Original article

Comparison of Synchronised Intermittent Mandatory Ventilation with Pressure Support versus Assist Control mode of ventilation on time to extubation

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Abstract

Introduction: Increased work of breathing causing inspiratory muscle fatigue can delay extubation. **Aim:** This study compared the time taken for extubation in patients admitted with acute respiratory failure and ventilated with assist control mode (ACV) of ventilation or synchronised intermittent mandatory ventilation and Pressure Support (SIMV-PS). **Patients and Methods**: This was an observational study conducted in medical and surgical intensive care unit of a tertiary care hospital in South India. Patients receiving invasive mechanical ventilation for more than 24 hours were enrolled into the study. Demographic data, ventilator settings, ABG values after initiation of mechanical ventilation and before extubation, change of initial mode were recorded. The primary outcome was to determine the difference in the time taken for extubation (hours). **Result:** A total of 34 subjects were enrolled, twenty in SIMV-PS and fourteen subjects in ACV. The median age of the subjects was 53 years, 23 (68%) were males and 11 (32%) were females. The median (interquartile range) of Acute Physiology and Chronic Health Evaluation II (APACHE II) score was 18.5 (14, 29). Majority had a diagnosis of sepsis (23.5%) and pneumonia (17.6%). The median time on mechanical ventilation in SIMV-PS group was 90 h (57, 133) and in ACV group was 131 h (64, 258). There were also no statistical differences in the duration of weaning (p). **Conclusion:** Mechanical ventilation with assist control mode of ventilation or synchronised intermittent mandatory ventilation and pressure support are comparable in the time to weaning patients off ventilator.

Keywords: Key Words: Intermittent Positive-Pressure Ventilation, Ventilator Weaning, Work of Breathing

Introduction

Mechanical Ventilation (MV) is a life-saving modality used in Intensive Care Units (ICU). It is used to mechanically assist spontaneous breathing or provide mandatory breaths if the patient is apnoeic.[1,2] The primary goal of mechanical ventilation is to improve gas exchange and reduce the work of breathing (WOB), especially in patients with acute respiratory failure (ARF), without causing any iatrogenic lung injury.[3] While initiating MV, the mode of ventilation is the first parameter selected. This determines how the ventilator breath is initiated, delivered and terminated.[1,4] In clinical practice, the commonly used ventilator modes are assist control (ACV), synchronised intermittent mandatory ventilation (SIMV) and pressure support ventilation (PSV).

In SIMV, breaths are patient or time-triggered, flow-limited, and volume-cycled. PSV is a patient-triggered, pressure limited and flow cycled type of ventilation.[1] SIMV and PSV modes are usually combined, where SIMV provides the mandatory breaths as described and PSV assists the spontaneous

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breaths of the patient. In ACV mode, the breaths are patient- or time-triggered, flow-limited, and volume-cycled similar to SIMV mandatory breaths but unlike SIMV, all spontaneous breaths are assisted in the same manner. In this mode, the volume or pressure delivered in every breath will be the same, regardless of patient or time triggering.

In patients with acute respiratory failure, SIMV+PSV may increase the WOB and may lead to respiratory muscle weakness gradually causing delay in weaning, as well as extubation.[5,6] ACV may reduce the WOB in patients with ARF.[7] Hence the selection of mode may have an impact on respiratory muscles thus prolonging the duration of mechanical ventilation (MV) or the days to extubation.[5] Reduction in WOB may reduce the duration of MV and reduce the time taken for extubation.

There is a paucity of studies comparing the effect of SIMV+PSV and ACV on the time taken to extubation. The aim of this study is to compare the effects of SIMV+ PSV and ACV modes on time taken to extubation in patients admitted with acute respiratory failure.

Patients and methods

All adults above the age of 18 years and who received invasive mechanical ventilation for more than 24 hours were included in the study. Ethical approval was obtained before the commencement of the study and informed consent was obtained from the relatives of the participants. All the data were collected from patient records using an expert validated proforma. Data collection was performed during the month of August 2016 to January 2017 (6 months). Participants receiving ventilation *via* noninvasive positive pressure ventilation (NIPPV), admitted with cardiac and neurological diseases, patients who had self-extubated and who were unwilling to take part in the study were excluded.

