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Comparison of Weaning Success from Mechanical Ventilation Using Heat and Moisture Exchangers (HME) and Humidifier in Intensive Care Unit (ICU) Patients: A Quasi-Experimental Study

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A B S T R A C T

Introduction: Weaning a patient from mechanical ventilation is an important step in the treatment of patients admitted to the intensive care unit, the failure of which can be associated with adverse effects in patients. Thus, the present study was conducted with the aim of determining and comparing the success rate in the process of weaning a patient from mechanical ventilation using heat and moisture exchangers (HME) and a humidifier in patients admitted to the intensive care unit (ICU).

Materials & Methods: In this quasi-experimental study, 40 patients treated with mechanical ventilation in the intensive care unit of hospitals of Ilam (Iran) were evaluated by random sampling in two intervention groups of 20 with HME and humidifier filters. In the first group, humidification of inhaled air was used using a humidifier filter, and in the second group, an HME filter was used to humidify inhaled air. Data related to the process of weaning patients from mechanical ventilation before and after the intervention were recorded in a checklist and analyzed by STATA V.12 using descriptive and inferential statistical tests in the significance less than 0.05.

Results: The rate of successful weaning was higher in the humidifier group (65%) compared with the HME group (40%), whereas weaning failure occurred in 35% and 60% of patients, respectively. Patients in the humidifier group showed a lower rate of weaning failure compared with the HME group; however, this association was not statistically significant in the adjusted analysis (OR = 0.40, P = 0.23). The PaO2/FiO2 ratio measured 30 minutes before weaning from mechanical ventilation was significantly associated with successful weaning (P = 0.003), such that each unit increase in this ratio reduced the odds of weaning failure by 3%.

Conclusion: Given the higher success rate of the humidifier filter compared to the HME in weaning patients from mechanical ventilation, the humidifier filter may be considered as a potential option for weaning from mechanical ventilation in patients admitted to the intensive care unit, though further research is needed to confirm its efficacy.

Keywords: Success, Weaning, Mechanical Ventilation, Patient, Heat and Moisture Exchangers (HME), Humidifier

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Introduction

The intensive care unit is one of the essential and vital foundations in medical and care centers that accommodate critically ill patients who are at risk of death (1). Meanwhile, mechanical ventilation treatment among patients hospitalized in the intensive care unit is one of the most commonly prescribed medical treatments (2). Mechanical ventilation is an artificial ventilation method that is able to take over half or all of the activities of the respiratory muscles and organs. Mechanical ventilation is used when the patient's ability to receive oxygen and excrete carbon dioxide is impaired (3). Mechanical ventilation is a special stage in the treatment of patients with respiratory failure to support patients, the goal of which is to create appropriate flow and volume for adequate alveolar ventilation or minimal work of breathing (4), which has beneficial effects on the pathophysiology of acute pulmonary failure by increasing the oxygen concentration of inspired air, reopening collapsed alveoli, and providing adequate alveolar ventilation (5). Mechanical ventilation suppresses the mechanisms that warm and humidify inhaled air. As a result, inadequate ventilation may thicken airway secretions, which increases airway resistance, reduces the effectiveness of gas exchange, and increases the risk of respiratory infections. For these reasons, the gas delivered during mechanical ventilation must be warmed and humidified to avoid serious complications associated with dry gases.

To date, humidifying devices can be divided into active heated humidifiers (humidifiers) (HH), which are devices that are heated with water, and passive devices such as heat and moisture exchangers (HME), which capture the heat of exhaled air and release it in the next breath (6). It has been reported that humidifiers may increase airway hydration, reduce the incidence of bacterial infection, and increase the work of breathing, whereas HMEs may increase the risk of airway obstruction (7). These complications may place patients at greater risk of ventilator-associated pneumonia, airway damage, muscle weakness, increased need for sedatives, and prolonged duration of mechanical ventilation (1). Therefore, considering the aforementioned, the need for mechanical ventilation saves the lives of many hospitalized patients but can also lead to many complications among the patients supported by it. Therefore, given that reducing the duration of mechanical ventilation can improve health-related quality of life and subsequently reduce medical costs associated with patients with acute diseases, it is essential to discontinue mechanical ventilation as soon as possible (8).

