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Comparison of the effects of two weaning methods of spontaneous breathing trial and synchronized intermittent-mandatory ventilation on the physiological indices of patients with mechanical ventilation

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ABSTRACT

Background: Weaning from mechanical ventilator might be risky since it directly affects the physiological indices of patients. Without success, this process may lead to the need for reintubation. This study aimed to compare the effects of two weaning protocols of spontaneous breathing trial (SBT) and synchronized intermittent-mandatory ventilation (SIMV) on the physiological indices of patients receiving mechanical ventilation in the intensive care unit (ICU).

Methods: This clinical trial was conducted on 44 intubated patients admitted in the ICU of a hospital in Arak, Iran in 2014. Patients were selected via convenience sampling and randomly allocated to two groups of intervention and control (n=22). SBT and SIMV were used as the weaning protocol in the intervention and control groups, respectively. Data were collected through the measurement of physiological indices and calculating Glasgow coma scale (GCS) scores before, during, and after the intervention. Data analysis was performed in SPSS version 20 using paired T-test, independent T-test, repeated measures ANOVA and Greenhouse-Geisser correction.

Results: In the SBT group, mean systolic blood pressure (107.90±5.2), heart rate (70.27±7.2), and respiratory rate (14.90±1.06) had a significant reduction after the intervention (9-12 am) (P<0.001). Moreover, mean Pao2 (89.12±1.16), diastolic blood pressure (76.09±4.6), SaO2 (93.09±0.97), and consciousness level (14.90±0.21) significantly increased after the intervention, improving the physiological status of the patients. However, no significant differences were observed in the physiological indices of the control group.

Conclusion: According to the results of this study, SBT improved the systolic and diastolic blood pressure, heart rate, Pao2, SaO2, and consciousness level of the patients in the intervention group. Therefore, it is recommended that this method be applied for weaning from mechanical ventilator in ICUs.

1. Introduction

Mechanical ventilator is a device used to improve the function of the respiratory tract in patients with airway disorders and acute medical conditions in intensive care units (ICU).[1-3] Weaning from mechanical ventilator could be risky since it directly affects physiological parameters, and in case of failure, it might lead to the reintubation of patients. Reducing the duration of attachment to the ventilator lowers treatment costs and the associated complications.[4-6] On the other hand, delayed weaning from mechanical ventilator could be life-threatening for some hospitalized patients. Duration of mechanical ventilation is essentially correlated with increased mortality, changes in physiological parameters, treatment costs, and life expectancy of the patients. Premature discontinuation of mechanical ventilation leads to weaning failure, disruption of vital parameters,[6-12] and increased patient mortality.[7]

During the past five years, more than 500 studies have been conducted about the removal of patients from mechanical ventilator through a process known as "weaning". The majority of these studies have focused on different methods of weaning, noting the importance of a consistent trend in this regard.[8, 9]

With recent advancement in mechanical ventilation technology, researchers have been concerned with developing a specific weaning protocol to be used in intensive care units (ICUs). It is noteworthy that conventional approaches, such as T-piece trial and pressure support ventilation (PSV), could preserve detachment from ventilator for only a short time and need for reintubation is still likely to arise.[10] Therefore, use of new methods and protocols to accelerate the process of weaning from mechanical ventilator with fewer complications seems necessary in order to improve the respiratory pattern of hospitalized patients.

Routine weaning is referred to as intermittent mandatory ventilation, in which the device mode is set on synchronized intermittent mandatory ventilation (SIMV). SIMV is a combination of assisted spontaneous breathing and controlled mechanical ventilation. In this approach, the patient breathes spontaneously through a ventilator airway, and the mechanical ventilator simultaneously delivers a certain volume of air to the tidal volume of the patient at regular intervals.[11]

Recent weaning methods incorporate the spontaneous breathing trial (SBT) mode. Initially, the patient is removed from the device by changing the mode to SIMV and continuous positive airway pressure (CPAP) afterwards, and the hemodynamic status of the patient is evaluated every 1-4 hours. In addition, T-piece trial is employed to detach the patient from mechanical ventilator for two hours. If the patient is able to breathe spontaneously within 24 hours after weaning, the weaning protocol (i.e., power respiratory boost) is accomplished; otherwise, the patient is returned to the previous mechanical ventilation setting.[12] Recent meta-analyses have proposed that using new weaning protocols could reduce the need for prolonged mechanical ventilation and length of ICU stay, while positively changing the physiological parameters of the patients.[8-10]

