

Evaluation of the Effects of the Closed Sputum Suction Method in Ventilated Patients at Intensive Care Unit from Vietnam

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Abstract— Introduction: Ventilator Associated Pneumonia (VAP) is one of the leading causes of hospital-acquired infections. In Vietnam, the rate of VAP according to a study at the National Children's Hospital in 2015 was 34%. Closed sputum suction (CSS) is one of the effective methods to reduce the rate of VAP. **Materials and methods:** randomized controlled experimental study was conducted on two groups of patients with mechanical ventilation through endotracheal intubation at the Vung Tay Nguyen General Hospital from September 2020 to November 2021: (1) the experimental group consisted of 30 patients who were cared for by CSS method, (2) the control group consisted of 30 patients who were cared for by the open sputum suction (OSS) method. **Result:** The results showed that the CSS reduced the VAP rate from 66.7% to 30% compared with the OSS. This method is also effective on improving the average SpO₂ index, stabilizing the SpO₂ index during sputum suction process. In addition, CSS also improves the treatment period, especially the time of mechanical ventilation is reduced and the time to diagnose VAP of patients using the CSS method also starts later. The factors of body mass index (BMI), SpO₂, length of hospital stay, time of mechanical ventilation are the factors that are related to the VAP rate with statistical significance ($p < 0.05$).

Keywords— Closed suction, ventilated patients, Ventilator Associated Pneumonia.

I. INTRODUCTION

Currently, the concept of hospital-acquired infections, also known as healthcare-associated infections, is one of the top concerns in the medical field. According to a 2017 census, an estimated 7% of patients in developed countries and 10% in developing countries have nosocomial infections. Consequences of nosocomial infections can be prolonged hospital stays, drug resistance, or even disability. In addition, hospital-acquired infections also increase the economic burden for both patients and society [10]. There are many causes leading to hospital-acquired infections such as urinary tract infections, hospital-acquired pneumonia, surgical site infections, and infusion-related infections. While in Europe, a multi-center prospective study reported that the 30-day mortality rate of VAP was 29.9%, the mortality rate of early VAP was 19.2%, and the mortality rate of the late VAP was 31.4% [14]. The hospital stay of VAP patients in Europe was extended by 4-14 days, costing from 4,200 to 13,030 euros [1]. Some initial surveys on hospital-acquired infections in Vietnam show that the prevalence of hospital-acquired infections ranges from 3-7% depending on hospital level and

class [24]. VAP rate according to a study at the National Children's Hospital in 2015 was 34% [15].

VAP prevention measures such as aspiration pneumonia prevention, prevention of cross-contamination from healthcare workers, proper disinfection and sterilization of respiratory equipment, and education for health workers and patients have been shown to contribute the part that reduces the VAP rate. One of the recommended measures is the use of CSS tubes in mechanically ventilated patients to reduce VAP. The reason for the effectiveness of the CSS tube is that the patient is aspirated in a closed environment, reducing the risk of cross-contamination in the practice of health workers. Recent studies have demonstrated that CSS is more effective than OSS in the prevention of VAP [22]. According to the results of a study in Cho Ray Hospital in 2011, the rate of pneumonia related to mechanical ventilation in the group using a CSS tube was 50% less statistically significant compared with the group using an OSS, the mortality rate in the CSS group decreased by 33.4% and the length of stay in the intensive care unit significantly reduced compared with the group of OSS [19].

II. OBJECTIVES

At the Department of Intensive Care and Anti-Poison in Vung Tay Nguyen General Hospital only uses the CSS method on patients with acute pulmonary edema. Therefore, we carried out this study at the At the Department of Intensive Care and Anti-Poison - Vung Tay Nguyen General Hospital, with two objectives: (1) Comparing the effectiveness of CSS and OSS on mechanically ventilated patients, (2) determining factors related to the rate of VAP in mechanically ventilated patients.

III. MATERIALS AND METHODS

A. Study Design and Setting

A randomized controlled experimental study was conducted to comparing clinical indicators of VAP rate, SpO₂ index, duration of treatment, cost of treatment between the group of mechanically ventilated patients using CSS method and OSS method. Evaluation of risk factors related to VAP.