Timely, rapid, uncomplicated, and successful weaning by shortening the duration of mechanical ventilation reduces the complications of ventilation (decreased cardiac output and infections caused by mechanical ventilation, hyperventilation and hypoventilation, atelectasis, oxygen toxicity, pressure trauma, and psychological dependence on mechanical ventilation) (9). Meanwhile, unsuccessful withdrawal of mechanical ventilation support often causes respiratory muscle fatigue and imposes serious stress on the cardiovascular and respiratory systems (10). For this reason, an important step in the treatment process in the intensive care unit is weaning the patient from the mechanical ventilation device, which can cover more than 56-90% of the duration of mechanical ventilation (11). Several specific clinical problems can lead to disruption of the weaning phase, including pulmonary edema caused by weaning, respiratory muscle weakness, high-dose sedative intake, and factors related to the mechanical ventilation device (12). Although these complications cannot be completely eliminated, it is possible to reduce their amount and frequency by using There are many strategies for optimal ventilation and the promotion of standardized and meticulous care (13). To reduce the incidence of complications of mechanical ventilation, solutions have been proposed, one of which is the use of standardized guidelines or protocols (14).

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As mentioned, both HME and humidifier devices have side effects such as increased airway hydration and increased risk of airway obstruction, which may interfere with the process of weaning patients from mechanical ventilation. The results of the studies are also contradictory, as the results of the study by Vargas et al. showed that humidifier had a lower risk of airway obstruction compared to HME (6), while the results of a meta-analysis study showed that there was no significant difference in airway obstruction or pneumonia between HMEs and humidifier devices (15). The results of the study by Hess et al. showed that HMEs were associated with a lower incidence of pneumonia compared to humidifier devices (16). The results of another study also showed that there was no superiority between HMEs compared to humidifier devices in reducing pneumonia, mortality, or complications (17). In clinical practice, the impact of mechanical ventilation filters on complications and failure of mechanical ventilation weaning is widely accepted. However, there is no consensus on the optimal filter for mechanical ventilation weaning (6). While attention to mechanical ventilation weaning in intensive care unit patients is of great importance, failure to wean patients from mechanical ventilation can lead to increased need for mechanical ventilation, failed weaning and reintubation, nosocomial and mechanical ventilation-related infections, increased length of hospital stay, increased medical costs, and increased mortality.

Therefore, given that no study has been conducted to date to compare the success rate of weaning patients from mechanical ventilation using HME and humidifier in patients hospitalized in the intensive care unit, the present study aimed to determine and compare the success rate of weaning patients from mechanical ventilation using HME and humidifier in patients hospitalized in the intensive care unit.

Materials and methods

Study Design

The present study was a quasi-experimental study in which the research population was patients undergoing mechanical ventilation hospitalized in the intensive care unit of hospitals affiliated with Ilam University of Medical Sciences in 2022 (Iran).

Setting and Participants

The inclusion criteria included obtaining written informed consent from the patient's first-degree relatives, the absence of blood or foam in the pulmonary secretions, the absence of hypothermia in the patients, the absence of burns in the patients, and the spontaneous minute ventilation rate of less than ten liters per minute. The exclusion criteria included the presence of frequent leaks in the distal area (fistula in the bronchus and large bronchopleural fistula), treatment with aerosol drugs, and patients with a long treatment duration. The death of patients during the intervention, transfer to other medical centers, surgery during the isolation process, and the occurrence of acute disorders in the patient's hemodynamic status.

Sample Size

In order to estimate the required sample size, the formula for comparing the ratio estimate in the two groups was used (success rate of the first method P1, success rate of the second method P2). Considering the results of similar studies that the success rate of patient separation with different methods was different, the effect size of the difference between the two groups was used to estimate the required sample size, which was 45 percent. That is, if one type of separation has a greater effect size of 45 percent. In a one-sided test with a type I error of 5 percent and a test power of 80 percent, the required sample size was determined using G*Power software as 40 people, with 20 people in each group.

Randomization & Blinding

In this study, patients who met the inclusion criteria were enrolled in the study using convenience sampling, and then each sample was randomly

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assigned to the HME mechanical ventilation group and the humidifier group. Eligible patients were randomly allocated to the HME or humidifier groups using a simple randomization method based on a random number table. Recruitment continued until equal sample sizes (20 participants per group) were achieved. After selecting the required number of samples from even and odd numbers, all the written numbers were placed in separate envelopes and numbered sequentially so that for each sampling, the samples were studied in two groups depending on the number inside the envelope, which was even or odd.