In a study, Burns et al. (2013) demonstrated that new methods of weaning could significantly decrease the complications associated with weaning from mechanical ventilator.[13] Similarly, Bein (2014) stated that compared to conventional approaches, new weaning methods could improve the interactions of patients with the mechanical ventilator, diminishing the load imposed on respiratory muscles.[14] Overall, this exerts a positive effect on the physiological parameters of the patients.

In another research, Mabrouk et al. (2015) investigated the success rate of different weaning protocols. According to the findings, non-invasive positive pressure ventilation method, in which the air flow speed and time of inhalation change depending on the breathing effort of the patient, volume of adjusted pressure, and changes in compliance and resistance, had a success rate of 92% compared to other weaning methods, such as PSV, SIMV, and CPAP. This denotes patient stability and positive changes of physiological parameters.[15]

Furthermore, Teixeira et al. (2012) suggested that airway obstruction occurs mainly due to the damage caused by the failure in the weaning of patients from mechanical ventilator. In patients who are connected to the mechanical ventilator for more than four weeks, endotracheal tube might increase airway resistance, leading to deleterious changes in some physiological parameters, such as increased respiratory rate and reduced arterial blood oxygen tension.[16] Considering the results of the aforementioned studies regarding the effects of different weaning methods on physiological parameters and necessity of new approaches to diminish the complications caused by conventional weaning protocols,[1-4] this study aimed to compare the effects of SBT and SIMV on the physiological indices of patients receiving mechanical ventilation.

2. Methods

2.1. Design

This clinical trial was conducted on all the patients admitted in the ICU of a hospital in Arak, Iran in 2014.

2.2. Participants and setting

In this study, Sample size was determined by performing a pilot study using the sample size formula (μ_1=90.92, $\mu2$=89.6, S_1=1.73, S_2=1.35, $Z_{1-\alpha/2}$=1.96, $Z_{1-\beta}$=0.84). Finally, 22 patients were assigned to each study group (total: 44).

Patients were selected via convenience sampling and randomly allocated to two groups of intervention and control. Random allocation was performed by drawing lots with two pieces of paper labeled with numbers one and two. To enter each study group, the researcher randomly picked a paper out of an envelope in order to select the patients. Number one would assign the patient to the control group, and number two would allocate them to the intervention group. This process continued until the completion of sample size.

Inclusion criteria were as follows: 1) age of >18 years; 2) having multiple injuries; 3) passage of more than 48 hours from intubation in the ICU; 4) absence of pneumonia and 5) written physician's order for the weaning of patient from mechanical ventilator. Exclusion criteria of the study were severe changes of physiological parameters and patients with problematic weaning.

2.3. Instruments

Data collection tools were demographic questionnaires, Glasgow Coma Scale (GCS), and checklists of hemodynamic status and mechanical ventilation. Demographic forms contained 10 items on data such as age, gender, marital status, history of hospitalization, disease diagnosis, presence of underlying diseases, patient conditions, length of ICU stay, and duration of intubation.

GCS was first developed by Teasdale and Jennett in 1974, and its reliability and validity have been confirmed. This standard instrument is widely used to assess the consciousness level of different patients.[17] In GCS, level of consciousness is evaluated in three domains of eye response (four points), verbal response (five points), and motor response (six points), which are scored within a range of 3-15; score 15 is interpreted as full consciousness, and score three indicates deep coma.

Checklists of physiological indices consisted of eight propositions to assess arterial blood oxygen tension, arterial blood oxygen partial pressure, respiratory rate, breathing patterns, heart rate, systolic blood pressure, diastolic blood pressure, and level of consciousness. Validity and reliability of this tool were confirmed in a study by Mahmoodi et al. (2015).[18]

In this study, we used the Drager Evita 2 mechanical ventilator. Before sampling, the device was calibrated by medical equipment engineers, and a certification was issued to confirm the vigor of the system.