B. Sample Size

The study participants included 60 patients assigned to mechanical ventilation through an endotracheal tube At the

Department of Intensive Care and Anti-Poison - Vung Tay Nguyen General Hospital, the minimum duration of mechanical ventilation was 48 hours and there were no factors of nosocomial infection.

C. Data collection and analysis

All study subjects were randomly divided into two groups, the experimental group consisted of 30 mechanically ventilated patients using the CSS method and 30 patients using the OSS method. The data collection process takes place from the time the patient is admitted to the hospital to the time of discharge according to a pre-designed template. All research collaborators will be trained in advance to agree on indicators and data collection methods. The study used statistical software SPSS Ver.25 to make descriptive statistics and analyse the relationship between variables. Logistic regression method to evaluate factors related to VAP. In addition, to evaluate the possibility of pneumonia, the possibility of hospital discharge over time, this study used the method of survival analysis to evaluate. All tests have statistical significance $p \leq 0.05$.

D. Approval

This study was approved by the IRB of Buon Ma Thuot University for human objects research. The code of decision: 139/QD-DHBM.T.

IV. RESULTS AND DISCUSSION

A. Characteristics of the Participants

The results of Table I show that men account for a large proportion, this rate in the CSS group is 77.3%, the OSS group is 67.7%. This rate is similar to some other studies at Cho Ray Hospital [19] and Thanh Hoa General Hospital [18]. When compared with a study in Egypt by author Ahmed Elmansoury, the proportion of men is only 53.2% [6]. This difference may be related to the characteristics of the disease pattern in Vietnam, according to WHO statistics in 2015 on cardiovascular disease risk factors of Vietnamese people aged 18-69, the results showed that the proportion of men with hypertension was 35.1%, significantly higher than 26.3% of women, this survey also showed that men are the target group with 3 or more risk factors for cardiovascular disease such as eating salty foods, using alcohol and smoking is 18.2%, this rate is only 7.1% among women [27]. Meanwhile, according to the results of Table II, the rate of patients diagnosed with cardiovascular diseases in this study was up to 65%.

The mean age of the CSS group was 60.7 ± 16.5 , the OSS group was 65.33 ± 16.33 ($p=0.027$), the overall mean age was 63.0 ± 16.4 ($p=0.278$). This result is consistent with the studies of other authors in Vietnam such as Do Minh Thai at Thanh Hoa General Hospital, with the average age of the study subjects being 62.9 ± 17.5 years [18]. However, when compared with a study on mechanically ventilated patients at Cho Ray hospital, the mean age was 46.8 ± 18.9 years, and 36.9 ± 17.2 for women [19]. This difference is related to the hospital's degree of disease diversity, Cho Ray hospital special-class hospitals have much more diversity in terms of demographic characteristics and many diseases than other

patients at provincial hospitals, which in turn leads to a lower mean age. In addition, in fact, during the implementation of the study, the proportion of elderly patients diagnosed with chronic diseases was relatively high, some chronic patients had a history of being admitted to the hospital many times.

TABLE I. Characteristics of the Participants (n=60).

Variables	CSS		OSS	
	Frequency	Percentage	Frequency	Percentage
Male	22	73.3	20	67.7
Female	8	26.7	10	33.3
Mean ages	60.7 ± 16.5		65.33 ± 16.3	
BMI	22.2 ± 2.02		22.4 ± 1.98	
Apache II	20.1 ± 3.8		22.4 ± 5.3	

The BMI of the CSS group was 22.2 ± 2.02 , the OSS group was 22.4 ± 1.98 ($p=0.654$), showing the similarity in the physical status of the two groups. In addition, this study also evaluated the Apache II score at the time of admission to assess the similarity and mortality of the study subjects [12]. The results showed that the Apache II index of the OSS group was 22.4 ± 5.3 , the CSS group was 20.1 ± 3.8 ($p=0.055$). From the above data, it can be seen that there are similarities between the two intervention groups and the control group in terms of the individual characteristics of the study subjects.

