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Efficacy of compliance with ventilator-associated pneumonia care bundle: A 24-month longitudinal study at Bach Mai Hospital, Vietnam

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Abstract

Introduction: To decrease the risk of complications from ventilator-associated pneumonia, it is essential to implement preventative measures in all ICU patients. Since 2018, with the help of Japanese experts, we have applied a ventilator-associated pneumonia care bundle with 10 basic standards in patient care and monitoring. Therefore, we conducted a study to evaluate the results of applying 10 solutions to prevent ventilator-associated pneumonia over 24 months.

Methods: A cross-sectional descriptive study with longitudinal follow-up for 24 months on 170 mechanically ventilated patients at the Center for Critical Care Medicine, Bach Mai Hospital. According to the Centers for Disease Control (CDC, 2021), the diagnosis of ventilator-associated pneumonia is when pneumonia appears 48 h after intubation by confirmation by at least two doctors. Evaluate compliance with each solution in the care bundle through camera monitoring, medical records, and directly on patients daily.

Results: The rate of ventilator-associated pneumonia is 12.9%, the frequency of occurrence is 16.54 of 1000 days. The compliance rate for complete compliance with a 10-item ventilator-associated pneumonia was only 1.8%, while the average value was 84.1%. Average values of compliance with each solution for hand hygiene, head elevation 30–45 degrees, oral hygiene, stopping sedation, breathing circuit management, cuff pressure management, hypoplastic suction, Spontaneous breathing trial (SBT) daily and assessed extubation, mobilization and early leaving bed, ulcer and thrombosis prevention were 96.9%, 97.3%, 99.4%, 81.5%, 99.9%, 99.9%, 86.3%, 83.5%, 49.3%, and 46.4%, respectively. The time to appear ventilator-associated pneumonia in the high compliance group was 46.7 ± 5.0 days, higher than in the low compliance group, 10.3 ± 0.7 days, $p < 0.001$.

Conclusions: A 10-item ventilator-associated pneumonia care bundle has helped reduce the incidence of ventilator-associated pneumonia. To reduce the risk of ventilator-associated pneumonia and shorten ICU and hospital stays, it is essential to fully adhere to subglottic secretion suction, daily SBT, and early mobilization and leaving the bed.

Keywords

Ventilator-associated pneumonia, care bundle

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Introduction

Ventilator-associated pneumonia (VAP) is one of the most common complications in patients with invasive mechanical ventilation. According to Kollef et al.,[1] the VAP rate is 15.6% (293/1873), of which there are differences between geographical areas, with the rate in the United States being 13.5%; in Europe, it is 19.4%; Latin America and Asia Pacific is 16.0%. The incidence ranges from 2.86 to 125 cases per 1000 days of mechanical ventilation depending on the resuscitation unit, of which in Vietnam it is 23.89 cases.[2]

Bacteria can enter the lower respiratory tract in four ways: (1) Inhalation of bacterial secretions directly from the throat or from contaminated gastric fluid; (2) Bacteria from pleural infection enter directly; (3) Bacteria from outside are introduced through medical instruments, aerosols or contaminated air; (4) Bacteria from infection sites elsewhere in the body travel through the bloodstream to the lungs. According to the CDC's 1994 guidelines for preventing hospital pneumonia and VAP, intubation increases the risk of pneumonia by 6–21 times.[3] Many studies suggest that the number of reintubations should be limited by using a tube with a separate line to continuously suction fluid from the nasopharynx above the cuff (Hi-Lo Evac), the VAP rate and the rate of The mortality rate due to VAP decreased significantly.[4,5]

The ventilator and the ventilator's air delivery system are not risk factors for VAP. However, combustion humidification systems will cause condensation in the circuit and the water traps of the breathing circuit. Therefore, the water trap of the course must be placed in the lowest place to avoid water refluxing into the breathing circuit and the lungs. Some studies also show no difference in the rate of VAP between groups of patients whose ventilator circuit systems are regularly changed every 2 days, 7 days, or even 14 days.[6–8] Furthermore, daily nursing care is also a risk factor for VAP. Therefore, before and after patient care activities such as bronchial sputum aspiration and dental care, nurses must seriously practice hand hygiene. Most studies suggest that the quality of hand hygiene of medical staff when caring for patients on ventilators is also a factor causing VAP.[9–11]