2.4. Data Collection

After explaining the objectives of the study to patients and their families, informed consent for participation was obtained. Initially, the researcher attempted to communicate with the patients and their companions to elaborate on the process of weaning from mechanical ventilator and prepare them for the intervention.

After obtaining the physician's order for the weaning of patients from mechanical ventilator, vital parameters and consciousness level were assessed in both study groups prior to weaning (8 am) using physiological checklists and GCS. After weaning, vital parameters were checked and recorded every one hour during four hours (until 12 pm) by the researcher.

In the intervention group, weaning of the patients from mechanical ventilator was carried out via SBT. In this method, along with the changes in the respiratory parameters of the mechanical ventilator, the device gradually switches from the assist-control ventilation mode to CPAP. Finally, the patient is detached from the ventilator for two hours using a T-piece (this duration was similar for all the patients in the intervention group).

Subjects in the control group received routine weaning via SIMV, which is commonly practiced in the selected hospital ward. In this approach, two breaths were reduced from the respiratory rate of control subjects every half an hour, and in case of intermittent respiratory muscle fatigue twice in a row, respiratory rate of the patient was returned to the former state; this process was repeated after 24 hours.

During the intervention, patients of the two groups were examined in terms of respiratory muscle fatigue at five consecutive intervals (8-12 pm). Respiratory muscle fatigue was detected in case of the following indicators: increased heart rate to 30 beats/min more than the baseline value, respiratory rate of more than 35 beats/min continuing for five minutes, and arterial blood oxygen of less than 90%.10 If patients presented with respiratory muscle fatigue, they would be connected to the mechanical ventilator on the previous mode, and the weaning process was postponed. In case of weaning tolerance, the aforementioned parameters were examined every one hour during four hours. Eventually, the tracheal tube was removed, and patients received oxygen via a mask and nasal cannula (three liters per minute).

Physiological indices of arterial blood oxygen tension, arterial blood oxygen partial pressure, respiratory rate, breathing patterns, heart rate, systolic blood pressure, diastolic blood pressure, and level of consciousness were recorded by the researcher in both study groups before (8 am), during (9, 10, and 11 am) and after the intervention (12 pm).

2.5. Ethical considerations

After explaining the objectives of the study to patients and their families, informed consent for participation was obtained.

2.6. Statistical analysis

Data analysis was performed in SPSS version 20 using Chi-square to compare the groups in terms of gender, history of hospitalization, patient conditions, and underlying diseases. In addition, Fisher's exact test was used to compare the two groups in terms of marital status and diagnosis, and paired sample T-test was applied to compare the mean differences of physiological parameters before and after the intervention. In this study, comparison of the mean differences of physiological indices between the study groups was performed using independent T-test, and repeated measures ANOVA was used to assess the changes of physiological parameters before and after the intervention. Moreover, Greenhouse-Geisser correction was applied to assess the changing trend of physiological parameters between the groups at five different intervals.

3. Results

Demographic characteristics of the participants are shown in Table 1. According to the information in this table, no statistically significant differences were observed in the demographic variables of the two study groups. Moreover, results of paired sample T-test were indicative of no significant difference in the vital parameters of the two groups before the intervention (P>0.05).

According to the results of paired sample T-test, vital parameters of the intervention group, including arterial blood oxygen tension (P<0.001), arterial blood oxygen partial pressure (P<0.001), and diastolic blood pressure significantly increased after the intervention, compared to the intervention period. On the other hand, parameters such as respiratory rate (P<0.001), heart rate (P<0.001), systolic blood pressure (P<0.001), and level of consciousness (P=0.016) significantly decreased after the intervention, compared to the intervention period. Meanwhile, after the intervention, vital parameters of control subjects, including arterial blood oxygen tension (P<0.001), arterial blood oxygen partial pressure (P<0.001), and level of consciousness (P<0.001) reduced significantly. However, respiratory rate (P<0.001), heart rate (P<0.001), diastolic blood pressure (P=0.02), and systolic blood pressure (P<0.001) significantly increased, compared to the intervention period.

Results of repeated measures ANOVA indicated that the results of Mauchly's test of sphericity (P>0.05) rejected the conditions of sphericity in the intervention and control groups. Therefore, assuming the rejection of sphericity, we used the Greenhouse-Geisser correction test for both study groups in order to evaluate intra-group effects at five different intervals.

