ORIGINAL ARTICLE

Synchronized Intermittent Mandatory Ventilation with Pressure Support versus Assist Control Ventilation in Treatment of Acute Respiratory Distress Syndrome

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Abstract

Background: ***The ARDS Berlin definition classifies acute respiratory distress syndrome (ARDS) as a sudden worsening of lung damage due to several illness types.***

Aim: ***In the management of patients with acute respiratory distress syndrome (ARDS), we aim to evaluate the efficacy of assist control ventilation (ACV) in comparison to synchronized intermittent mandatory ventilation with pressure support (SIMV+PS).***

Subjects and methods: ***Participating in this prospective randomized controlled open label trial that included acute respiratory distress syndrome (ARDS) were fifty patients admitted to the critical care unit of the emergency medicine and critical care departments at Bab El-Shaareya, Al-Azhar University Hospital in Egypt from May 2023 to May 2025.***

Results: ***Group A had considerably lower PaCO2 and FiO2 than group B at 2, 12, 24, 36, 48, and 72 hours. There was no statistically significant difference in PaO2 between the two groups at various time points. Group A had a considerably higher PaO2/FiO2 ratio than group B at 2, 12, 24, 36, 48, and 72 hours. The ratio of P/F was noticeably different in the two groups. Group A had a substantially lower PEEP compared to group B. The two groups did not differ significantly with respect to total ventilator days, intensive care unit days, hospital stay, delirium, or mortality rate.***

Conclusion: ***In patients with ARDS, SIMV+PS showed superior outcomes in terms of PaCO2, FiO2, and PaO2/FiO2 ratio, indicating better oxygenation and ventilation efficiency. However, the modes did not differ significantly in terms of clinical outcomes like ICU stay, delirium, or mortality.***

Keywords: ARDS; PS; SIMV; ACV

1. Introduction

The extremely high death rate associated with acute respiratory distress syndrome (ARDS) remains a major therapeutic concern. Reports of ARDS mortality rates ranging from 30% to 40% have been made in recent decades.[1,2]

There is presently no medicine that addresses acute respiratory distress syndrome (ARDS), and patients who require life support rely on invasive mechanical ventilation, which can cause lung damage.[3]

To prevent additional damage to the lungs caused by mechanical ventilation, new methods such as open-lung techniques and lung protective ventilation were developed. These methods improve hypoxemia and decrease mortality.[1]

In SIMV, breaths are either prompted by the patient or by a specific time, and they are also flow-limited and volume-cycled. Pressure-limited, flow-cycled, patient-triggered ventilation is known as PS ventilation.

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The patient is ventilated in a hybrid mode that combines SIMV and PS, with the former providing the necessary breaths and the latter assisting with the patient's spontaneous breaths. Like SIMV obligatory breaths, ACV breaths are patient-or time-triggered, flow-limited, and volume-cycled; however, in contrast to SIMV, all spontaneous breaths in ACV mode are assisted. Every breath in this mode will have the same volume or pressure provided to it, independent of the patient or the moment it was triggered.[4]

It may be more effective and faster than ACV to increase oxygenation in ARDS patients with decreased PEEP and FiO2, since the results demonstrated that the mechanisms of spontaneous breaths may play a critical role, which are mostly conserved in SIMV+PS.[5]

In order to better treat patients with acute respiratory distress syndrome (ARDS), this study compared the results of SIMV+PS with assist-control ventilation.

2. Patients and methods

Fifty patients admitted to the critical care unit from the emergency medicine and critical care departments at Bab El Shaareya, Al-Azhar University Hospital, Egypt, between May 2023 and May 2025, were part of this prospective randomized controlled open label trial. An ethical review board from Egypt's Al-Azhar University's Faculty of Medicine gave the study the green light, and all patients' guardians provided their written agreement.

Inclusion criteria:

Subjects were selected from among adults (18+) on mechanical ventilation who met the Berlin criteria for acute respiratory distress syndrome (ARDS).