To minimize complications of pneumonia for patients with endotracheal tubes or mechanical ventilation, applying effective preventive measures right from the time the patient enters the hospital is extremely necessary and is a practical and urgent issue. Many authors worldwide have proposed individual efforts to prevent VAP, such as oral care with Chlorhexidine solution, an endotracheal tube with a suction port on the cuff, and intermittent sedation and assessment daily ventilator weaning.[12–14] Since 2018, with the help of Japanese experts, we have applied a VAP care bundle with ten basic measures in patient care and monitoring. After initial implementation, improvements were seen in reducing the frequency of VAP occurrence. Therefore, we conducted a study to evaluate the results of applying ten solutions to prevent VAP for 24 months.

Material and methods

This cross-sectional, longitudinal descriptive study was conducted at the Center for Critical Care Medicine (ICU), Bach Mai Hospital, from April 2021 to March 2023.

Diagnosis criteria

Patients are diagnosed with VAP when having symptoms of clinical pneumonia according to CDC 2021 diagnostic criteria[15]: Pneumonia occurring in a patient who has been intubated or has a tracheostomy for 48 h is determined using a combination of imaging, clinical, and laboratory criteria (standards for Clinical Pneumonia) (PNEU/PNU1/PNU2/PNU3). Two doctors will confirm the VAP diagnosis.

Selection criteria. The patient was intubated for 48 h but did not develop VAP. The patient or the legal representative agrees and signs the informed consent.

Exclusion criteria. All patients who had the following symptoms were excluded: 1. Patients with evidence of pneumonia before being intubated/ventilated: fever, cough, chest pain, rales on auscultation, chest X-ray with damage; 2. Patients with hospital stay <48 h since diagnosis of VAP (including all patients transferred, discharged, or died before 48 h).

Sample size. The sample size was calculated using the formula recommended by the World Health Organization, where "p" represents the proportion of patients with VAP, as reported by Sekihara et al.[16] ($p=0.194$). The calculated sample size for this study was $n=167$ patients.

Evaluation standards. Full compliance when a patient fully implements all ten backup solutions. Non-compliance when any one of the 10 solutions was not performed on that patient during the study period. The research team determines treatment compliance based on the ratio between the number of opportunities and the number of attempts. Patients are considered fully compliant with each solution when this rate is 100%. This calculation is applied similarly to compliance with the entire backup package (Table 1).

Data collection and analysis process

Step 1: Record every day the number of new patients admitted to the department who have been previously intubated, or patients currently being treated in the department who have been intubated. The research team will assess the clinical condition and X-ray of the patient's lungs to determine the appropriate criteria for selection into the study.

- Group A: Record patients with clinical evidence of pneumonia according to CDC 2021 standards at the time of admission to the department or the time of endotracheal intubation. Apply VAP prophylactic solutions, but do not include them in the study group.

Table 1. Data collection method for each solution.

