison Table 1

	Biphasic Positive Airway Pressure	BiPAP®	APRV
Origins	Benzer 1988 -name of mode of ventilation on Evita ventilator allowing spontaneous breathing in all phases	The proprietary name of a ventilatory support system by the Respironics Inc. for non invasive therapy	Downs/Stock 1987- APRV device with 2 alternating levels of CPAP with short low level release times
Further development	BIPAP enhanced to integrate Pressure Support and replicate most modes of ventilation	Enhancement of timing, pressure and rate (BPM) variables	1.No developments from original device are commercially available yet. 2. APRV mode integrated in Evita

It should be noted that Biphasic Positive Airway Pressure and APRV as modes of ventilation cannot be directly compared with a machine marketed under the trademark BiPAP® and comparison tables will have to be incomplete

BiPAP® (Respironics) (Figure 2)

The name is derived from Bi-Level Positive Airway Pressure and is described as a low pressure electrically driven unit primarily intended to augment patient ventilation by delivering two different levels of pressure through a single hose to a mask. Cycling to and from inspiratory levels is in response to patient flow. A timed phase can be introduced if the patient fails to initiate a pressure change. It is not intended to provide the total ventilatory requirements of the patient (8).

Airway Pressure Release Ventilation (APRV) is a technique which allows spontaneous breathing on 2 CPAP levels. After establishing an adequate level of CPAP ventilatory support is achieved by adjusting the level of pressure release. As the release valve opens and pressure drops exhalation occurs, as CPAP is reinstated the previous volumes are restored in the lungs. Mechanical ventilation is achieved by decreasing instead of increasing intrapulmonary pressure (9). In the absence of spontaneous breathing APRV is identical to Pressure Controlled Inverse Ratio Ventilation.

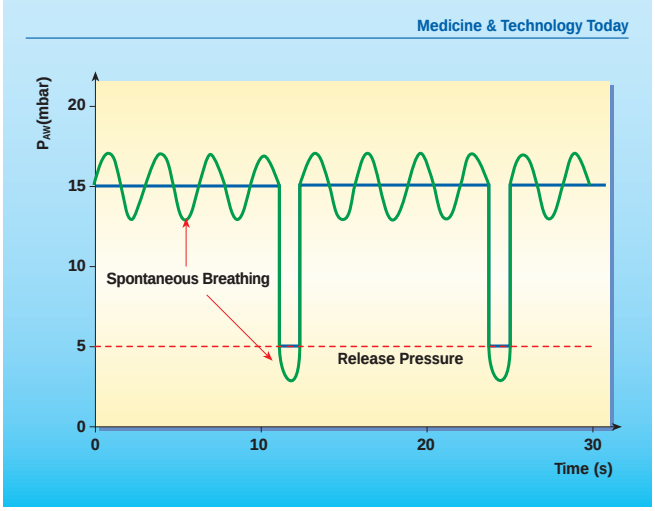

Figure 3

Clinical Applications – Biphasic Positive Airway Pressure Ventilation

This mode has now been used for full ventilatory support in clinical practice for 9 years and has generated many studies on its effects on lung mechanics, Acute Respiratory Distress Syndrome (ARDS), Acute Lung Injury (ALI), Asthma, weaning and the use of sedatives and muscle relaxants (10). Experience to date suggests a measurable positive contribution effect of interfacing spontaneous breathing with mechanical ventilation. This results in the reduction of mechanically imposed pressures and volumes which can have haemodynamic consequences.

Spontaneous breathing has been found to redistribute ventilation to well perfused dependent lung regions whereas mechanical ventilation is directed to the less well perfused non dependent regions. Finally, in the cost sensitive area of pharmacology there is less requirement for sedative drugs which has been demonstrated in studies by Burchardi, Rathgeber et al (10, 11) which has also major implications for the weaning process as withdrawal of mechanical control can begin as soon as the patient commences therapy (11).