Exclusion criteria:

This encompasses patients who are expecting a child, have a history of cardiac issues (e.g., rheumatic or ischemic heart disease or heart failure), severe arrhythmia or acute myocardial ischemia, pneumothorax, mediastinal emphysema, intracranial hypertension, neuromuscular diseases that could impede spontaneous breathing, severe multi-organ dysfunction (e.g., a Marshall score of 3 or higher), and a significant chronic pulmonary disorder.

Randomization and blindness:

To create a random list, we used an internet randomization program (http://www.randomizer.org). We sealed each patient's code in an opaque envelope. Two parallel groups of patients were randomly assigned at a 1:1 ratio: Patients in Group A (n=25) were cared for using SIMV+PS. Group B (n=25): ACV was used for patient management.

Methodology:

A comprehensive medical history, anthropometric measures, physical examination, standard laboratory testing, electrocardiogram (ECG), and echocardiogram were all administered to all study participants in order to rule out left-sided heart failure.

Determination of APACHE II score:

If a patient is in a critical illness, their APACHE II score can help determine how bad their condition is. Based on a number of physiological parameters, age, and chronic health issues, it aids in predicting the probability of mortality. The APACHE II total score is the product of three subscores: Acute Physiology, Chronic Health, and Age. There is a possible overall score range of 0–71. Scores less than 10, scores between 10 and 20, and scores greater than 20 indicate high risk.

Ventilator procedures, analgesia, and sedation strategies:

Puritan Bennett 840 Ventilator patients were administered the "Open-lung approach" and "Lung protective ventilation" protocols. Using volume-controlled mode, the expected tidal volume (VT) was 6 mL/kg of predicted body weight, with allowances ranging from 4 to 8 mL/kg, and plateau airway pressures kept below 30 cmH2O. With a fraction of inspired oxygen (FiO2) of 1.0 and a pressure of 40 cmH2O, the patient was required to hold their breath for 30 seconds four times daily as part of a recruiting maneuver. After that, the FiO2 was used to modify PEEP so that it met the needs of either a PaO2 of 55 mmHg or an oxygen saturation of 88% as determined by pulse oximetry.

Ventilation rates were altered for SIMV+PS patients so that they could maintain a respiratory rate below 35 breaths per minute while still allowing for spontaneous breathing. Permissive hypercapnia was allowed with an arterial pH of 7.15 or above, while the objective pH range for arterial blood gas analysis was 7.30 to 7.45. The ventilator was set to begin inspiration at a flow rate of 2 L/min or when the ratio of inspiration to expiration stayed between 1:1 and 1:3.

We followed the most recent evidence-based recommendations while weaning the patients, which included checking in with them every day to see if they were ready to try the spontaneous breathing test. Both groups used analgesic and sedative techniques that were identical and backed by current recommendations. After fentanyl was administered for pain relief, the patients were sedated with midazolam and propofol in order to achieve a RASS score between -2 and -4. In order to wake the patients up following the conventional criteria, the sedative infusions were interrupted daily at 8:00 in the morning. At 0, 2, 12, 24, 36, 48, and 72 hours after starting either the SIMV+PS or ACV mode, the co-primary end objectives were

ABG analysis and PaO2/FiO2 levels. Each time point (0, 2, 12, 24, 36, 48, and 72 hours) within the first 72 hours was used to determine the oxygenation (PaO2/FiO2), which was defined as the oxygenation within 72 hours.

Secondary outcomes:

Pulmonary end-expiratory pressure (PEEP), mechanical ventilation time, critical care unit stay duration, overall hospital stay, delirium occurrence, and hospital mortality.

Sample size calculation:

The sample size was calculated using Epi Info STATCALC according to the following parameters: The odds ratio is 1.04, and the two-sided confidence level is 95%. The power is 80%. Fifty people made up the final sample size determined by the Epi Info results.

