International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Randomised Controlled Study Comparing Adaptive Support Ventilation (ASV) and Synchronised Intermittent Mode of Ventilation (SIMV) with Respect to Weaning

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Received: 16/01/2017 *Revised: 28/01/2017* *Accepted: 30/01/2017*

ABSTRACT

Aim: ASV is a closed-loop ventilation mode that can act both as pressure support ventilation and pressure-controlled ventilation. The aim of the present randomised controlled study was to compare ASV mode with SIMV in ICU (Intensive Care Unit) patients with respect to weaning on the following parameters: time from readiness to wean to extubation with total numbers of ventilation days and ICU stay.
Methods: 40 patients, who were on intermittent positive pressure ventilation (IPPV), were included in this study, randomly, 20 patients were weaned by ASV mode group A, and 20 patients were weaned by conventional weaning (SIMV) group B (control group).
Result: We found that the patients who were on adaptive support ventilation (group A) had higher P/F ratio and better oxygenation than synchronised intermittent mode of ventilation during the period of weaning. Mean time duration of weaning upto extubation and length of stay in the ICU was shorter with ASV than SIMV mode but the difference was not statistically significant.
Conclusion: This study suggest that ASV can be a useful alternative to conventional mode of ventilation for weaning from mechanical ventilation with advantage of better oxygenation and P/F ratio.
Keywords: Adaptive Support Ventilation (ASV), Syncrhonized Intermittent mode of ventilation (SIMV), Weaning, Mechanical Ventilation.

INTRODUCTION

Mechanical ventilation is frequently used to provide respiratory support in times of critical illness or in patients undergoing general anaesthesia. Mechanical ventilation is indicated when the patient's spontaneous breathing is not adequate to maintain life. It is also indicated as prophylaxis for imminent collapse of other physiologic functions, or ineffective gas exchange in the lungs. [1]

The main goals of mechanical ventilation are oxygenation and carbon dioxide elimination, which are ensured by maintaining adequate tidal volumes and respiratory rates. But from past many years, it has been a issue of concern that mechanical ventilation aggravates existing lung injury or may itself induces lung injury (ventilator-associated lung injury -VALI). [2,3]

Traditionally, SIMV was used for mechanical ventilation and for weaning. A new mode (which is called intelligent mode) included in new ventilators, was optionally started to be used in some patients. Results were analyzed to prove the benefit of this new mode, ASV for early weaning from ventilator. ASV evolved as a form of mandatory minute ventilation (MMV) implemented with adaptive pressure control**.** MMV is a mode that allows the operator to preset target minute ventilation, the ventilator then supplies either volume or pressure-controlled mandatory breaths if the patient's spontaneous breaths generate lower minute ventilation. [4]

ASV first clinical application was described in 1994. [4] It is considered to be the first commercially available ventilator system that uses an "optimal" targeting schema. In this context, "Optimal" means minimizing the mechanical work of breathing.The machine selects tidal volume (V_T) and frequency that the patient's brain would presumably select if the patient were not connected to a ventilator. This pattern is assumed to encourage the patient to generate spontaneous breaths. [4]

This mode provides specific minute ventilation and a breathing pattern optimized to the point of the smallest total energy expenditure, and it is based on patient's requirements. Thus, the ASV replaces other ventilatory modes designed solely for a specific phase of mechanical ventilation. It can be used for total or partial ventilatory support during the initiation, maintenance or weaning from mechanical ventilation.

Weaning from mechanical ventilation is an essential and universal element in the care of critically ill patients receiving mechanical ventilation. It is the gradual withdrawal of ventilatory support with total spontaneous ventilation, and appropriate rest periods for muscle unloading. Weaning covers the entire process of liberating the patient from mechanical ventilation and from the endotracheal tube. [5] The process of weaning is not static but it requires continous reassessment of patient so that the particular ventilatory needs of the patient are met while the disease process is corrected.