B. Effectiveness of closed sputum suction method

According to the results of Table II, the rate of VAP in the OSS was 66.7%, significantly higher than that in the CSS group of 30% ($p=0.004$). When compared with other studies at Cho Ray hospital, the rate of VAP in the CSS group was 13.3%, a 50% reduction, statistically significant ($p=0.03$), compared with the OSS group (26.7%) [19].

TABLE II. Effectiveness of closed sputum suction method (n=60).

Variables	CSS	OSS	p
VAP (%)	30	66.7	0.004
SpO ₂ (%)	98.5 ± 0.8	95.2 ± 0.9	0.001
SpO ₂ increase (%)	0.1 ± 0.3	1.54 ± 1.2	0.001
Length of stay (days)	9.8 ± 7.4	12.9 ± 8.6	0.18
Ventilation period (days)	7.3 ± 3.0	12.4 ± 8.6	0.049
Time of diagnosis VAP (days)	7.0 ± 0.7	4.1 ± 2.8	0.001
Hospital fees (VND) average per day	2,685,160	3,420,089	0.086
Bed fees average per day (VND)	406,589	420,123	0.788

According to another study at Military Hospital 175 in 2017, the overall rate of VAP was 50.8% [11]. Although the rate of VAP in this study was significantly reduced in intervention group. However, this is still a very high percentage. A study at Thanh Hoa General Hospital that combined CSS method combined with bronchoalveolar irrigation with Decasan solution showed much better efficiency, specifically, the VAP rate of the experimental group was 6.67%, the control group 26.7% ($p<0.05$) [20]. Another study in 2014 in Iran stated that: if OSS is considered a risk factor, OSS increases the rate of VAP by 92% compared with the CSS group [7], our results also showed that the rate of VAP in the OSS group increased 4.76 times compared with the CSS group. This shows that additional measures are needed to reduce the high VAP rate.

The results showed that the average SpO₂ index of the

CSS group was $98.5\% \pm 0.8$, higher than 95.2 ± 0.9 ($p < 0.001$), in terms of the change after suction in SpO₂ index of the CSS and OSS group 0.1 ± 0.23 and 1.54 ± 1.22 , respectively ($p < 0.001$). This shows that in addition to helping to increase the oxygen concentration in the blood of mechanically ventilated patients, the CSS method also helps to stabilize the blood oxygen concentration, the difference in blood oxygen concentration in the group of patients using the method. CSS was lower than the OSS group, showing that it is as effective as reducing the side effects of sputum suction, which is the destabilization of blood oxygen levels and airway pressure during suction, which brings higher clinical effectiveness, especially in patients requiring high PEEP. according to Le Thi Anh Thu's study, the change in oxygen concentration before and after sputum aspiration of the control group and the experimental group was 0.7% and 0.2%, respectively [19].

When comparing the length of hospital stay, the results showed that the average length of stay in the CSS group was 9.8 ± 7.4 days, the OSS group was 12.9 ± 8.6 , but this difference was not statistically significant with $p = 0.18$. On the other hand, when comparing the time of mechanical ventilation, there is a marked reduction. The duration of mechanical ventilation of the CSS group was 7.4 ± 3.0 days, compared with the OSS group was 12.45 ± 8.55 days ($p = 0.049$). Compared with this result with the study of author Elmansoury et al in 2017 on 141 mechanically ventilated patients, the results were similar, with the mean duration of treatment being 9.3 ± 2.5 days in the CSS group and 10 ± 3.2 days of OSS group [6]. Comparing these results with another study at Thanh Hoa general hospital combining closed sputum suction and irrigation with Decasan solution, the results showed that the time of mechanical ventilation decreased from $7.5 \pm 2, 5$ days in the control group reduced to 6.3 ± 1.6 days in the experimental group ($p < 0.05$) [20]. This again shows that CSS is a method to help reduce treatment time, but it should be combined with other methods to improve efficiency.