Statistical analysis:

This statistical analysis was done using SPSS v27, a program created by IBM at its Armonk, NY, USA, facility. The data was examined using histograms and the Shapiro-Wilks test to ascertain if it followed a normal distribution. Mean and standard deviation (SD) were the outputs of an unpaired Student's t-test used to analyze the quantitative parametric data. This quantitative non-parametric data was evaluated using the Mann-Whitney U-test. The data was presented as the median and interquartile range (IQR). The qualitative variables, presented as percentages and reported as frequencies, were analyzed using the Chi-square test or Fisher's exact test, as appropriate. A two-tailed P-value<0.05 was used to determine a statistically significant result.

3. Results

Table 1. The demographic information of the groups under study

		GROUP-A (N=25)	GROUP-B (N=25)	P-VALUE
AGE (YEARS)	Mean± SD	50.52±19.11	54.12±19.88	0.517
	Range	24-85	22-87	
SEX	Male	14(56%)	12(48%)	0.571
	Female	11(44%)	13(52%)	
WEIGHT (KG)	Mean± SD	66.88±11.18	65.68±13.05	0.728
	Range	53-95	50-93	
HEIGHT (CM)	Mean± SD	163.16±7.16	161.96±6.81	0.547
	Range	151-174	153-173	
BMI (KG/M^2)	Mean± SD	25.3±4.95	25.1±5.08	0.891
	Range	18.8-37.3	19-39.2	
APACHE II SCORE	Mean± SD	18.44±6.35	17.76±7.08	0.722
	Range	13-30	14-35	

APACHE II: Acute physiology and chronic health evaluation, BMI: Body mass index,

and *: Significant as P-value≤0.05.

No significant differences were seen between the groups in terms of APACHE II score, body mass index (BMI), height, weight, age, or sex, (table 1).

Table 2. PaCO2 of the groups under study following the start of mechanical ventilation.

	GROUP-A (N=25)	GROUP-B (N=25)	P-VALUE
0 H	40.56±1.96	41.16±2.43	0.341
2 H	42.64±2.25	44.6±2.86	0.010*
12 H	42.4±1.98	44.28±3.12	0.014*
24 H	42.44±2.2	44.4±2.78	0.008*
36 H	42.64±2.08	44.2±2.68	0.026*
48 H	42.2±2.31	43.76±2.68	0.032*
72 H	41.2±1.73	42.84±3.27	0.032*

PaCO2: Partial pressure of carbon dioxide, *: Significant as P-value≤0.05.

after 0 hours, there was no significant difference in PaCO2 between the two groups; however, after 2 hours, 12 hours, 24 hours, 36 hours, 48 hours, and 72 hours, group-A's PaCO2 was considerably lower than group-B's (P-value<0.05), (table 2; figure 1).

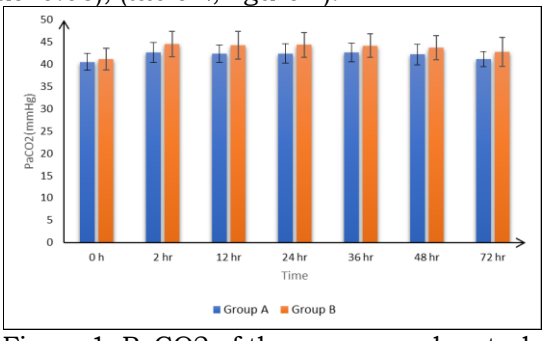

Figure 1. PaCO2 of the groups under study.

Table 3. PaO2 of the studied groups after initiation of mechanical ventilation.

	GROUP A (N=25)	GROUP B (N=25)	P VALUE
0 H	75.4±5.33	73.76±7.15	0.363
2 H	78.48±5.29	75.72±7.24	0.131
12 H	78.56±5.25	75.8±7.08	0.124
24 H	77.8±5.11	75.88±7.25	0.285
36 H	79.56±5.55	77.24±7.42	0.216
48 H	80.72±5.33	77.68±7.05	0.092
72 H	83.72±5.48	80.64±6.87	0.086

PaO2: Partial pressure of arterial oxygen.

PaO2 was insignificantly different (0 h, 2 h, 12 h, 24 h, 36 h, 48 h and 72 h) between both groups, (table 3; figure 2).