Solution	Detailed description	Evaluation methods
Hand hygiene		Patients are monitored through in-person observation during the day and camera observation at night. The Vital Signs and Treatment form is filled out three times a day
Elevated head 30–45 degrees	Place the patient in a position with the head of the bed raised above 30° (in case there are no contraindications)	The angle of the patient's joint is measured three times a day at the bedside using a protractor and recorded in the nurse's monitoring chart
Oral hygiene	After pharyngeal suction, oral hygiene with a solution containing 0.12% chlorhexidine	The patient's vital signs are recorded daily from the nurse's bedside monitoring board. Additionally, using a checklist, the patient is observed via camera at least once daily
Stop sedation	Daily nursing stops sedation after patient care in the morning (unless contraindicated)	Obtain from the nurse's bedside monitoring chart and record appropriately in the medical record once daily
Manage the breathing circuit	Maintain endotracheal tube cuff pressure between 25–30 cm H_2O	Measure the strain directly at the hospital bed using a manometer thrice daily at random intervals
Cuff pressure control	Please do not change the breathing circuit periodically; only change it when visibly dirty or damaged	Nurses record patient observations three times per day on the bedside monitoring board
Subglottic secretion suction	The patient has an endotracheal tube suctioned on the cuff, intermittent suction every 4 h, or continuous suction. If the patient has a suction endotracheal tube on the cuff but does not suction, it is noncompliant	The nurse records suctioning on the monitoring chart once a day, based on their work shift
Daily Spontaneous breathing trial (SBT) and extubation assessment	Comply when the patient performs the spontaneous breathing test and is assessed for daily extubation. Patients who did not meet the criteria for weaning from mechanical ventilation were assessed as compliant	The doctor may record the application of this solution on the VAP care bundle application evaluation form or in the medical record
Exercise and get out of bed early	During the day shift, patients are allowed to sit at a height of 70–90 degrees or get out of bed early at least once	Patients' daily exercise and waking time are recorded in the nursing chart
Prevention of ulcers and thrombosis	Patients are prescribed medication to prevent gastric and duodenal ulcers and prevent deep vein thrombosis according to instructions	Patients are evaluated daily using the care bundle application evaluation form, which records and marks solutions for preventing gastric ulcers

Only record the number of days on a ventilator to calculate the total number of days on a ventilator by month and year.

- Group B: Apply preventive solutions to patients who satisfy the selection criteria, and begin evaluating compliance with the solutions in the package.

Step 2: On day 2, apply the VAP prevention package to patients in Group B. Conduct clinical assessments such as breathing rate, temperature, Glasgow,[17] RASS,[18] APACHE II,[19] SOFA score assessment; blood tests, blood gas, chest X-ray, and endotracheal sputum collection for identification culture test. If the patient meets the criteria for diagnosis of pneumonia, exclude them from the study.

Step 3: Clinically evaluate patients daily with blood tests, blood gases, and chest X-rays after 2 days of mechanical ventilation or when there are clinical signs suspicious of pneumonia. If the criteria for diagnosis of pneumonia, extubation, or death within 48 h are met, exclude them from the study.

Step 4: Patients still in the study continue to be monitored and evaluated as in step 3 until the patient leaves the department. For the group that was successfully extubated, clinical monitoring is required within 48 h. If there are clinical signs suspicious of pneumonia, an assessment test should be performed as in step 3.

Step 5: After extubation, continue to monitor and evaluate patients within 48 h. If the patient meets the criteria for VAP diagnosis within 48 h after extubation, it is still considered VAP.

Step 6: End data collection when the patient leaves the department.

The data was processed and analyzed using IBM SPSS statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Statistical analysis was performed using the corresponding statistical tests to determine the relationship between variable values. T-test, odds ratio OR, Chi-square, and Fisher exact test (when the value is less than 5) were used. The Kaplan-Meier function was used to analyze the time of appearance of VAP. A p-value of less than 0.05 was considered to be a statistically significant difference.

Ethics approval

Ethical approval was waived by the Institutional Review Board of Bach Mai Hospital (Approval Number: 1435/BVBM – HĐĐĐ).