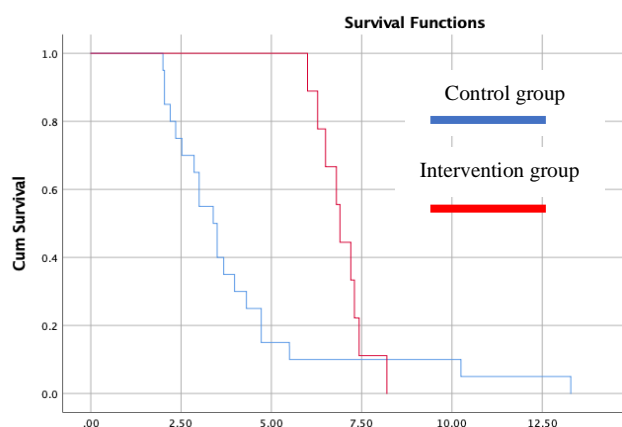


Fig. 1. Time of diagnosis VAP (days)

The mean time to diagnose VAP of the CSS group was 7.0 ± 0.7 days, significantly higher than that of the OSS group of 4.1 ± 2.8 days ($p < 0.001$). According to a study by Quang Ninh General Hospital in 2016 with comparable results, the average time to be diagnosed with VAP was 4.6 ± 1.5 days [8]. The

results show that the effectiveness of the CSS method will slow down the process of VAP compared to the OSS group. According to the results of the survival analysis of Figure 1, it shows that the time to predict the possibility of VAP of the CSS group can start from day 6, significantly slower than the OSS group from day 4. 2 onwards ($p = 0.028$). However, after 7.5 days of mechanical ventilation, this predicted rate between the two groups was similar with about 90%.

In terms of economic efficiency, the data in Table II show that there is no statistically significant difference, although there is a rather large difference between the two groups, 2,685,160 VND/day in CSS group compared to 3,420,089 VND/day of the OSS group. This may be related to the high cost of some patients using high technology leading to dissimilarities between the two groups of subjects. A number of studies around the world have shown that reducing the rate of VAP helps to reduce a large part of treatment costs for patients with mechanical ventilation. A study in France showed that VAP increased the duration of therapeutic breathing by about 7 days and the cost increased by about 40,000 USD [21], which is an increased cost due to VAP in a developed country, the level of live high. But according to a Vietnamese statistic, hospital-acquired pneumonia lasts from 6-13 days, the additional cost per case ranges from 15-23 million VND [24].

C. Factors related to the rate of VAP

According to the results of Table III, it shows that when comparing the mean age of the group with VAP and without VAP, there is no difference in age ($p = 0.592$) with the mean age of the group with VAP is 64.1 ± 15.5 , the group without VAP is 64.1 ± 15.5 years old. has a VAP of 61.8 ± 17.3 . This result is consistent with some other studies in Vietnam such as the study by author Nguyen Van Canh done at 108 Central Military Hospital [5], author Pham Ngoc Trung at the hospital. An Giang Central General Hospital also gave similar results [23]. In addition, according to a statistic in France in 2015 on 3028 ventilator-associated patients, the age of the group with Ventilator-associated conditions (VAC) is 65.3 years old, which was not different from the group without VAC at 65.9 years old [4]. However, according to the guidelines on the prevention of hospital-acquired pneumonia of the Ministry of Health, those aged 65 years and over are still a risk factor for hospital-acquired pneumonia [25].

TABLE III. Factors related to the rate of VAP (n=60).

Variables	VAP	No VAP	p
Mean ages	64.1 ± 15.5	61.8 ± 17.3	0.592
Gender (male/female)	22/7	20/11	0.25
BMI	23.0 ± 1.6	21.6 ± 2.1	0.006
SpO ₂	96.2 ± 2.1	97.5 ± 1.4	0.011
Length of stay (ngày)	16.3 ± 8.8	6.6 ± 3.1	<0.001
Ventilation period (days)	13.9 ± 7.4	6.0 ± 3.1	<0.001

When comparing VAP rates by sex, there was no significant difference. The rate of pneumonia in male is 52.4%, female is 38.9%. This rate is similar to that of some other domestic researchers [5], [17]. However, there are some statistics that show that the rate of community-acquired

pneumonia and hospital-acquired pneumonia is often higher in men, the authors also give factors related to culture and habits. Behavioral factors are responsible for the higher prevalence of pneumonia in men [13]. This may also be a potential risk factor for VAP risk for men on mechanical ventilation.