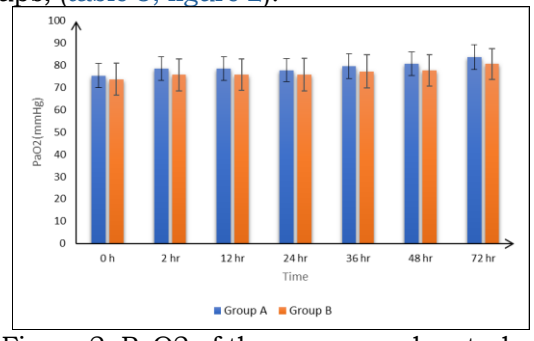

Figure 2. PaO2 of the groups under study.

Table 4. FiO2 of the studied groups after initiation of mechanical ventilation.

	GROUP A (N=25)	GROUP B (N=25)	P VALUE
0 H	80.6±4.39	81.12±4.33	0.224
2 H	73.52±4.45	76.16±4.14	0.035*
12 H	71.52±4.4	75.96±4.22	<0.001*
24 H	70.44±4.58	75.76±4.66	<0.001*
36 H	69.72±3.76	74.12±4.42	<0.001*
48 H	66.28±2.73	73.76±4.59	<0.001*
72 H	58.52±4.8	68.16±4.81	<0.001*

FiO2: Fraction of inspired oxygen

At 0 hours, there was no significant difference in FiO2 between the two groups; however, at 2 hours, 12 hours, 24 hours, 36 hours, 48 hours, and 72 hours, group A's FiO2 was considerably lower than group B's (P value<0.05), (table 4; figure 3).

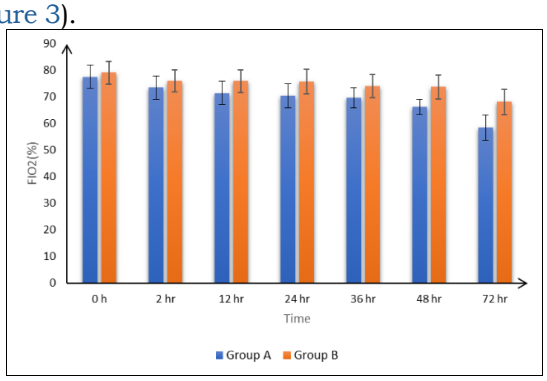

Figure 3. FiO2 of the groups under study.

Table 5. PaO2/FiO2 of the studied groups after initiation of mechanical ventilation.

	GROUP-A (N=25)	GROUP-B (N=25)	P-VALUE
0 H	137.56±16.62	124.32±35.9	0.101
2 H	183.84±17.12	105.6±25.63	<0.001*
12 H	202.24±15.08	122.92±20.26	<0.001*
24 H	181.76±13.72	121.16±23.31	<0.001*
36 H	175.12±17.77	134.48±23.24	<0.001*
48 H	185.68±19.02	130.6±21.19	<0.001*
72 H	191.52±14.4	140.12±22.22	<0.001*

PaO2/FiO2: Partial pressure of oxygen in arterial blood/fraction of inspiratory oxygen concentration,

*: Significant as P-value≤0.05.

PaO2/FiO2 was insignificantly different at 0 h between both groups and was significantly higher at 2 h, 12 h, 24 h, 36 h, 48 h and 72 h in group-A than group-B (P-value<0.001), (table 5; figure 4).

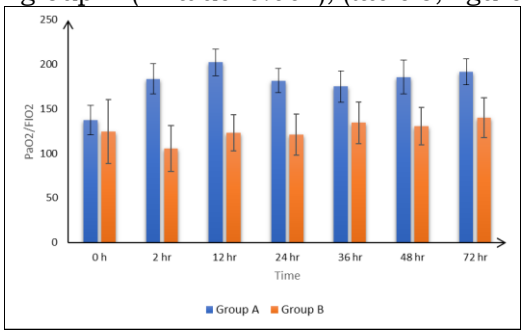

Figure 4. PaO2/FiO2 of the groups under study.

Table 6. Severity of ARDS of the studied groups.