Comparison Table 2

Feature/function	Biphasic Positive Airway Pressure	BiPAP® S/T	APRV
Performance characteristic	Demand flow system	Continuous flow (15-20 l/min)	1. High flow venturi system 2. Demand flow as used on Evita
Hose system	Inspiratory and expiratory limb with monitoring	Single hose system - rebreathing valve & minimal monitoring	Single or dual hose system depending on the device used
PCV and Pressure Support combination	Yes	N/A	No
Rate of pressurisation (ramp adjustment)	Yes	No *	Yes
Compensation for work of breathing through ET- tube	Yes (Optional-Automatic Tube Compensation)	N/A	Yes (with ATC)

*Newer models allow some adjustment

Clinical Application : BiPAP® S/T Ventilatory Support System

The system is applied to patients who are able to breathe spontaneously but whose efforts are unable to meet their total respiratory requirements (7). User set parameters such as pressure and rates (BPM) in the timed mode are outside the scope of full ventilatory support requirements. The system has its primary clinical applications in the area of obstructive sleep apnea, chronic obstructive pulmonary disease (COPD) and musculoskeletal disorders in the home care environment.

Clinical Application: APRV

APRV is increasingly used in critically ill patients with and without repiratory failure. The proposed clinical applications are in patients where there is a need to minimise the risk of pulmonary barotrauma by reducing the difference between peak and mean airway pressures. Experience also suggests a lesser circulatory compromise and decreased mismatching in terms of ventilation perfusion ratios. Sydow et al (12) compared APRV volume controlled inverse ratio ventilation (VC-IRV) in moderate to severe lung injury and observed a time dependent improvement in arterial oxygenation, the maximum benefit reached after 8 hours of ventilation which was achieved with lower maximum airway pressures. Results so far suggest that low airway pressures appear to be a consistent major advantage of APRV when compared with conventional controlled modes. This has lead some researchers to consider possible benefits in infants but there are no studies yet published.

Clinical Benefits

Biphasic Positive Airway Pressure Ventilation and APRV can be combined when discussing the expected clinical benefits of these modes which apply to the ICU environment and cannot be

directly compared with therapeutic benefits seen in the area of intermittent ventilatory assistance. Evidence and experience to date shows that in pulmonary compromised patients alveolar dead space and shunt are reduced and as a consequence gas exchange is improved. Sedation levels can be reduced and weaning can begin early in ventilatory therapy. Less

recent adjunct where the resistance of the endo-tracheal tube is automatically compensated is showing early promising results when combined with BIPAP and APRV in reducing the work of breathing in spontaneously breathing patients. Widespread user acceptance (non published controlled randomised data) due to simplicity of implementation of

ventilation are increasingly documented (14) and now with the contribution of spontaneous breathing many positive factors are added to the equation. In the absence of spontaneous breathing BIPAP is identical to PCV and likewise APRV without spontaneous breathing is identical to pressure controlled inverse ratio ventilation (PC-IRV).

Summary Comparison Table 3

Feature/Function	Biphasic Positive Airway Pressure	BiPAP® S/T System	APRV
Concept	Universal mode of ventilation integrated in ICU ventilator Evita	Low level pressure system for patient ventilation assistance	1. Stand alone, 2 level CPAP device 2.Mode of ventilation on ICU ventilator
Application method	Intubation/Mask	Mask	Intubation/Mask
Uses	All critical and non critical patients	Non continuous ventilatory support.	All critical and non critical patients.
Range of pressure settings	Full range (safety thresholds)	Restricted to low levels	Full range (safety thresholds)
Peak Inspiratory flow (max.)	180 Litres/min	N/A	180 Litres/min
Timed -high & low pressure intervals	Yes	Optional	Extended settings
Rate of pressure rise (ramp)	Full adjustment	Limited adjustment on new models only	Full adjustment
O_2% adjustment	21 - 100 %	Optional entrainment	21 -100 %
CO_2 rebreathing	No -dual hosecircuit	Possible (13) single hose/ circuit system	No -dual hose/circuit
Monitoring/Alarms	Integrated monitoring with back up ventilation	Limited monitoring -optional	1. Limited monitoring on stand alone deivice 2. Full monitoring on ICU ventilator-Evita