The results of BMI showed that this was a factor related to the VAP rate ($p = 0.006$). Overweight and obesity are one of the risk factors for VAP through two mechanisms: ventilation and immune disorders. Risks related to the ventilation mechanism: When obese, especially severe, there is often compromised ventilation, due to decreased respiratory muscle strength, reduced effective lung volume, increased airway resistance, and finally reduced gas exchange. Obesity can disrupt the immune response, so it is more susceptible to infections as well as influenza viruses, this risk increases and is more susceptible to long-term infections than non-obese people. Over-weight and obesity are also often associated with another disease such as diabetes or obstructive sleep apnea syndrome, especially related to the current rate of severe pneumonia in Covid-19 patients [16]. In addition, overweight patients often have difficulty in intubation and oral hygiene, causing more stagnation of oropharyngeal fluid. This is one of the risk factors for VAP due to the proliferation of enteric aerobic Gram-negative bacteria residing in the oropharynx of hospitalized patients [25].

The average SpO₂ index of subjects with VAP was 96.2 ± 2.1 , significantly lower than that of subjects without VAP of 97.5 ± 1.9 ($p=0.011$). SpO₂ is an important indicator and easy to check for patients. This indicator not only measures assess the patient's condition, it can also evaluate the effectiveness of intervention and treatment. In addition, SpO₂ is also used as an index to predict patient outcomes at the time of admission [2]. Especially during the time when the Covid-19 pandemic is breaking out very strongly in many countries, SpO₂ is also used to evaluate the rate of severe pneumonia and death due to Covid-19, a study by the author showed that if When the SpO₂ concentration of Covid-19 patients was $<88\%$, the rate of hospitalization increased to 3.97 times, the mortality rate increased to 2.88 times [3]. Therefore, it is necessary to monitor, evaluate and ensure a stable SpO₂ index for each disease, preferably at 95% or more [26].

The results from Table III also show that, when comparing the length of hospital stay and the time on mechanical ventilation of the two groups with VAP and without VAP, the results show that the hospital stay and the time of mechanical ventilation of patients with high VAP than the group of patients without VAP ($p<0.001$). This suggests that prolonged treatment time is a risk factor leading to an increased incidence of VAP. On the other hand, as discussed above, VAP is also a factor that prolongs the duration of treatment, these two factors are a spiral of reciprocal influence. Results of effective care and treatment in mechanically ventilated patients. This is also mentioned in many other documents and studies such as the author, [9], [19], [20], [8], [21]. In addition, the data on factors related to VAP were tested in the logistic regression model, the results showed that only the mechanical ventilation time factor could independently explain the VAP rate. The results also showed that the incidence of VAP

increased to 1,378 times when the duration of mechanical ventilation increased by one day ($OR = e^{0.321 * \text{number of days on mechanical ventilation}}$), equivalent to when the duration of mechanical ventilation was 10 days, this rate increased to 24.78 times.

V. CONCLUSION

The results of the study showed that the CSS method reduced the VAP rate from 66.7% to 30% compared with the OSS method. This method is also effective in improving the average SpO₂ index as well as stabilizing the SpO₂ index during sputum aspiration. In addition, CSS also improves the treatment time for patients, especially the time of mechanical ventilation is significantly reduced, the time to diagnose VAP of patients using the CSS method also starts later than with the group of patients using OSS method. Regarding the factors related to VAP, the factors of age and sex are two factors that are not related to the rate of VAP. The factors of BMI, SpO₂, length of hospital stay, time of mechanical ventilation are factors related to the rate of VAP.

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