		GROUP-A (N=25)	GROUP-B (N=25)	P-VALUE
P/F RATIO	Mild ARDS	15(60%)	5(20%)	
	Moderate ARDS	7(28%)	11(44%)	
	Severe ARDS	3(12%)	9(36%)	0.012*

ARDS: Acute respiratory distress syndrome, *: Significant as P-value≤0.05.

As regard Severity of ARDS of the studied groups there were significantly different between both groups (P-value=0.012), (table 6; figure 5).

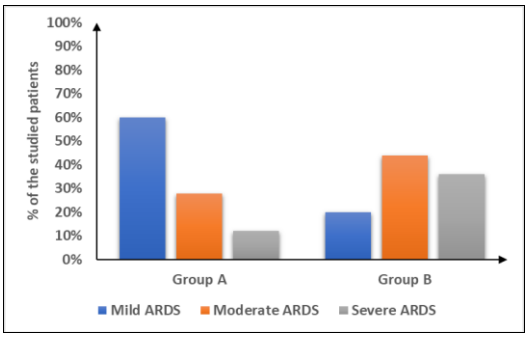

Figure 5. Severity of ARDS of the groups under study.

Table 7. Secondary outcomes variables of the studied groups.

		GROUP-A (N=25)	GROUP-B (N=25)	P-VALUE
PEEP (CMH_2O)	Mean± SD	8.7±3.19	10.86±3.96	0.038*
	Range	3.1-14.4	4.9-16.4	
TOTAL VENTILATOR DAYS (DAYS)	Mean± SD	9.44±2.75	9.32±2.76	0.878
	Range	5-14	7-16	
ICU DAYS (DAYS)	Mean± SD	20.48±6.17	19.04±4.96	0.130
	Range	11-37	9-27	
HOSPITAL STAY (DAYS)	Mean± SD	32.12±5.73	29.04±5.4	0.056
	Range	22-46	16-38	
DELIRIUM		0(0%)	4(16%)	0.109
MORTALITY RATE		7(28%)	8(32%)	0.978

PEEP: Positive end-expiratory pressure, ICU: Intensive care unit, *: Significant as P-value≤0.05.

PEEP was significantly lower in group A than in group B (P-value=0.038). The total number of ventilator days, ICU days, hospital stays, delirium, and death rates did not significantly differ between the two groups, (table 7; figure 6).

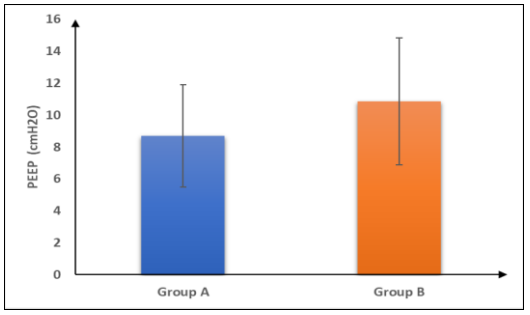

Figure 6. PEEP of the groups under study

4. Discussion

The abrupt onset of lung damage caused by various disorders is known as acute respiratory distress syndrome (ARDS), and it remains a significant clinical problem with a very high mortality rate. The use of MV is crucial for the survival of patients with ARDS.[5]

In the treatment of acute respiratory distress syndrome (ARDS), mechanical ventilation (MV) is essential for regulating the patient's breathing and ensuring sufficient gas exchange. Although mechanical ventilation (MV) saves lives, it can worsen lung injury in a condition known as ventilator-induced lung injury (VILI). Expansion of the lungs, epithelial and endothelial layer damage, and generation of inflammatory mediators are the causes of ventilator-induced

lung injury (VILI).[6,7]

In this investigation, there was no discernible difference in terms of age, gender, weight, height, body mass index, or APACHE II scores (Table 1). In terms of diabetes mellitus, hypertension, and smoking, there was hardly any variation between the categories.