Due to the nature of the intervention, blinding of patients and care providers was not feasible. Outcome assessment was performed by the researcher; therefore, lack of blinding is considered a limitation of this study.

Measurements & Validity and Reliability

Demographic tool

It included age, gender, diagnosis, time of hospitalization, length of stay in the intensive care unit, type of ventilation, pH, respiratory parameter values of oxygen pressure (PO2), carbon dioxide pressure (PCO2), arterial blood oxygen saturation (O2Sat), and ratio of arterial blood oxygen to fraction of inspired oxygen (PaO2/FiO2).

Burn's weaning assessment

This tool was designed by Bern et al. in 1990, has 26 items, 12 of which assess the patient's general condition, and 14 items measure the patient's respiratory function. The questions are divided into three options: yes, no, and not evaluated, with the yes option receiving a score of 1, and the no and not evaluated options receiving a score of 0. The total scores for assessing the patient's readiness to be weaned from mechanical ventilation based on this checklist range from 0 to 26, and when the patient scores 17 or higher, the weaning process can be started (18). This tool was reported in Iran by Keikhova et al. with a Cronbach's alpha coefficient of 0.91 (19) and in the study by Salmani et al. with a Cronbach's alpha coefficient of 0.85 (20).

Intervention

To begin the intervention, the researcher visited the selected hospitals after obtaining a letter of introduction and, after making the necessary arrangements with the center officials, began sampling. Before starting the intervention, the researcher designed the intervention protocol (separation of patients from mechanical ventilation using two methods: HME and humidifier) in consultation with the specialist physicians and nurses of the intensive care unit. To perform the intervention, in the first group, humidification of the inhaled air was performed using a humidifier filter, and in the second group, an HME filter was used to humidify the inhaled air. The HME filter and the humidifier were installed between the patient's Y-shaped piece to increase resistance to airflow during inhalation and exhalation. All devices and equipment used in this study (mechanical ventilator, pulse oximetry, and cardiorespiratory monitoring system) were calibrated before the start of the study, during the study, and afterwards by a medical equipment expert at the selected center, ensuring the reliability of the devices.

Then, the personal information of the patients was recorded in the relevant form through the patient files in both groups in order to calculate the blood and respiratory indices evaluated in this study before the start of the intervention and after 30 minutes of spontaneous breathing after separation from the device by the researcher with the help of mechanical ventilation and arterial blood sampling from the patients and recorded in the form. In order to separate the patients from mechanical ventilation, the sedation received by the patients was first discontinued, and if the patient needed to continue the drug injection for pain relief, only the fentanyl injection was continued as an infusion at a minimum dose of 1 microgram/kg/hour. After 4 hours of

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discontinuation of sedative drugs, the patient was examined sequentially using the Berne Weaning Checklist. This assessment was performed only in the morning and evening shifts, and at each stage of the assessment, if the patient scored higher than 17 on the Berne Weaning Checklist. The patient was isolated by injecting a dose of intravenous dexamethasone and placing him on a T-piece with 6-7 liters of oxygen for one hour. If he tolerated it and there was no drop in arterial blood oxygen saturation, if the patient had a tracheal tube, he was discharged after preoxygenation with 100% oxygen and suctioning the trachea and the mouth of the tracheal tube. If he had a tracheostomy, oxygen administration was discontinued with the T-piece. Then, the patient was continuously monitored for recurrent respiratory failure (drop in arterial blood oxygen saturation, use of accessory respiratory muscles) so that if necessary, the patient could be re-intubated or connected to a mechanical ventilator via a trach and was included in the unsuccessful cases. If he tolerated the isolation and there was no respiratory distress and no drop in arterial blood oxygen saturation until the time of transfer to the general ward, he was considered a successful case. Finally, the success rate in different groups was examined. Berne checklist parameters were assessed at the patient's bedside for 10-15 minutes each shift based on the daily clinical symptoms and data recording sheet of the special ward (ward sheet). After the patient was weaned from mechanical ventilation, spontaneous breathing training was performed for 30 minutes without mechanical ventilation support. During the entire 30 minutes, patients were monitored for signs of intolerance or signs of failure in spontaneous breathing training. The patient was considered successful in weaning from mechanical ventilation if any of the following signs were present during spontaneous breathing exercise: oxygen pressure (PO2) greater than 60 mmHg, partial pressure of carbon dioxide (PCO2) less than 50 mmHg, respiratory rate less than 35 breaths per minute, positive end-expiratory pressure (PEEP) between 0 and 5 cmHg, fraction of inspired oxygen (FiO2) less than 0.4, arterial blood oxygen saturation (SatO2) greater than 92%, tidal volume (TV) at least 500 ml, peak inspiratory pressure (PIP) greater than 15 cmHg, and minute ventilation greater than 10 l/min (19, 21, 22) (Figure 1).