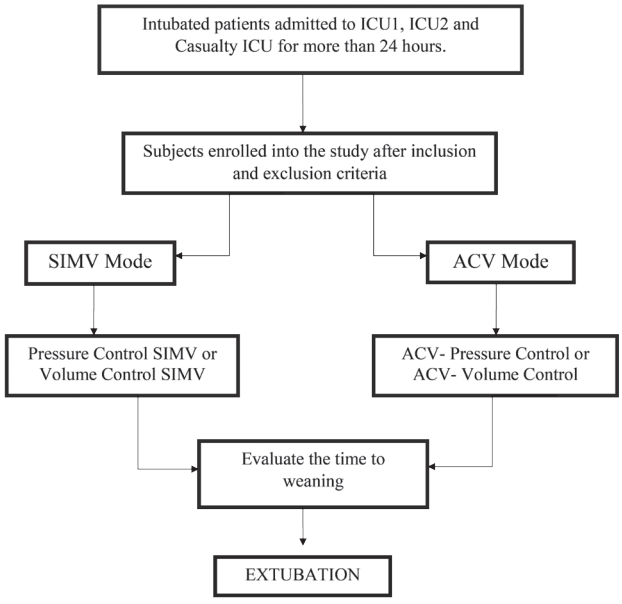

Figure 1: Consort diagram of the study

The need for mechanical ventilation, sedation, ventilator settings, mode of ventilation and the decision to wean or extubate were solely decided by the consulting physician. All patients received critical care services provided by the consulting physician irrespective of the mode of ventilation. The decision to not to participate in the trial was decided by the consulting physician. The primary outcome was time taken (hours) to extubate the patient. The secondary outcomes were levels of oxygenation (PaO_2) and reintubation rates. Apart from these, the subject demographics, ventilator settings, arterial blood gas (ABG) values on the day of initiating mechanical ventilation and on the day of extubation, and the change of initial mode along with its reason were recorded. All data were compiled in Excel and transferred to SPSS for Windows, Version 16.0 for analysis.

The data was tested for normality. The level of statistical significance was considered as 5% ($p<0.05$). Continuous variables with normal distribution are represented as mean with standard deviation and others as median with interquartile range (IQR). The categorical variables are presented as the frequency and percentage. Independent t-test, Mann-Whitney U test, and Chi-square test are used to analyse the data.

Results

A total of 39 participants were enrolled in the study, of which 20 were ventilated with SIMV+PSV and 19 were ventilated with ACV. The baseline characteristics of participants are summarised in *Table 1*. The mean age of the participants was 56 years. 69% were males and 31% were females. Sepsis (23.5%) was the major cause of admission and the second being pneumonia (17.6%). The APACHE II score was found significantly higher in ACV group (p=0.011).

Table 1: Baseline characteristics of subjects in SIMV+PSV and ACV groups

Demographic Characteristics	Total (n = 39)	SIMV+PSV (n = 20)	ACV (n = 19)	P value
Age in years (mean ± SD)	56.6 ± 18.7	52.3 ± 18.5	53 ± 19	0.936
Gender n (%)				
Male	27 (69)	14 (70)	13 (68)	0.915
Female	12 (31)	6 (30)	6 (32)	
Cause of Admission n (%)				
Sepsis	12 (31)	5 (26)	7 (32)	0.579
Pneumonia	6 (15)	4 (20)	2 (11)	
Post-surgery	3 (8)	0	3 (16)	
Snakebite	1 (3)	1 (5)	0	
Seizure	4 (10)	2 (10)	2 (11)	
Leptospirosis	2 (5)	1 (5)	1 (5)	
OP	2 (5)	2 (10)	0	
Poisoning	3 (8)	1 (5)	2 (10)	
RTA	1 (3)	1 (5)	0	
Liver cirrhosis AKI/CKD	5 (13)	3 (15)	2 (10)	
APACHE (median, IQR)	19 (14,29)	18 (14,19)	25 (16,30)	0.011*

SIMV-PS =Synchronized intermittent mandatory ventilation with pressure support, ACV = Assist control, SD = Standard deviation, RTA = Road traffic accident, AKI/CKD =Acute kidney injury/chronic kidney disease, IQR = Interquartile range.