In agreement with the findings of this study, Luo et al.,[5] forty patients with acute respiratory distress syndrome (ARDS) and assigned them to one center at random. They were divided into two groups: one that received SIMV + PS and another that received ACV. Age, sex, weight, height, and APACHE II score were not significantly different between the SIMV + PS group and the ACV group.

At2,12,24,36,48, and 72 hours, group-A had much lower PaCO2 and FiO2 than group-B did, according to Tables 2 and 4, respectively, of the current investigation. At various time intervals, there was no significant difference in PaO2 between the two groups (Table 3).

Mathews and Unnikrishnan[8] revealed that the SIMV-PS group had superior oxygenation and ventilation than the ACV group, with lower PaCO2 and FiO2 levels, but considerably higher PaO2 levels in the SIMV+PS group.

In the same line, Luo et al.,[5] We found that the FiO2 levels in the SIMV + PS group were much lower than those in the ACV group, indicating that this combination can safely and effectively enhance oxygenation.

Group A had a considerably higher PaO2/FiO2 ratio than group B at 2 hours, 12 hours, 24 hours, 36 hours, 48 hours, and 72 hours in this investigation (Table 5). Self-initiated breathing is now possible with SIMV+PS, which has the potential to enhance ventilation-perfusion (V/Q) matching. This results in enhanced oxygenation and more efficient exchange of oxygen. It is possible to improve respiratory mechanics and lessen the likelihood of ventilator-induced diaphragmatic dysfunction by preserving spontaneous breathing, which helps sustain diaphragmatic activity.[9]

Validating the findings of the present study, Mathews and Unnikrishnan[8] discovered that the SIMV-PS group had a considerably greater PaO2/FiO2 ratio than the ACV group. Both the SIMV-PS and ACV groups showed statistically significant differences in their P/F ratios.

In the same line, Luo et al.,[5] discovered a substantially higher PaO2/FiO2 in the SIMV + PS group compared to the ACV group at every observational time point.

The present investigation found that compared to the ACV group, the SIMV + PS group had much decreased PEEP (Table 7). Backing up our results, Luo et al.,[5] saw a considerable decrease in PEEP in the SIMV + PS group compared to the ACV group.

Table 6 shows that the two groups' ARDS severity scores were significantly different; for example, 88% of patients in the SIMV + PS group had mild or moderate ARDS, whereas 80% in the ACV group had moderate or severe ARDS. This disparity may explain why the SIMV + PS group had better oxygenation than the ACV group.

Total ventilator days, intensive care unit days, hospital stay, delirium, and death rate were shown to be statistically indistinguishable between the two groups (Table 7).

In the same line, Casali[10] compared the effects of ACV and SIMV+PS on outcomes including mortality, mechanical ventilation duration, and hospital stay duration in a systematic review. The researchers found no statistically significant differences between the two modes in these respects.

Also, de Godoi et al.,[11] conducted a retrospective and observational study with 345 adult volunteers, splitting them into two groups based on their breathing modalities (ACV and SIMV+PS). Hospital stay, mechanical ventilation duration, and mortality were not significantly different across the types of ventilation (ACV and SIMV+PS), according to their report. When comparing SIMV+PS to the ACV mode in terms of evaluated medical outcomes, the results were statistically identical.

Endorsing the study's results, Luo et al.,[5] were found to be statistically indistinguishable between the SIMV + PS group and the ACV group with respect to mechanical ventilation duration, intensive care unit days, delirium, and in-hospital fatalities.

Besides, Ortiz et al.,[12] found no benefit to clinical outcomes when comparing ventilation with SIMV-PS to ACV.

Limitations: Single center study that may result in different findings than elsewhere, small sample size that may produce insignificant results and severity of cases of ARDS was significantly different between both groups and this may give superiority for better outcomes in SIMV + PS group compared to ACV group.

4. Conclusion

In patients with ARDS, SIMV+PS showed superior outcomes in terms of PaCO2, FiO2, and PaO2/FiO2 ratio, indicating better oxygenation and ventilation efficiency. However, the modes did not differ significantly in terms of clinical outcomes like ICU stay, delirium, or mortality.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

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Conflicts of interest

There are no conflicts of interest.

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