There is uncertainty about the best methods for conducting weaning, which will generally require the cooperation of the patient during the phase of recovery from critical illness. This makes weaning an important clinical issue for patients and clinicians. Mechanical ventilation can be discontinued as soon as the patient is able to protect his/her airway and sustain a physiologically-competent minute ventilation.

METHODOLOGY

This randomized and prospective double blind study was undertaken in the Intensive Care Unit of Trauma Centre, King George's Medical University, Lucknow after getting permission from the Institutional Ethics Committee. 40 patients, who were on IPPV, were included in this study. After satisfying the weaning criteria, randomly, 20 patients were weaned by ASV mode – group A, and 20 patients were weaned by conventional weaning (SIMV)– group B. Both ASV and SIMV were provided with Hamilton C1 ventilator.

In the ASV group, in addition to FiO_2 we set 2 other parameters patient's Ideal Body Weight (IBW) and %Min Vol. The IBW is calculated with ***Devine's Formula:*** [6]

For Males: IBW = 50 + 2.3 (height in inches - 60)

For Females: IBW = 45.5 + 2.3 (height in inches - 60)

The ASV guidelines provided by Hamilton Medical suggest that % Min Vol started at 100% in normal patients, at 90% in COPD patients, at 120% in ARDS patients, at 110% in other patients (+ 20 if body temperature > 38.5°C).% Min Vol. was reduced by 10% (not less than 70%) after a period of time with patient tolerating minimum respiratory support as measured by increased acceptable spontaneous breaths, acceptable Exp Min Vol, decreased P_{insp} (<8 cm of H_2O) and acceptable blood gases.

In a haemodynamically stable patient with FiO_2 <40% and PEEP <8 mmHg tolerates minimum respiratory support after a period of time with Pinsp<8 cmH_2O, fControl = 0, weaning can be considered to be achieved, with acceptable minimum fSpont and ExpMinVol, and patient consider for extubation.

Patients in group B are switched over to spontaneous mode of ventilation using the same Hamilton C1 ventilator with Pressure support of 10-12 cm H_2O, Fraction of Inspired Oxygen (FiO_2 = 40%-50%), Positive End Expiratory Pressure (PEEP) = 3-5 cmH_2O.

To study the impact of two modes on time from readiness to wean to extubation, number of ventilator days and final outcome of the patients in two groups were compared. For this we assessed the following variables:

- Blood Pressure, heart rate, SPO_2 are measured at baseline and for 36 hours during the period of spontaneous breathing trial and weaning, to quantify hemodynamics.
- Arterial blood gases are performed before and during the period of spontaneous breathing trial and weaning.
- The severity of illness was evaluated by APACHE II score, GCS score at the time of admission.

For initial assessment of the readiness for weaning we calculated rapid shallow breathing index (RSBI) after 30 min of spontaneous breathing trial. As measures of pulmonary function, P/F ratio at baseline and for 36 hours thereafter was noted.

A set of weaning criteria is established and patients are weaned randomly, after fulfilling the criteria, either by ASV or by conventional weaning method.

Clinical Criteria:

- Initial reason for providing ventilatory support to be resolved or significantly improved
- Stable hemodynamics (systolic blood pressure (SBP) between 100 to 140 mmHg, diastolic blood pressure (DBP) between 60 to 90 mmHg with minimal or no vasopressors, and heart rate ≤ 140 beats per minute)
- No evidence of myocardial ischemia or cardiac arrhythmias
- No significant fever or infection
- Patient should be arousable
- No significant electrolyte abnormality

Ventilatory Parameters:

- Stable spontaneous ventilator drive
- Tidal volume 4-6 ml/kg
- Pinsp less than equal to 10 cm H_2O

ABG Parameters:

- PaO_2> 60 mmHg on $FiO_2 \leq 50\%$
- PaCo2 < 50mmhg on $FiO_2 \leq 50\%$
- PaO_2 / FiO_2 ratio : > 200 mmHg
- pH : 7.35 to 7.45
- HCO_3^- = 22 to 26 meq/l

