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The Comparative Evaluation of Active and Passive Humidifiers on Ventilator-associated Pneumonia

Abin M [1], Shiri Qidari P [1*], Hanifi N [2], Faghihzadeh S [3]

[1]MSc. Dept. of Critical Care Nursing, School of Nursing and Midwifery, Zanjan University of Medical Sciences, Zanjan, Iran
[*2]PhD. Dept. of Nursing, Assistant Professor, School of Nursing and Midwifery, Zanjan University of Medical Sciences, Zanjan, Iran
[3]Professor of Biostatistics, Zanjan Social Dept. of Health Research Center, Zanjan University of Medical Sciences, Zanjan, Iran

Corresponding Author: Dept. of Critical Care Nursing, School of Nursing and Midwifery, Zanjan University of Medical Sciences, Zanjan, Iran

Email: shirig@zums.ac.ir

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Abstract

Background: Ventilator-associated pneumonia (VAP) is considered a common infectious disease in the intensive care units (ICU) and it is associated with increased morbidity and mortality. Therefore, humidifying the artificial airway is important care for patients under mechanical ventilation in the ICU.

Objectives: The present study aimed to compare the effect of using active and passive humidifiers on VAP in ICU patients.

Methods: The samples of this clinical trial included 80 patients under mechanical ventilation who were selected by simple sampling method and randomly assigned to two groups of 40 cases. Active and passive humidifiers were applied in the first and second groups, respectively. In addition, data were collected using a demographic questionnaire and clinical pulmonary infection score (CPIS) checklist. Patients were assessed for seven days (days one, three, and seven) in terms of VAP incidence rate. Finally, data were analyzed by the SPSS software, version 16 using independent t-test and Fischer's exact test.

***Results*:** The heated humidifier standard (HHS) and heat and moisture exchangers (HME) groups were homogeneous with regard to the rate of VAP incidence, indicating no significant difference on days three (P=0.239) and seven (P=0.370). Further, the number of patients with VAP was clinically higher in the HHS group (52.5%) compared to the HME group (42.5%).

Conclusion: Based on the results of the study, no significant difference was found between the research groups regarding VAP incidence. However, humidifiers are suggested to be selected based on the needs of the patents and duration of ventilation.

Keywords: mechanical ventilation, ventilator-associated pneumonia, active and passive humidifiers, intensive care unit

Introduction

Patients admitted to intensive care units (ICUs) are critically ill individuals who are in a serious condition and require using artificial respiration (ventilator) in order to maintain oxygenation, keep the airway open, and prevent aspiration [1, 2]. Humidifying the artificial airway in patients with mechanical ventilation makes breathing easier and improves the parameters of the lung, a better pulmonary discharge removing, and timely separation of the patient from the ventilator [3]. However, according to [4], improper selection of humidifiers can lead to pulmonary complications such as airway obstruction, increased residual volume, increased airway resistance, and ventilator-associated pneumonia (VAP). VAP is considered one of the most significant complications of ventilation, which is a subgroup of hospital-related pneumonia and occurs 48-72 hours after the tracheal intubation in patients. Early-onset and late-onset VAP occur within 48-96 hours after the ventilation and more than 96

hours after the intubation, respectively. In addition, the incidence of mortality related to VAP is higher compared to other hospital-related pneumonia and has a rate above 71% [5,6]. Further, the risk of VAP is in the first days of mechanical ventilation [7]. Statistics indicate that the rate of VAP-related death is approximately 50% and increases the hospital stay up to five-seven days [8].

Given the high incidence of VAP and its expensive treatment, prevention is the most important method of VAP reduction. The protocol proposed for controlling and preventing VAP by the Institute for health care improvement (IHI) included issues such as raising the bed head up to 30-40 degrees, reducing the use of analgesics, assessing the patient (on a daily basis) in terms of the possibility of separation from mechanical ventilation and decrease of intubation time, preventing peptic ulcers and deep vein thrombosis, oral care, drainage of pulmonary edema and suction of secretion, if necessary, in an effective way. In this regard, the correct selection of humidifier can be crucial in preventing VAP [9]. The inappropriate selection of airway humidifier causes lung damage in patients connected to mechanical ventilation, which may lead to unsuccessful separation [10,11]. The indications of selecting the humidifier by the nurses are regarded as one of the most essential overlooked issues for which there is no accurate information. Furthermore, using the heated humidifier standard (HHS), the possibility of lung infection increases. Therefore, heat and moisture exchanger (HME) filter is more commonly utilized due to its ease of application [12]. Several studies were conducted regarding pneumonia and various types of lung humidifiers in patients admitted to ICU. However, various other studies reported conflicting results in this respect [13-14].