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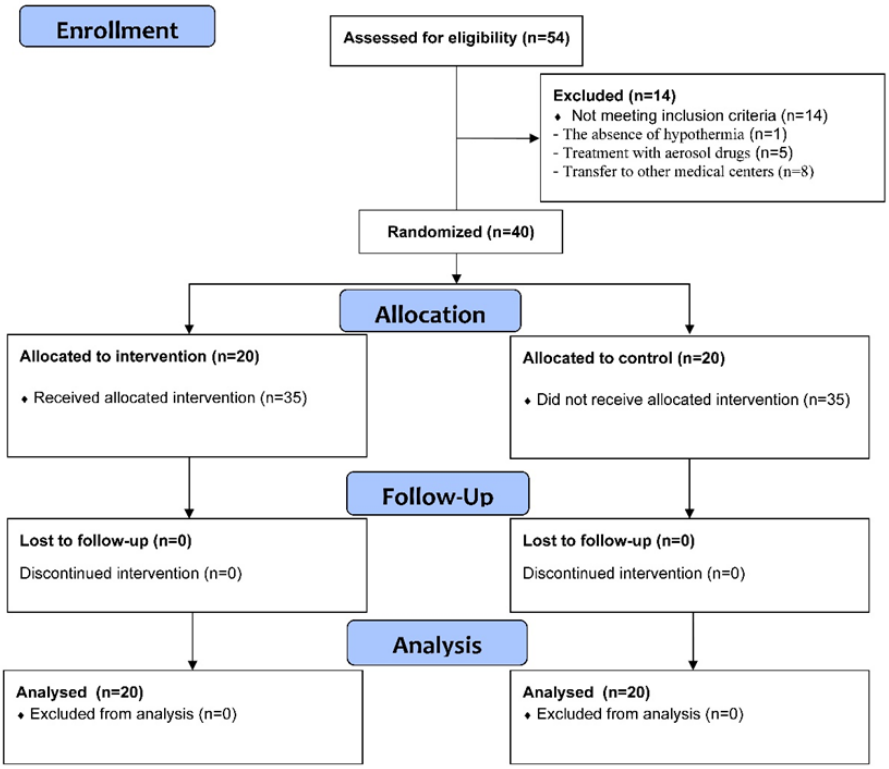

Figure 1. The sequence of selecting and study protocol related on control and intervention groups.

Statistical and Data Analysis

Data analysis was performed using STATA12 software. To analyze the variables, initially, the Shapiro-Wilk statistical test was used to assess their normality between the two study groups, and then they were evaluated by independent t-tests and Fisher's exact test. In order to determine the effect of various factors on the success or failure of isolation in patients, logistic regression models were used. The significance level in univariate analysis was $P < 0.2$, and in the multivariate and adjusted model was $P < 0.05$, and all significant variables were entered into the multivariate model. Also, all possible interactions between the study variables were examined. In order to evaluate the entry of different variables into the multivariate model and the fit of the final model, the criterion (AIC) was used.

Results

In this study, 40 patients undergoing mechanical ventilation (20 patients in the HME group and 20 patients in the humidifier group) were evaluated. According to the results in Table 1, the mean and standard deviation of the ages of patients in the HME and humidifier groups were 57.90 ± 15.10 and 57.45 ± 14.40 years, respectively ($P = 0.92$). In the HME group, the pH value before separation was slightly higher than in the humidifier group ($P = 0.04$), but there was no statistically significant difference between other demographic information in the HME and humidifier groups ($P < 0.05$). According to Table 2 and the results of logistic regression in this univariate model, the odds ratio index for the type of separation (OR = 0.38) was obtained, which showed that in the group of patients in whom the humidifier method was used, the failure rate in separation from the device was 62% lower than in HME. In this model, variables such as oxygen saturation before (P=0.05) and after (P=0.01) separation had a significant relationship with the success or failure rate of separation, but because these variables showed a linear relationship

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with other study variables, they were excluded from the final model.