RESULTS

The ASV and SIMV groups were demographically similar at the time of randomisation. The severity of illness assessed by APACHE II score and GCS, were also comparable between the two groups. 36 patients were extubated and discharged after the weaning period. 3 patients in the ASV group (15%) and 1 patients in the SIMV group (5%) were considered to be weaning failures (p.0.29). The main finding in this study was higher P/F ratio and better oxygenation in ASV mode than SIMV mode during the period of weaning. The difference was found to be statistically significant **(p<0.05)** after 6 hours of ventilation. During weaning after 6, 12, 24 hrs of ventilation mean P/F ratio in ASV mode was 292, 308, 333, while in SIMV mode mean P/F ratio was 252 ,263 ,281 at same time interval. We found that mean time duration of weaning up to extubation was shorter in ASV mode (20.29±8.76) than SIMV mode (22.42±7.81).But this difference between both the groups was statistically insignificant **(p=0.44). Duration of ventilator days and ICU stay days** in ASV were 4.30±3.24 and 5.55±3.28 while in SIMV were 5.65±4.08 and 7.25±4.20. Mean number of ventilator days and ICU stay days was shorter in ASV group as compared to SIMV group, however statistically this difference was insignificant. **Hemodynamic variables** (heart rate, SBP, DBP) were measured among the two groups and the average values were compared between them. The mean pulse rate revealed statistically significant difference between the two groups ($p<0.05$) and it was higher in SIMV group after 2 hours and 6 hours of spontaneous breathing trial than the ASV group probably because of better patient comfort on ASV mode. Systolic blood pressure(SBP) was slightly lower in group A (ASV) than group B (SIMV) during the weaning process and did not reveal any significant difference between the two groups ($p>0.05$).

Table-1 . Difference between patients in each group

Groups	*Group A*	*Group B*
Age	32±7	35±13
Sex (Male/ Female)	10/10	6/14
GCS	9.35±0.81	9.40±0.82
Apache II	17.40±2.01	18.30±1.38

Table- 2. Difference in parameters in both groups

Groups	*ASV (A)*	*SIMV (B)*
ICU stay length (days)	5.55±3.28	7.25±4.20
Time from readiness to wean to extubation (hrs)	20.29±8.76	22.42±7.81
Ventilator days	4.30±3.24	5.65±4.08
SBP/DBP (mmHg)	124/72	126/73
Heart rate (/ min)	90.5	98.3
Respiratory rate (/min)	18	16

Table-3: Comparison of P/F ratio between the groups across the time periods.

Time period	**Group A (n=20)**		**Group B (n=20)**		**p-value[1]**
	Mean	**SD**	**Mean**	**SD**	
0 hr	110.45	27.24	113.20	18.90	0.71
1 hr	105.80	20.46	102.70	13.85	0.57
2 hrs	109.75	21.91	101.25	12.51	0.14
6 hrs	116.85	26.01	103.90	11.43	0.04*
12 hrs	123.35	27.76	106.55	10.61	0.01*
24 hrs	130.95	23.66	116.40	11.86	0.01*
36 hrs	116.75	18.90	118.70	16.75	0.73

[1]Unpaired t-test, *Significant

DISCUSSION

This study shows that using different ventilator modes results in different variable outcomes in the weaning process, such as oxygenation, P/F ratio, time of ventilation and then extubation which may differ from one mode to another. In this study we compared the most popular mode of ventilation used in our CCU, SIMV, with the new mode called ASV (intelligent mode) which was included in the new ventilator machine. We found P/F ratios to be higher in ASV group as compared to SIMV group at all time intervals during spontaneous breathing trial and weaning. With ASV mode P/F ratio was persistently improving with subsequent hours of ventilation. After 12 hrs of ventilation with ASV, P/F ratio was greater than 300 mmHg, this showing ASV lung protective mechanism and less association with ALI or ARDS. ***Kath et al*** [7] present a case report of successful management of ventilator associated pnemonia (VAP) by using ASV and found improvement in oxygenation and P/F ratio.