Finding a care standard for selecting a humidifier is one of the concerns of the researchers in this area since any negligence can lead to severe pulmonary damages in patients. VAP can cause dependency to mechanical ventilation, which increases the length of stay in the hospital, especially in the ICU ward [15]. Considering that routine care respecting humidifying the airways of the intubated patients is implemented by HME in Ayatollah Mousavi Hospital of Zanjan, and since there is no general consensus on this type of humidifier as the superior care, the current study sought to investigate the effect of using HHS and HME on VAP in patients hospitalized in the ICU of Ayatollah Mousavi Hospital.

Methods

This double-blind clinical trial was conducted in ICU ward of Ayatollah Mousavi Hospital in Zanjan after the approval of the Ethics Committee of Vice-chancellor for the Research Center of Zanjan University of Medical Sciences. Patients were selected through convenience sampling techniques. A pilot study was performed on 10 patients in each group in order to determine the sample size. Eventually, the final number of samples in both test and control groups was determined to be 80 patients (40 patients per group) after the initial analysis of the results using the following equation. It is notable that the sampling continued for four months during July-November, 2017.

Moreover, pilot patients were considered as the main samples of the study since they were representative of the main population. Additionally, the sampling methods and all the intervention-related techniques employed in the pilot study were similar to the main study. In addition, the selected patients were divided into two test and control groups in order to control the confounding variables in both groups applying random allocation and blocking method to obtain the appropriate sample size. In the blocking technique, blocks were made in the form of quadruples in six modes including [BBAA], [BABA], [ABBA], [AABB], and [ABAB]. Then, each quadruple composition was assigned one of the 1-6 values. Next, sample placement was performed 20 times for the four-member groups. In this respect, half of the patients (n=40) were placed in the heated humidifier standard (HHS) group and the remaining cases were allocated to the heat and moisture exchanger (HME) group.

The inclusion criteria were trauma patients who were connected to mechanical ventilation (for 12 hours) or Mark Raphael ventilator, had a seven-eight tracheal tube, ventilated in the mode of SIMV ventilator, had no artificial teeth, were

within the age range of 18-60 years, had no history of pneumonia, were not under chemotherapy, consumed no pantoprazole, had no trauma in lower airways or exacerbated myasthenia grave disease, were not pregnant, and had no acute burns. Further, the exclusion criteria included lack of connectivity to mechanical ventilation during the research, patient death, lack of willingness to participate in the research by the legal guardian or patient's physician at each stage of the study, and modification of the patient's medication from ranitidine to pantoprazole.

At the beginning of the sampling, the objectives of the research were explained to the patient's legal guardians and written informed consent was obtained from these guardians and the attending physician. Furthermore, they were ensured of the confidentiality terms regarding the personal information of the patients. Data were collected employing a demographic questionnaire designed based on previous studies. The validity of this questionnaire was confirmed by 10 faculty members of the university specializing in this field. Moreover, Apache II system was applied to control the severity of the disease among the two groups. Additionally, the clinical pulmonary infection score (CPIS) was utilized to confirm ventilator-associated pneumonia (VAP) incidence in patients. Generally, CPIS is a standard diagnostic instrument for pneumonia, where a score higher or equal to six is considered a clinical diagnosis [16].

The CPIS includes five variables, and scores regarding the diagnosis of pneumonia encompass body temperature between 36.5-38.4 ℃ (zero score), 38.5-39 ℃ (one score), and above 39 ℃ (two scores); cell counts including white blood cell (WBC) of 4-11 thousand (zero score) 11-17 thousand (one score), and above 17 thousand (two scores); lung secretions containing no discharge (zero score), low discharge (one score), and high discharge (two scores); the ratio of the partial pressure of oxygen in arterial blood (PaO2) to the inspired oxygen fraction (FiO2, pao2/fio2 ratio) being above 200 (zero score) and below 200 (one score); infiltration in radiography comprising clear (zero score), scattered infiltration (one score), and localized infiltration (two scores).