According to the results of this study, there was a significant difference in the mean arterial blood oxygen tension, arterial blood oxygen partial pressure, respiratory rate, heart rate, systolic blood pressure (mmHg), diastolic blood pressure (mmHg), and coefficient of consciousness level before and after the intervention within the groups (P<0001); this difference was considered significant between the groups (P<0.001) (Table 2).

Results of post-hoc test demonstrated a statistically significant difference in the parameters measured at different time intervals (Table 3).

According to the information in Table 4, a statistically significant difference was observed in the frequency of respiratory patterns between the two groups. As such, the majority of participants in the intervention group had regular, sinusoidal breathing patterns at 9, 10, and 11 am and 12 pm. However, patients in the control group presented with irregular breathing patterns (Cheyne-Stokes respiration) and required reintubation.

Table 1. Demographic characteristics of participants

Variables	Groups	Intervention N (%)	Control N (%)	P-value
Age (year)	18-25	2 (9.1)	5 (22.7)	0.415***
	25-50	9 (40.9)	9 (40.9)	
	≥50	11 (50)	8 (36.4)	
Gender	Male	6 (36.4)	15 (68.2)	0.035*
	Female	16 (63.6)	7 (31.8)	
Marital status	Single	3 (13.6)	2 (9.2)	0.675*
	Married	8 (36.4)	12 (54.5)	
	Divorced	10 (45.5)	7 (31.8)	
	Widowed	1 (4.5)	1 (4.5)	
History of hospitalization	Yes	14 (63.7)	16 (72.7)	0.517*
	No	8 (36.3)	6 (27.3)	
Patient conditions	Stable	8 (36.3)	7 (31.8)	0.750*
	Critical	14 (63.7)	15 (68.2)	
Disease diagnosis	Chronic obstructive pulmonary disease	9 (40.9)	9 (40.9)	1*
	Intracerebral hemorrhage	3 (13.6)	3 (13.6)	
	Cerebrovascular disease	2 (9.1)	2 (9.1)	
	Distress	8 (36.4)	8 (36.4)	
Length of ICU admission (day)	2-9	15 (68.2)	16 (72.8)	0.693***
	10-19	5 (22.8)	3 (13.6)	
	≥20	2 (9.0)	3 (13.6)	
Duration of intubation (day)	2-5	14 (63.6)	17 (77.4)	0.525***
	6-10	6 (27.3)	3 (13.6)	
	≥10	2 (9.1)	2 (9.0)	
Underlying diseases	Hypertension	2 (9.1)	1 (4.5)	0.850*
	Diabetes	3 (13.6)	3 (13.6)	
	Asthma	1(4.5)	3 (13.6)	
	Heart attack	1 (4.5)	1 (4.5)	
	Other	15(68/3)	14 (63.8)	

*Chi-square test; **Fisher's exact test; ***ANOVA

Table 2. Comparison of mean vital parameter variations in control and intervention groups