Table 1. Comparison of demographic characteristics in two groups of patients undergoing mechanical ventilation with HME and humidifier group.

Variables	HME group (n=20) Mean ± SD / n (%)	Humidifier group (n=20) Mean ± SD / n (%)	Between-group comparison (p-value)
Age (years)	57.90 ± 15.10	57.45 ± 14.40	p = 0.92*
Length of hospital stay (days)	9.95 ± 3.2	10.80 ± 4.5	p = 0.50*
pH			
Before weaning	7.40 ± 0.03	7.39 ± 0.02	p = 0.04*
After weaning	7.38 ± 0.03	7.37 ± 0.03	p = 0.16*
Arterial oxygen saturation (SpO_2, %)			
Before weaning	92.65 ± 2.5	92.35 ± 1.8	p = 0.92*
After weaning	91.05 ± 2.7	90.95 ± 2.3	p = 0.92*
PaO_2/FiO_2 ratio (30 min before weaning)	260.75 ± 49.6	273.50 ± 39.06	p = 0.38*
Rapid shallow breathing index (RSI)	92.15 ± 10.2	91 ± 12.7	p = 0.75*
Arterial carbon dioxide pressure ($PaCO_2$, mmHg)			
Before weaning	40.05 ± 2	39.45 ± 2.6	p = 0.42*
After weaning	41.65 ± 2.6	41.10 ± 3.1	p = 0.55*
Gender			
Male	15 (75%)	12 (60%)	p = 0.31**
Female	5 (25%)	8 (40%)	
Underlying disease			
Acute respiratory distress syndrome (ARDS)	3 (50%)	3 (50%)	p = 1.00**
Chronic obstructive pulmonary disease (COPD)	3 (50%)	3 (50%)	
Intracerebral hemorrhage (ICH)	3 (50%)	3 (50%)	
Multiple trauma (MT)	4 (50%)	4 (50%)	
Pulmonary thromboembolism (PTE)	4 (50%)	4 (50%)	
Subarachnoid hemorrhage (SAH)	3 (50%)	3 (50%)	
Mode of mechanical ventilation			
Synchronized intermittent mandatory ventilation (SIMV)	11 (55%)	9 (45%)	p = 0.91**
Controlled/mandatory ventilation (CMV)	7 (50%)	7 (50%)	
Spontaneous ventilation	2 (40%)	3 (60%)	
Pressure support ventilation (PS)	0 (0%)	1 (100%)	

Table 2. Logistic regression models of factors affecting weaning from mechanical ventilation in univariate and multivariate analyses.

Variables	Successful weaning (n=21) Mean ± SD / n (%)	Weaning failure (n=19) Mean ± SD / n (%)	95% Confidence Interval	Between-group comparison (p-value)
Age (years)	54.67 ± 15.20	61.00 ± 13.5	0.98 – 1.08	p = 0.19