The scores were collected per day; the diagnosis of pneumonia was definite if the score of six or higher was obtained. In addition, the axillary temperature was calculated in order to diagnose VAP, and 0.6 degrees were added to the temperature to determine the degree of the central temperature. Further, CPIS was used to measure the temperature and the mean temperatures of the same day in order to diagnose the disease. In each shift, the cuff of the tracheal tube was computed and maintained in the range of 20-25 cm of water to prevent aspiration. Furthermore, the patient's secretion was suctioned as PRN by observing the sterile notes. Moreover, the level of discharge was not measured using a specific instrument while the amount of discharge was estimated based on the frequency of suction. Additionally, the lack of discharge was assumed in the case of only one section in a shift. In addition, two-three times of the suction (score=1) for patients indicated a low discharge rate whereas the suction ≥four times demonstrated a high level of discharge (score=2). Further, the obtained blood samples were transferred to the laboratory every day. Furthermore, the pao2/fio2 ratio existed in arterial blood gas (ABG) which was prepared from the arterial blood samples of intubated patients after they were delivered. It is noteworthy that CPIS issues, except for pulmonary infiltration, were diagnosed by the researcher while the graphic interpretation of the lungs was the responsibility of the ICU physician (i.e., ICU specialist).

All the patients hospitalized in the ICU ward of Ayatollah Mousavi Hospital in Zanjan, who were intubated over 12 hours and met the inclusion criteria were entered into the study. Moreover, chest X-rays were taken upon entering the research to dismiss previous pneumonia, and patients were evaluated for VAP. Additionally, the Apache II CPIS score was determined for all patients at the time of entering the research. In the HHS group, the HHS humidifier with a temperature of 36±2°C and relative humidity of 40% was used since the first day of mechanical ventilation whereas, in the HME group, the HME humidifier was employed from the beginning of the research.

Patients were daily examined for the symptoms of

pneumonia related to mechanical ventilation including tracheal tube discharge, body temperature, WBC, and pao2/fio2 ratio. In addition, the patients were followed up for seven days and evaluated in terms of the incidence of VAP in the first, third, and seventh day at the night shift at 9 P.M. using the CPIS scale. Finally, data were assessed in the SPSS software, version 16 using the Kolmogorov-Smirnov test and generalized equation estimation model (GEE) in order to determine the normal distribution of the variables and compare the data of the research groups regarding CPIS, respectively.

Results

In total, 80 patients hospitalized in the ICU of Ayatollah Mousavi Hospital of Zanjan were selected and classified into two heated humidifier standard (HHS) and heat and moisture exchanger (HME) groups (40 patients per group). Based on the results, 61.25% of the patients (n=49) were males and the remaining 38.75% (n=31) were females. The findings of Chi-square represented no significant difference between the two groups concerning gender distribution (P=0.818). Further, the minimum and maximum ages of the patients were 20 and 60 years, respectively, and the majority of the participants were in the age range of 30-39 years. Furthermore, based on the results of the independent *t*-test, no significant difference was observed between the groups regarding the mean ages (P=0.920). Eventually, the Glasgow Coma Scale (GCC) of the patients was 8.2±2, which indicated no significant difference between the patients in this regard (P=0.296). Demographic characteristics of the patients are provided in Table 1.

Table 1: Demographic Characteristics of the Patients

Group Demographic characteristics		HHS Group		HME Group		Chi-square	df	P value
		N	%	N	%			
Gender	Male	24	60	25	62.5	0.153	1	0.818
	Female	16	40	15	37.5			
Addiction	Smoking	11	27.5	9	22.5	0.267	1	0606
	No smoking	29	72.5	31	77.5			
History of underlying disease	Yes	12	30	9	22.5	1.95	1	0.582
	No	28	70	31	77.5			
		Mean (SD)		Mean (SD)		t	df	Pvalue
Age		36.40±9.9		36.1±9.8		0.101	3	0.920
GCS		8.6±2.3		8.02±2.5		1.04	4	0.296
Apache II score		24.67±5.9		25.50±4.8		-1.321	2	0.190

Note. SD: Standard deviation; GCS: The Glasgow coma scale

In the present study, the generalized equation estimation model was applied to compare HHS and HME groups on days one, three, and seven and in terms of the level of pneumonia diagnosis. The results of this test indicated a significant difference between days one and three (P<0.001), as well as days three and seven (P<0.001). In other words, the level of the disease diagnosis varied in the HHS group on days one and seven and three and seven. Moreover, the level of diagnosis was different in the HME group on days one and seven, as well as days three and seven. However, no difference was observed between the groups regarding pneumonia diagnosis. Accordingly, the statistical results represented a similar prevalence of pneumonia in HHS and HME groups (Table 2).