Vital parameters	Time intervention	Before	During			After	**P-value
		8 am	9 am	10 am	11 am	12 pm	
		M±SD	M±SD	M±SD	M±SD	M±SD	
Arterial blood oxygen tension	Intervention	89.86±1.95	89.18±2.08	91.22±1.9	92.04±1.32	93.09±0.97	<0.001
	Control	89.63±2.17	82.04±5.8	78.31±4.7	75.86±5.23	74.63±3.8	
	*P-value	0.717	<0.001	<0.001	<0.001	<0.001	
Arterial blood oxygen partial pressure	Intervention	85.77±3.25	84.5±2.1	87.8±2.21	88±1.4	89.12±1.16	<0.001
	Control	85.36±3.65	77.72±2.21	755±2.79	73.59±2.73	72.43±2.4	
	*P-value	0.817	<0.001	<0.001	<0.001	<0.001	
Respiratory rate	Intervention	16.04±2.64	21.04±1.9	15.4±1.09	14.36±1	14.90±1.06	<0.001
	Control	17.72±2.22	25.27±2.7	27.13±2.51	28.09±2.09	28.59±1.86	
	*P-value	0.0634	<0.001	<0.001	<0.001	<0.001	
Heart rate	Intervention	88.22±2.7	91.31±4.7	88.77±6.4	90.27±2.45	70.27±7.2	<0.001
	Control	89.81±6.5	123.63±10.6	125.54±9.7	129.04±8.98	131.4±7.43	
	*P-value	0.518	<0.001	<0.001	<0.001	<0.001	
Systolic blood pressure (mmHg)	Intervention	118.72±12.88	119.68±10.5	117.4±7.5	116±6.57	107.9±5.26	<0.001
	Control	117.81±10.25	135±27±9.2	137.9±9.3	138.4±8.46	140.7±6.54	
	*P-value	0.416	<0.001	<0.001	<0.001	<0.001	
Diastolic blood pressure (mmHg)	Intervention	69.6±9.6	76.5±7.7	74.5±7.14	84±4.5	76.09±4.6	<0.001
	Control	72.72±8.4	86.5±10.1	90.4±8.37	91±7.87	93.04±5.96	
	*P-value	0.308	<0.001	<0.001	<0.001	<0.001	
Coefficient of consciousness level	Intervention	13.83±1.4	14.18±1.3	14.6±0.56	15±0	14.9±0.21	<0.001
	Control	13.90±0.97	9.95±0.95	8.90±0.86	8.68±0.89	8.59±0.59	
	*P-value	0.068	<0.001	<0.001	<0.001	<0.001	

*LSD Independent T-test; **repeated measures ANOVA

Table 3. Paired comparison of systolic blood pressure, diastolic blood pressure, heart rate, arterial blood oxygen tension, arterial blood oxygen partial pressure, and consciousness level of intervention and control groups

Parameters	Time		Intervention (SBT)			Control (SIMV)		
			Variance of mean difference	SD	*P-value	Variance of mean difference	SD	*P-value
Arterial blood oxygen tension	9 am	10 am	-2.04	0.31	0.0001	3.72	0.8	0.0001
		11 am	2.8	0.34	0.0001	6.18	1	0.0001
		12 pm	-3.9	0.35	0.0001	7.4	1	0.0001
	10 am	11 am	-0.8	0.19	0.0001	2.4	0.8	0.0001
		12 pm	-1.8	0.3	0.0001	3.6	0.7	0.0001
	11 am	12 pm	-1.04	0.21	0.0001	1.2	0.8	0.164
Arterial blood oxygen partial pressure	9 am	10 am	-3.3	0.5	0.0001	2.22	0.4	0.0001
		11 am	-3.5	0.4	0.0001	4.13	0.4	0.0001
		12 pm	-4.6	0.47	0.0001	5.2	0.6	0.0001
	10 am	11 am	-0.18	0.51	0.726	1.90	0.3	0.0001
		12 pm	-1.3	0.45	0.458	3.04	0.6	0.0001
	11 am	12 pm	-1.13	0.178	0.0001	1.13	0.5	0.046
Respiratory rate	9 am	10 am	5.6	0.5	0.0001	-1.8	0.6	0.006
		11 am	6.6	0.4	0.0001	-2.8	0.4	0.0001
		12 pm	6.1	0.45	0.0001	-3.3	0.5	0.0001
	10 am	11 am	1.04	0.1	0.0001	-0.9	0.4	0.039
		12 pm	0.5	0.2	0.03	-1.4	0.4	0.007
	11 am	12 pm	-0.5	0.19	0.01	-0.5	0.3	0.157
Heart.rate (per minute)	9 am	10 am	2.5	1.6	0.147	-1.90	0.5	0.002
		11 am	1.04	1.1	0.363	-5.4	0.8	0.0001
		12 pm	21.04	1.8	0.0001	-7.77	1.3	0.0001
	10 am	11 am	-1.5	1.2	0.244	-3.5	0.8	0.0001
		12 pm	18.5	2.3	0.0001	-5.8	1.1	0.0001
	11 am	12 pm	20	1.7	0.0001	-2.3	1.03	0.032
Systolic blood pressure (mmHg)	9 am	10 am	2.2	2.2	0.317	-2.6	1.5	0.107
		11 am	3.6	2.6	0.173	-3.1	1.3	0.031
		12 pm	11.7	2.1	0.0001	-5.5	1.4	0.001
	10 am	11 am	1.4	1.6	0.414	-0.5	1.4	0.728
		12 pm	9.5	1.4	0.0001	-2.8	1.3	0.054
	11 am	12 pm	8.09	0.7	0.0001	-2.3	0.8	0.011
Diastolic blood pressure (mmHg)	9 am	10 am	1.9	1.9	0.336	-3.5	0.9	0.001
		11 am	-7.5	1.8	0.0001	-5.09	1.2	0.0001
		12 pm	0.4	1.7	0.8	-6.5	1.2	0.0001
	10 am	11 am	-9.4	1.4	0.0001	-1.54	0.5	0.006
		12 pm	-1.5	1.5	0.34	-3	0.8	0.002
	11 am	12 pm	7.9	0.9	0.0001	-1.45	0.7	0.054
Level of consciousness	9 am	10 am	-0.5	0.3	0.134	1.04	0.18	0.0001
		11 am	-0.8	0.2	0.009	1.2	0.28	0.0001
		12 pm	-0.7	0.2	0.01	1.36	0.25	0.0001
	10 am	11 am	-0.3	0.1	0.01	0.227	0.20	0.285
		12 pm	-0.2	0.11	0.03	0.318	0.21	0.148
	11 am	12 pm	0.04	0.04	0.32	0.091	0.14	0.540