The ventilator settings used initially and before extubation were compared and are represented in *Tables 2a and 2b*. No statistically significant differences were found in the inspired oxygen (FiO_2) requirement and inspiratory times (T_{insp}). The frequency of breaths and PEEP used differed between the modes of ventilation (P = 0.001). There was no significant difference in the ventilator settings during spontaneous breathing trial (SBT).

Table 2a: Comparison of initial ventilator setting in SIMV-PS and ACV groups

Ventilator parameter	SIMV-PS group	ACV group	P value
FIO_2 (%)	90 (80, 100)	100 (80, 100)	0.232
RR (breaths/min)	12 (12,14)	15 (14, 16)	0.001*
PEEP (cm H_2O)	5 (5, 5)	8 (7, 10)	0.001*
Tinsp (s)	1.5 (1.2, 1.6)	1.5 (1.3, 1.6)	0.977

Table 2b: Comparison of ventilator settings before extubation in PSV mode

Ventilator parameter	SIMV-PS group	ACV group	P value
FIO_2 (%)	40 (30, 40)	35 (30, 40)	0.904
RRspont (breaths/min)	21 (18, 23)	21 (16, 22)	0.551
PEEP (cm H_2O)	5 (5, 5)	5 (5, 5)	0.261
PSV level (cmH_2O)	8 (6, 10)	8 (7, 11)	0.537

The ABG parameters obtained after initiation of mechanical ventilation were compared between the ventilator modes *(Tables 3a and 3b)*. Oxygenation was better in the SIMV-PS group with a significantly higher PaO_2/FiO_2 ratio (P = 0.02) in the SIMV + PSV group than ACV group after the initiation of mechanical ventilation. Ventilation was also better in the SIMV + PSV group as evidenced by a lower $PaCO_2$ (P = 0.033) and a higher pH (P = 0.008) as compared to ACV group. were significantly high.

Table 3a: Comparison of blood gas values after initiation of mechanical ventilation

Variables	SIMV-PSV group	ACV group	P value
pH	7.43 (7.29, 7.46)	7.31 (7.21, 7.39)	0.008*
$PaCO_2$ (mm Hg)	32 (28, 38)	40 (33, 47)	0.033*
PaO_2 (mm Hg)	181 (121, 284)	104 (61, 148)	0.004*
HCO_3 (mmol/L)	20 (18, 23)	19 (14, 22)	0.261
PaO_2/FIO_2	252 (126, 342)	133 (61, 186)	0.02*

Table 3b: Comparison of blood gas values before extubation

Variables	SIMV + PSV group	ACV group	P value
pH	7.44 (7.40, 7.46)	7.43 (7.37, 7.45)	0.448
$PaCO_2$ (mm Hg)	36.2 (33, 42)	35.5 (32, 42)	0.897
PaO_2 (mm Hg)	125 (87, 173)	119 (96, 158)	0.606
HCO_3 (mmol/L)	24 (21, 26)	22.6 (20.4, 27)	0.376
PaO_2/FIO_2	413 (277, 455)	343 (260, 486)	0.568

The severity of acute lung injury was compared between the two groups. Ninety percent of the

patients in the SIMV+PSV group had mild to moderate lung injury. However, eighty percent of the patients in ACV group had moderate to severe acute lung injury. The difference was significant.

Table 4: Comparison of P/F ratio in SIMV-PS and ACV groups

P/F Ratio	SIMV-PS group	ACV group	P Value
Mild ARDS	12 (60%)	4 (21%)	0.03
Moderate ARDS	6 (30%)	8 (42%)	
Severe ARDS	2 (10%)	7 (37%)	

There was no change of primary mode of ventilation in 20 patients ventilated with SIMV+PSV group. Ten out of nineteen patients ventilated with ACV were either switched to SIMV+PSV or to advanced mode of ventilation were excluded from the analysis of time taken to extubation. There was no statistically significant difference between the groups in terms of time taken for extubation (p= 0.496).