Table 2: The Estimation of Parameters and Their SD Using the GEE for the Comparison of the Rate of VAP Incidence in HHS and HME groups

Parameter Estimates										
Parameter	**B**	**Std. Error**	**95% Wald Confidence Interval**		**Exp(B)**	**95% Wald Confidence Interval for Exp(B)**		**Hypothesis Test**		
			Lower	**Upper**		**Lower**	**Upper**	**Wald Chi-Square**	**df**	**Sig.**
(Intercept)	-0.355	0.2713	-0.887	0.176	0.701	0.412	1.193	1.716	1	0.190
[HEMODIFAIRE=1,000]	0.508	0.3842	-0.245	1.261	1.663	0.783	3.530	1.751	1	0.186
[HEMODIFAIRE=2,000]	0[a]				1					
[Index1=1]	-17.33	2.2091	-21.664	-13.004	2.964E-8	3.903E-10	2.250E-6	61.572	1	0.000
[Index1=2]	-1.47	0.3286	-2.114	-0.826	0.230	0.121	0.438	20.011	1	0.000
[Index1=3]	0[a]				1					
(Scale)	1									

Note. SD: Standard deviation; GEE: Generalized equation estimation model; VAP: Ventilator-associated pneumonia; HHS: Heated humidifier standard.

Discussion

Based on the results of the present study, the evaluated groups revealed no significant difference in terms of the incidence of ventilator-associated pneumonia (VAP). Although the level of VAP was lower in patients of the HME group, the difference between the groups was negligible. Additionally, the results by Kelly et al. and American thoracic society clinical practice guideline demonstrated that inadequate evidence exists respecting the difference between heated humidifier standard (HME) and heat and moisture exchanger (HHS) in terms of VAP emergence [17]. In recent two-day research by Lacherade et al., no difference was found between the HHS and HME groups regarding VAP incidence, which is consistent with the findings of the current study [14]. In addition, Oğuz S, Değer found no significant difference between the HME and the HHS groups concerning VAP incidence [7].

Noticeably, the results of the above-mentioned studies are in congruence with those of the current study. However, in other similar studies, no significant difference was observed between the groups; in other words, several other variables improved in the HHS group. For instance, Nadir et al. compared the HME-booster and HHS in humidifying the airway of 42 patients under mechanical ventilation and concluded that VAP incidence was similar in both groups. Further, the amount of exhaled CO_2 was lower and the pulmonary secretions were thinner in the HHS group compared to HME group [18].

Contrarily, the results of some other studies contradict the findings of the current study. For example, Kirton et al. conducted research on ICU patients including burn patients with lung penetrating trauma and highlighted a significant reduction in VAP of those patients in the HME group compared to the HHS group. However, the HME filter was daily altered in the above-mentioned study [19]. Furthermore, Kola et al. reported a significant decrease in VAP of the patients in the HME group [20].

As regards the incidence of VAP, no significant difference was observed between the two types of humidifiers based on the results of the present research and those of other similar studies. However, the usefulness of the humidifier for each patient depends on the duration of hospitalization, age, underlying disease, and several other factors. Despite the VAP incidence in patients, other factors can contribute to the selection of humidifiers. More importantly, the mechanical ventilation of patients causes the least pulmonary complications of clinical pulmonary infection score (CPIS) in patients.

Moreover, the researchers aimed to increase the external validity of the study through the accurate description of intervention in order to minimize the research limitations. Additionally, the advantages and disadvantages of these two types of humidifier are suggested to be evaluated in

future studies using CPIS. Finally, researchers are recommended to assess other pulmonary factors and the costs of selection related to each of these humidifiers in the hospitalization of patients and the workload of nurses associated with these instruments. Therefore, based on the type of humidifier used in Iran, a suitable CPIS guideline could be developed to select the best CPIS humidifier for each patient.