*LSD

Table 4. Comparison of respiratory patterns between intervention and control groups

Time	Breathing pattern	Sinusoidal	Labored	Cheyne-Stokes	*P-value
		N (%)	N (%)	N (%)	
Before intervention (8 am)	Intervention	17 (77.3)	0 (0.0)	5 (22.7)	0.698
	Control	18 (81.8)	1 (4.5)	3 (13.7)	
During intervention (9 am)	Intervention	22 (100)	0 (0.0)	0 (0.0)	0.0001
	Control	7 (31.8)	3 (13.6)	12 (54.6)	
During intervention (10 am)	Intervention	22 (100)	0 (0.0)	0 (0.0)	0.0001
	Control	7 (31.8)	2 (9.1)	13 (59.1)	
During intervention (11 am)	Intervention	22 (100)	0 (0.0)	0 (0.0)	0.0001
	Control	8 (36.4)	1 (4.5)	13 (59.1)	
After intervention (12 pm)	Intervention	22 (100)	0 (0.0)	0 (0.0)	0.0001
	Control	6 (27.3)	2 (9.1)	14 (63.6)	

*Chi-square test

4. Discussion

According to the results of the present study, patients in the intervention group with the weaning method of SBT had a significant reduction in parameters such as respiratory rate, heart rate, systolic blood pressure (9-12 pm), while these parameters were observed to increase in the control group. Furthermore, indices of arterial blood oxygen partial pressure, arterial blood oxygen tension, consciousness level, and diastolic blood pressure of the patients in the intervention group increased, while these parameters decreased in the control group. In fact, patients in the control group were not provided with the optimal conditions of weaning from mechanical ventilator.

In a study, Meade et al. (2001) reviewed 65 observational studies regarding different methods of weaning from mechanical ventilator and concluded that despite the use of multiple protocols, indices of systolic blood pressure and respiratory rate showed no significant differences before and after the intervention. In other words, none of the applied weaning protocols caused significant changes in these parameters.[19] This finding is inconsistent with the results of the current study, which could be due to the differences in the study design. Our research was a clinical trial carried out under the close supervision of the researcher during sampling, whereas the study by Meade et al. was observational, focusing on the examination of various protocols used for patients receiving mechanical ventilation, and no intervention was implemented.

Another study by Frazier et al. (2006) was performed to evaluate myocardial ischemic changes in mechanically ventilated patients, and the researchers suggested that after applying routine weaning methods (e.g., CPAP), 70% of the patients showed ST-segment changes on the electrocardiogram during and after weaning,[20] which signified the unstable physiological conditions of the patients. In the mentioned study, use of CPAP failed to stabilize the physiological conditions of the patients. Therefore, the SBT protocol, which was examined in the present study, could adjust the physiological conditions of patients after weaning from mechanical ventilator.