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Length of hospital stay (days)	9.57 ± 3.8	11.26 ± 3.8	0.95 – 1.32	p = 0.19
Arterial oxygen saturation (SpO_2, %)				
Before weaning	93.19 ± 1.9	91.74 ± 2.2	0.51 – 1.00	p = 0.05
After weaning	92.10 ± 2.2	89.79 ± 2.2	0.45 – 0.91	p = 0.01
PaO_2/FiO_2 ratio (30 min before weaning)	289.76 ± 37.6	242.11 ± 39	0.95 – 0.99	p = 0.003
Rapid shallow breathing index (RSI)	78.38 ± 11.4	96.21 ± 9.7	1.01 – 1.16	p = 0.04
Gender			0.26 – 3.37	p = 0.91
Male	14 (51.8%)	13 (48.2%)		
Female	7 (53.8%)	6 (46.2%)		
Underlying disease				
Acute respiratory distress syndrome (ARDS)	4 (66.7%)	2 (33.3%)	0.36 – 28.84	p = 0.29
Chronic obstructive pulmonary disease (COPD)	2 (33.3%)	4 (66.7%)	0.21 – 15.32	p = 0.59
Intracerebral hemorrhage (ICH)	3 (50%)	3 (50%)	0.15 – 8.86	p = 0.89
Multiple trauma (MT)	5 (62.5%)	3 (37.5%)	0.24 – 13.62	p = 0.57
Pulmonary thromboembolism (PTE)	4 (50%)	4 (50%)	0.21 – 15.32	p = 0.59
Subarachnoid hemorrhage (SAH)	3 (50%)	3 (50%)	0.95 – 1.32	p = 0.19
Mode of mechanical ventilation				
Synchronized intermittent mandatory ventilation (SIMV)	12 (60%)	8 (40%)	1.00	—
Controlled/mandatory ventilation (CMV)	5 (35.7%)	9 (64.3%)	0.65 – 9.24	p = 0.18
Spontaneous ventilation	3 (40%)	2 (40%)	0.17 – 6.63	p = 0.96
Pressure support ventilation (PS)	1 (100%)	0 (0%)	0.02 – 13.52	p = 0.67
Study group				
HME	8 (40%)	12 (60%)	1.00	—
Humidifier	13 (65%)	7 (35%)	0.10–1.76	p = 0.23

The final model (Table 2) included the significant variables in the univariate model. The final model with the above variables plus the variable "current volume before separation" had the lowest fit of the final model using the criterion and showed that it had the best fit to the data. For this model, the AIC value of 9.42 was obtained, which was the lowest fit of the final model using the criterion and the highest power for the final model. In the multivariate and adjusted analysis, only the PAO2/FIO2 ratio 30 minutes before weaning from mechanical ventilation showed a significant relationship with weaning success, such that with each unit increase in this index, the chance of failure in weaning from the device decreased by 3%, but the other variables did not show a significant effect on the success or failure of weaning. In this model, weaning with a humidifier method reduced the chance of failure in weaning by 60%, although this relationship was not statistically significant (OR = 0.40, 95% CI: 0.10 – 1.76, P = 0.23).

Discussion

The present study was conducted to determine and compare the success rate of weaning patients from mechanical ventilation using HME filters and a

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humidifier in patients admitted to the intensive care unit. The results showed that the humidifier was more successful in weaning patients from mechanical ventilation compared to HME. These results indicate the superiority of using a humidifier in the success of weaning patients from mechanical ventilation. Very few studies have investigated and compared the success rate of weaning patients from mechanical ventilation using HME filters and a humidifier in patients (23). The results of previous studies, consistent with the results of the present study, showed that the use of HMEs may interfere with pressure support ventilation due to the dead space they add to the system (24, 25). In fact, although both the HME filter and the humidifier are placed between the Y-piece and the patient, the internal volume of the HME can vary between 30 and 100 ml depending on the manufacturer, which potentially doubles or triples the physiological dead space, and therefore the probability of failure in weaning from mechanical ventilation in the HME is expected (26). Also, the results of the study by Pelosi et al. (2010) are also consistent with the results of the present study and showed that the HME can increase the flow resistance compared to the humidifier due to the presence of an internal membrane (27), which can lead to failure of weaning from mechanical ventilation through the accumulation of water inside the device, so one of the reasons for the higher success rate of weaning from mechanical ventilation is the better structure of the humidifier compared to the HME. It has been reported that during mechanical ventilation, HMEs may be responsible for increasing the patient's inspiratory effort and decreasing alveolar ventilation with increased PaCO2 due to high resistive load and increased dead space, which can contribute to failure of mechanical ventilation (28, 29). In the present study, it was shown that the humidifier device was superior to the HME in terms of the success rate of mechanical ventilation weaning; therefore, according to the results of the present study, the humidifier device may remain the device of choice to increase the chance of successful weaning of patients from mechanical ventilation. In accordance with other results of the present study, only a higher PaO2/FiO2 ratio 30 min before weaning the patient from mechanical ventilation was effective in increasing the success of the weaning process. The PaO2/FiO2 ratio is the ratio of the arterial partial pressure of oxygen to the inspiratory fraction of oxygen. This ratio is commonly used as a clinical index of the level of hypoxia (30). Very few studies have examined the PaO2/FiO2 ratio before weaning from mechanical ventilation as a tool to predict success in weaning from mechanical ventilation, but the results of these studies have reported the predictive value of a higher PaO2/FiO2 ratio in the success of weaning from mechanical ventilation in patients (31, 32). However, due to the limited number of studies in this field, it is necessary to conduct more studies on the effect of the PaO2/FiO2 ratio on the outcome of weaning from mechanical ventilation in patients. While the results of studies inconsistent with the results of the present study showed a higher success rate in weaning patients from mechanical ventilation in patients with smaller hips, shorter duration of hospitalization, blood oxygen level, and type of weaning method from mechanical ventilation (33, 34), such an association was not observed in the present study.