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References

1. Alazmani Noodeh F, Ramezanibadr F, Shiri Ghidari P, Naghibi Mahmoud abadi T. Effect of Open Suctioning of Artificial Airway Based on the Comprehensive Criteria for Suctioning on the Patients' Hemodynamic Status Hospitalized in the Intensive Care Units. PCNM. 2016; 6 (2) :1-12. [In Persian]
2. Ahmadinejad M, Bouzari A, Ghahreman M, Sattari H, Mohajer E .Comparison of legionella pneumophila pneumonia in two airway humidifying systems in patients undergoing mechanical ventilation: randomized clinical trial.2013; 2(4): 3-9. [In Persian]
3. Tobin MJ. Principles and practice of mechanical ventilation. 2nded. New York: McGraw-Hill Professional; 2006.
4. MA. K. The effect of a pediatric heat and moisture exchanger on dead space in healthy pediatric anesthesia. . Korean J Anesthesiol. 2012; 62(5): 418-22.
5. Korhan EA, Yont GH, Kilic SP, Uzelli D. Knowledge levels of intensive care nurses on prevention of ventilator-associated pneumonia. Nurs Crit Care. 2014; 19(1): 26-33.
6. Labeau S, Blot S. Humidifier Type and Prevention of Ventilator-Associated Pneumonia: Chronological Overview of Recommendations. Humidification in the Intensive Care Unit. 2012: 187-92.
7. Oğuz S, Değer I. Ventilator-associated pneumonia in patients using HME filters and heated humidifiers. Ir J Med sci. 2013; 182(4): 651-55.
8. Johnson K, Domb A, Johnson R. One evidence based protocol doesn't fit all: Brushing away ventilator associated pneumonia in trauma patients. Intensive Crit Care Nurs. 2012; 28(5): 280-87.
9. Al-Tawfiq JA, Abed MS. Decreasing ventilator-associated pneumonia in adult intensive care units using the Institute for Healthcare Improvement bundle. Am J Infect Control. 2010; 38(7): 552-56.
10. Bilan N, Ganji S. Comparison of CPAP with Humidifier, Blender, and T-piece on the Outcome of Weaning in Patients with Neurological Disorders. Iran J Child Neurol. 2015; 9(2): 42-5.
11. Dessap AM, Katsahian S, Roche-Campo F, et al. Ventilator-associated pneumonia during weaning from mechanical ventilation: role of fluid management. Chest. 2014;146(1):58-65.
12. Brook I, Bogaardt H, Van As-Brooks C. Long-term use of heat and moisture exchangers among laryngectomees: medical, social, and psychological patterns. Ann Otol Rhinol Laryngol. 2013; 122(6): 358-63.

13. Saito N, Shime N, Sugiyama K, et al. Validation of the 2005 American Thoracic Society/Infectious Diseases Society of America guidelines for ventilator-associated pneumonia: a Japanese multicenter observational study. Critical Care. 2014; 18(1): P305.
14. Lacherade JC, Auburtin M, Cerf C, et al. Impact of humidification systems on ventilator-associated pneumonia: a randomized multicenter trial. Am J Respir Crit Care Med. 2005; 172(10): 1276-82.
15. Lerma FÁ, García MS, Lorente L, et al. Guidelines for the prevention of ventilator-associated pneumonia and their implementation. The Spanish "Zero-VAP" bundle. Med Intensiva. 2014; 38(4): 226-36.
16. Hanifi N, Masoumi M, Jamshidi MR, Faghihzadeh S. The Effect of Ozonated Water and Chlorhexidine Gluconate on Prevention of Ventilator-Associated Pneumonia: A Double-Blind, Randomized, Clinical Trial. Iran Red Crescent Med J. 2017:e60576.
17. Kelly M, Gillies D, Todd DA, Lockwood C. Heated humidification versus heat and moisture exchangers for ventilated adults and children. Cochrane Database Syst Rev. 2010; 4: CD004711.
18. Nadir OT, Ozcan KD, Oğuzülgen I, et al. The clinical and microbiological comparison of the use of heated humidifiers and heat and moisture exchanger filters with Booster in mechanically ventilated patients. Tuberk Toraks. 2009; 57(3): 259-67.
19. Kirton OC, DeHaven B, Morgan J, Morejon O, Civetta J. A prospective, randomized comparison of an in-line heat moisture exchange filter and heated wire humidifiers: rates of ventilator-associated early-onset (community-acquired) or late-onset (hospital-acquired) pneumonia and incidence of endotracheal tube occlusion. Chest. 1997; 112(4): 1055-9.
20. Kola A, Eckmanns T, Gastmeier P. Efficacy of heat and moisture exchangers in preventing ventilator-associated pneumonia: meta-analysis of randomized controlled trials. Intensive Care Med. 2005; 31(1): 5-11.