In their research, Heydari and Jabbari (2004) compared three methods of weaning from mechanical ventilator, including T-piece trial, SIMV and positive-pressure ventilation. According to the results, reduced duration of mechanical ventilation decreases the frequency of reintubation, which increases the length of hospital stay and mortality rate in the ICU. Moreover, positive-pressure ventilation was reported to have the highest success rate in the weaning of patients from mechanical ventilator, while the lowest success rate in this regard belonged to SIMV. It is also noteworthy that in the mentioned study, indices of arterial blood oxygen tension and arterial blood oxygen partial pressure were measured, the results of which are in line with the findings of the present study. This similarity could be due to the fact that SIMV did not lead to successful extubation in our research while maintaining the physiological parameters. In addition, resemblance of study populations and relatively similar conditions of the patients and wards of admission could be another reason for the consistency of the findings.[10]

In this regard, Teixeira et al. (2012) reported that possibility of reintubation in patients with chronic obstructive pulmonary disease, who were weaned from mechanical ventilator via SBT, was 29.6% lower compared to the patients who were removed using other methods (e.g., T-piece trial).[16]

The mentioned study was performed on patients who had difficulty in weaning from mechanical ventilator, and reintubation was considered as success until 48 hours after weaning. Similar to the current study, SBT was observed to be remarkably effective in the weaning of patients from mechanical ventilator. Furthermore, arterial blood oxygen tension was reported to have a significant increase, while the respiratory rate of patients significantly decreased.[16]

In another research by Girard et al., it was reported that use of SBT and interruption of sedatives was largely influential in the early weaning of patients from mechanical ventilator. Moreover, it reduced intubation complications, increased arterial blood oxygen tension, and decreased respiratory rate.[21] These findings are in congruence with the results of the present study. However, interruption of sedatives might be more effective in successful weaning compared to SBT.

With respect to respiration patterns, the majority of our patients in the intervention group had sinusoidal and regular breathing patterns during 9-12 pm. On the other hand, the majority of subjects in the control group showed Cheyne-Stokes respiration and required reintubation.

In the research by Thille et al. (2011), it was stated that patients using the weaning protocol of SBT had normal breathing patterns and adequate coughing ability after detachment from mechanical ventilator.[22] These findings are consistent with the results of the current study, emphasizing on the pivotal role of SBT in the weaning of patients from mechanical ventilator.

According to the results obtained by Lima (2013), respiratory rate is a significant predictor of the success rate of weaning from mechanical ventilator. In other words, if the respiratory rate of the patient is less than 24 breaths per minute before weaning, the process of weaning has a higher success rate.[23] In the current study, we examined the influential parameters in weaning from mechanical ventilator and concluded that SBT could be more effectual in this regard compared to other methods.

However, findings of Roh et al. (2012) indicated that patients who were weaned from mechanical ventilator (usually through SBT) by ICU nurses had better breathing patterns compared to those with routine weaning protocols (e.g., T-piece trial). Moreover, duration of intubation was reported to reduce in these patients.[24] This finding highlights the key role of ICU nurses in the effective weaning of patients from mechanical ventilator. In the mentioned study, respiratory rate of the patients was the only physiological parameter investigated by the researchers, while in the current research, we focused on all physiological indices.

Some of the limitations of the present study were the small sample size and time constraint, which restrict the generalizability of the findings.

5. Conclusion

According to the results of this study, SBT weaning protocol could improve systolic blood pressure, heart rate, arterial blood oxygen tension, and consciousness level in patients admitted in the ICU. Furthermore, this method could stabilize the breathing status of these patients and contribute to early weaning through enhancing physiological parameters. Therefore, use of SBT is more effective than other routine methods of weaning from mechanical ventilator, such as SIMV. It is recommended that further longitudinal studies be conducted on larger sample sizes.

Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions

Mokhtar Mahmoudi: implementation of research, participation in the editing of manuscript, first researcher. Davood Hekmatpou: monitoring the implementation of research, writing and editing of manuscript. Mohammad Khajeh Goodary: participation in the implementation of research and editing of manuscript. Parya Vakilian: participation in the implementation of research and editing of manuscript. Fatemeh Rafiei: statistical analysis, participation in the editing of manuscript. Parvaneh Asgari: participation in the implementation of research and editing of manuscript.

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