We found that mean time duration of weaning upto extubation was shorter in ASV mode than SIMV mode. However, this difference between both the groups was not significant in our study. ***Petter et al*** [8] evaluated automatic respiratory weaning in ASV for early tracheal extubation after cardiac surgery. They also found that there were no differences between groups in duration of tracheal intubation and intensive care unit stay. ***Dongelmans et al*** [9] concluded that weaning automation with ASV is feasible and safe in non-fast-track coronary artery bypass grafting patients. Time until tracheal extubation with ASV equals time until tracheal extubation with standard weaning. ***Schädler D et al*** [10] found that overall ventilation time did not significantly differ between the automated-weaning and control groups. While ***Kikrali et al*** [11] found that ASV shortens total mechanical ventilation duration and the duration of weaning with fewer manual ventilator settings.

In group A, ASV mode provides ventilation in pressure support (pressure control ventilation) and automatic change from pressure control ventilation to inspiratory pressure support. This also leads to fast spontaneous ventilation and the patient-machine interaction was improved in comparison with the SIMV mode, and this leads to early weaning from the ventilator. The ASV mode was possible in almost all types patients, including the moderate respiratory failure (PaO_2/FiO_2 ratio between 250-300mmHg) with appropriate inspiratory pressure. The smooth weaning and extubation in ASV mode decreased the requirement of serial ABGs with its re-ducing the use of resources, nursing effort, and finally the total cost, and simplifying of the weaning trials.

When ASV was used on passive patients with different respiratory system mechanics (normal lungs, restrictive disease, or obstructive disease), the ventilatory pattern applied by the automatic controller was markedly different: frequency and I:E ratio were adapted as expected, according to the type and severity of the respiratory disease. [12] ASV has been studied as the sole mode of ventilatory support in chronically ventilated patients and has been shown to be cost effective with minimal settings required to be altered for accomplishment of effective weaning process. [13] ASV has the capability to adjust automatically to the patient ventilatory requirements by selecting different VT-RR combinations based on respiratory mechanics in passive, mechanically ventilated patients [14] and hence can be successfully applied to any subset of patients. VAP is a fatal nosocomial infection which besides antibiotic cover and supportive measures requires lung protective advanced mode of ventilation which can be provided by effectively by ASV. [7]

CONCLUSION

We concluded that from both modes of ventilation neither of modes can be consider superior in respect to haemodynamics, ventilator parameters or overall survival benefit. The only significant difference observed is the oxygenation and P/F ratio which is found to be significantly better in our study group i.e. ASV mode. ASV can be a useful alternative to conventional mode of ventilation for weaning from mechanical ventilation. ASV is automatic ventilation mode and needed less manipulation of the setting that could simplify respiratory management. So this mode is easy to operate by ICU staff without the need for respiratory therapists or continuous attendance by intensive care specialist to conduct weaning.

Abbreviations

ALI – Acute Lung Injury
APACHE – Acute Physiologic and Chronic Health Evaluation
ASV – Adaptive Support Ventilation
ARDS – Acute Respiratory Distress Syndrome
COPD – Chronic Obstructive Pulmonary Diseases
DBP – Diastolic Blood Pressure
FiO_2 – Fraction of inspired Oxygen
GCS – Glasgow Coma Scale
ICU – Intensive Care Unit
IBW - Ideal Body Weight
IPPV – Intermittent Positive Pressure Ventilation
MMV – Mandatory Minute Ventilation
$PaCO_2$ – Partial pressure of Carbon dioxide
PaO_2 – Partial pressure of Oxygen
Pinsp – Inspiratory Pressure
PEEP – Positive End Expiratory Pressure
RR – Respiratory Rate
SBP – Systolic Blood Pressure
SIMV – Synchronized Intermittent Mandatory Ventilation
VAP – Ventilator Associated Pneumonia
V_T – Tidal Volume
VALI – Ventilator Associated Lung Injury

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How to cite this article: Doneria D, Arshad Z, Singh GP et. al. Randomised controlled study comparing adaptive support ventilation (ASV) and synchronised intermittent mode of ventilation (SIMV) with respect to weaning. Int J Health Sci Res. 2017; 7(2):37-42.

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