Several studies, inconsistent with the results of the present study, have shown a higher failure rate of mechanical ventilation in patients with respiratory disorders, neuromuscular disorders, poor cardiac function, nutritional status (low body mass), diaphragmatic function, hyperglycemia, anemia, metabolic acidosis, renal failure, and electrolyte imbalance (35-37). The results of the study by Pham et al. (2023), also inconsistent with the results of the present study, showed that older age, duration of mechanical ventilation in the intensive care unit, underweight status, and the presence of neuromuscular disorders were the main reasons for failure in weaning from mechanical ventilation (38). In several other studies, predictors of failure in weaning from mechanical ventilation included older

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age, duration of ventilation in the intensive care unit, renal failure, and hypoalbuminemia at admission (39-41).

The main reason for the inconsistency of the results of the present study with the studies mentioned is that the type of filter used during mechanical ventilation treatment and the time of its removal were not separately specified in the patients in these studies, but it seems that in the successful weaning from mechanical ventilation, factors such as age and the length of the patient's hospitalization in the hospital can play a role in the failure or success of weaning patients from mechanical ventilation, which requires further investigation by separating patients in relation to the use of HME and humidifier filters. Also, among other possible differences between the results of the present study and the studies mentioned, it can be pointed out that the difference in age, gender, comorbidities, and the difference in the duration of hospitalization in the intensive care unit can be indicated, which could have influenced the results. These findings strengthen the hypothesis that the baseline clinical conditions at the time of admission and the length of hospitalization of patients are very important in determining the results of mechanical ventilation weaning. Although the present study did not find a significant relationship between carbon dioxide pressure and weaning success in mechanical ventilation, the results of a study inconsistent with the results of the present study showed that the exhaled CO_2 level in the humidifier group was effective in weaning success in the HME group compared to the HME group (42), which indicates that carbon dioxide pressure can also be effective in the weaning process with mechanical ventilation filters, which requires further investigation.

Limitations and Strengths

This study is one of the highly valued approaches in the country to investigate and compare the success rate in weaning patients from mechanical ventilation using HME filters and humidifier in patients hospitalized in the intensive care unit, which can be used by researchers in future studies as a research-based study. The present study was conducted on a limited number of patients hospitalized in the intensive care unit from a medical center. It is recommended that similar future studies use a larger sample size of patients for re-evaluation.

Conclusion

In the group of patients undergoing intervention with a humidifier filter, the failure rate in weaning from mechanical ventilation was lower than that with HME, and a higher PaO2/FiO2 ratio 30 minutes before weaning from mechanical ventilation was associated with successful weaning. Given the higher success rate of a humidifier filter compared to HME in weaning patients from mechanical ventilation, a humidifier filter may be considered as a potential option for weaning from mechanical ventilation in ICU patients; however, further studies with larger sample sizes are required to confirm its effectiveness.

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CRediT authorship contribution statement

Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Resources, Software, Data Curation, Writing–Original Draft Preparation, Writing–Review & Editing, Visualization, Supervision, Project Administration: MP, AA, FT, MB, MN.

Declaration of Generative AI and AI-assisted technologies in the writing process

The authors confirm that the writing and preparation of this manuscript were conducted independently and without the involvement of any professional writing services. The content reflects the original work and contributions of the authors alone.

Conflict of interest

There is no conflict of interest.

Ethical considerations

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This work is a product of research that has received approval from the ethics committee of Ilam University of Medical Sciences with the reference number (IR.MEDILAM.REC.1396.049). Interviews and audio recordings were done subsequent to participants' comprehension of the study's objective and provision of informed consent. Participants were informed that the recorded information would be kept anonymous, and they were notified that they had the option to withdraw from the research at any time "without any consequences.".

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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