Among 39 patients, only 33 (85%) subjects received SBT *via* PSV mode, and the median number of SBT trials given in the both groups was 2.

Table 5: Comparison of outcome variables in patients ventilated with SIMV-PS and pure ACV mode

Outcome variables	SIMV + PSV group	ACV group	P value
Time taken to extubate (h) (Median, IQR)	90 (57, 133)	110 (36, 186)	0.49
ICU days (Median, IQR)	6 (4, 8)	7 (4, 10)	0.57
Total duration of hospital stay (days)	12 (7, 16)	12 (6, 22)	0.97
Reintubation n (%)	4 (20)	1 (5.2)	0.18
Mortality n (%)	4 (20)	5 (26.3)	0.89

The ICU and hospital length of stay were found similar in both the groups (p=0.57). No cases of barotrauma or any other complications of mechanical ventilation were observed in either group. Mortality and reintubation rate did not differ statistically. One subject from each group was discharged at request.

Discussion

Esteban *et al* conducted a one-day point prevalence study describing the characteristics of conventional mechanical ventilation in ICUs of North America, South America, Spain, and Portugal.[8] They found that acute respiratory failure (66%) was the most common indication of mechanical ventilation, the primary indication and ventilator settings were similar across the countries. The median age of patients was 61 years, ACV (47%) and SIMV (46%) were the common modes of mechanical ventilation utilised. However, the selection of modes and methods of weaning varied considerably from country to country.

In our study, all the patients were receiving mechanical ventilation due to acute respiratory failure, more than half, 51.28%, of participants received SIMV+PSV mode of ventilation while 48.71 % received ACV mode of ventilation, showing that both SIMV+PSV and ACV are utilised to ventilate patients suffering from acute respiratory failure. The weaning mode was PSV and 88% of the participants received SBT trial before extubation.

Chiumello D *et al* tested two protocols of ventilation, one targeting similar peak inspiratory flow (PIF) and another targeting high and low PIF.[4] The aim of the study was to assess the WOB across the different assisted modes of ventilation, *i.e.*, pressure support, pressure control and volume control. They concluded that if the PIF is similar all the assisted modes reduced WOB similarly and during ACV, tidal volume and PIF are main determinants of patient/ ventilator interaction. We did not study the determinants of WOB. The participants were not ventilated using similar ventilator settings and similar PIF, thus representing a difference in ventilator assistance.

Luo J *et al* conducted a trial that aimed to determine whether the SIMV+PSV could improve clinical outcome in patients with acute respiratory distress syndrome (ARDS).[9] They found that the SIMV+PSV mode provided a higher oxygenation (PaO_2/FiO_2 ratio) ($p< 0.05$), with lower PEEP and FiO_2 utilization ($p< 0.001$). There was no switching of mode from SIMV+PSV to A/C, $p<0.001$. Another outcome measure such as incidence of delirium, the dosage of sedative and analgesics, duration of mechanical ventilation, patient-ventilator asynchrony, hospital stay did not differ statistically. They concluded that in patients with moderate ARDS, SIMV+PSV can

safely and effectively improve oxygenation, although it does not influence the outcome measures studied. Although, this study did not find any difference in the time taken to extubation, the time taken to extubation may have been influenced by the difference in the severity of illness between the groups. Our study highlights the ability of SIMV+PSV mode in safely and effectively improving oxygenation in subjects with ARDS. This is the first study describing the effect of SIMV+PSV *versus* A/C on the time taken to extubation in patients admitted with acute respiratory failure. This is a small pilot study and the findings need to be confirmed with larger study including the work of breathing, ventilator parameters and sample size calculations.

Conclusion

The time taken to extubation in patients admitted with acute respiratory failure and ventilated with either assist control mode of ventilation or synchronised intermittent mandatory ventilation and pressure support is similar. Further studies are necessary to address the effect of SIMV+ PSV and ACV mode in patients with similar severity of illness.

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