Biphasic Positive Airway Pressure variations are now commericially available on several different ventilators

alarms and parameters to adjust are a factor for clinical staff. Automatic Tube Compensation (ATC) referred to in Table 2, a

these modes must also not be overlooked. The perceived advantages of some well known modes such as pressure controlled

Conclusion

The topic of spontaneous breathing in intubated patients interfaced with mechanical ventilation in BIPAP and APRV is a subject of wide investigation. In the modern clinical ICU environment new and old ventilation therapies run side by side and a clear consensus on the best approach to management of ventilatory disorders with the appropriate mode of support has yet to emerge (15). In essence Biphasic Positive Airway Pressure is a form of pressure controlled ventilation which allows spontaneous breathing at all times, APRV is similar with the emphasis on extended times at higher pressures. The BiPAP® System is a non continuous form of breathing support.

The benefits of using BIPAP and APRV indicate that this approach is not a passing vogue and that modes that facilitate and capitalise on the patients own breathing are a real step in the right direction in all ventilatory therapy – namely the early discontinuation of all mechanical intervention and reduction of invasiveness.

REFERENCES

1 Benzer H (1988) Ventilatory support by intermittent changes in PEEP levels. 4th European Congress on Intensive Care Medicine. Baveno-Stresa

2 Baum M, Benzer H, Putensen CH, Koller W. & Putz G (1989) – eine neue Form der augmentierenden Beatmung. Anaesthetist 38:452-458

3 Stock. M. CH, Downs J.B, Airway Pressure Release Ventilation:Anew concept in ventilatory support, Critical Care Medicine Vol 15 No 5 (1987) 459-461

4 Baum M, Mutz N. J, Hörmann C,B IPAP, APRV, IMPRV: Methodological Conceptand Clinical Indications. Yearbook of Intensive Care and Emergency Medicine. (Vincent), (1993)

5 Weismann D., 7 – The 'Physiological' Approach to Artificial Ventilation; Mechanical Ventilation for Experts; Congress proceedings, Jerez (1994)

6 Lofaso F, Brochard L, Hang T, Lorino H, Harf A,& Isabey D, Home versus Intensive CarePressure Support Devices; Am J Respir Crit Care Med (1996) vol 153. Pp1591 1599

7 Respironics Inc, Murrysville Pa, (1992) BiPAP® Systems Guidebook; A Discussion of the systems and their applications

8 Respironics Inc, Murrysville Pa (1990) BiPAP® Clinical Manual for Models S/T and S/T/D

9 Calzia E, Radermacher P. Airway Pressure Release Ventilation and BiPhasic Airway Pressure. A review over 10 years. Clin Intensive Care (1997); 8:296-301

10 Burchardi H, Rathgeber J, Sydow M, The concept of Analgo-Sedation depends on the concept of Mechanical Ventilation: Yearbook of Intens. Care & Emerg Medicine1995 (Vincent)

11 Rathgeber J, Schorn B, Falk V, Kazmaier S, Speiegel T, Burchardi H. The influence of CMV,I MV, BIPAP on duration of intubation, consumption of analgesics & sedatives. Eur J.Anaes 1997; 14:576-582

12 Sydow M, Burchardi H, Ephraim E, Zielmann S, Crozier T A, Long term effects of two different Ventilatory Modes on Oxygenation in Acute Lung Injury. Am J Respir Crit Care Med 1994; 149:1550-6

13 Ferguson T, Gilmartin M, CO2 rebreathing during BiPAP® ventilatory assistance. Am J Respir Crit Care Med 1995 151:1126-1135

14 Morley P, Pressure Controlled Ventilation (PCV) The Ideal Mode of Ventilation? Yearbook of Intensive Care & E mergency Medicine 1998 (Vincent)

15 Fitzgerald J, The requirements of present and future ventilation systems: World Medical Technology Update Yearbook 1997/98. (Kellock) Kensington Publications Ltd.