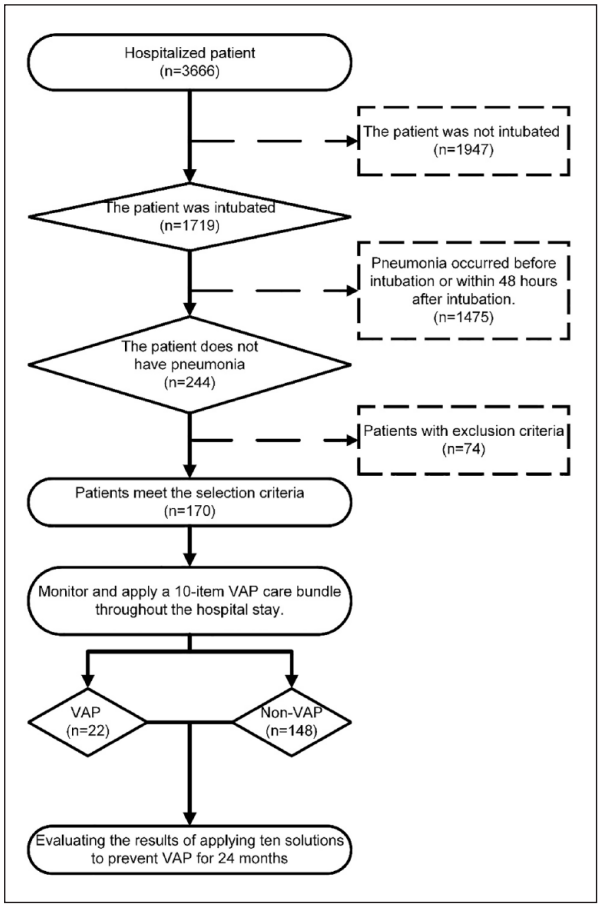

Figure 1. Flow chart for selecting research subjects.

Table 2. General characteristics of research subjects.

Characteristics	*n*	%
Age		
<45	82	48.2
45–59	28	16.5
⩾60	60	35.3
Mean	48.4 ± 19.1 (15–88)	
Gender		
Male	88	51.8
Female	82	48.2
Diagnosis of hospitalization		
Neuromuscular	48	28.2
Heart	44	25.9
Gastrointestinal	32	18.8
Allergy	15	8.8
Respiratory	15	8.8
Urinary	4	2.4
Endocrine	5	2.9
Other	7	4.1
Number of times the endotracheal tube was changed		
None	131	77.1
Once	34	20.0
⩾2 times	5	2.9
Clinical score		
Glasgow (*n* = 101)	13.5 ± 3.1 (3–15)	
Richmond agitation sedation scale (RASS) (*n* = 69)	−3.6 ± 1.3 ((−5) −2)	
Acute physiology and chronic health disease classification system II (APACHE II) (*n* = 170)	11.9 ± 6.3 (0–32)	
Sequential organ failure assesment (SOFA) (*n* = 170)	5.0 ± 3.8 (0–18)	

Results

From April 2021 to March 2023 at the Intensive Care Department of Bach Mai Hospital, there were 3666 patients hospitalized, of which 1719 patients had indications for endotracheal tube intubation; 1475 patients were excluded because they had pneumonia before the endotracheal intubation or within 48 h after intubation. The remaining 244 patients were initially eligible to be selected for the study. However, 70 cases had to be excluded from the study due to mechanical ventilation time <48 h or being discharged from the ICU within 48 h, and four were excluded due to family disagreement to participate in the study. Therefore, the study enrolled 170 eligible patients with 1330 days of mechanical ventilation (Figure 1, Table 2).

Level of compliance with invasive mechanical ventilation-associated pneumonia care bundle

Most patients still need to fully comply with the care bundle at a rate of 98.2%. Only three cases had a 100% compliance rate with all solutions.

The compliance rate of the care bundle was 84.1%. The five solutions with the lowest compliance rates are subglottic secretion suction, daily SBT, extubating assessment, stopping sedation, mobilizing and leaving bed early, and ulcer and thrombosis prophylaxis.

In most solutions, the average duration of mechanical ventilation, and length of hospital stay were all higher in the group with incomplete solution compliance than in the complete compliance group; $p > 0.05$. There is no difference in the duration of mechanical ventilation, length of stay at the ICU, and length of hospital stay between the groups with high and low compliance with a 10-item VAP care bundle.

The compliance rate with subglottic fluid suction, exercise and get out of bed early solutions with VAP was lower than that of the non-VAP group with $p < 0.05$.

Univariate analysis showed that inadequate compliance with morning sedation cessation, subglottic aspiration, daily SBT, extubation assessment, mobilization, and early leaving bed increased the rate of VAP by 3.1 fold, 16.4 fold, 3.1 fold, and 5.1 fold, respectively.

The time to appear VAP in the group with high adherence to a 10-item VAP care bundle was 46.7 ± 5.0 days, longer than in the group with low commitment at 10.3 ± 0.7 days with $p < 0.001$.

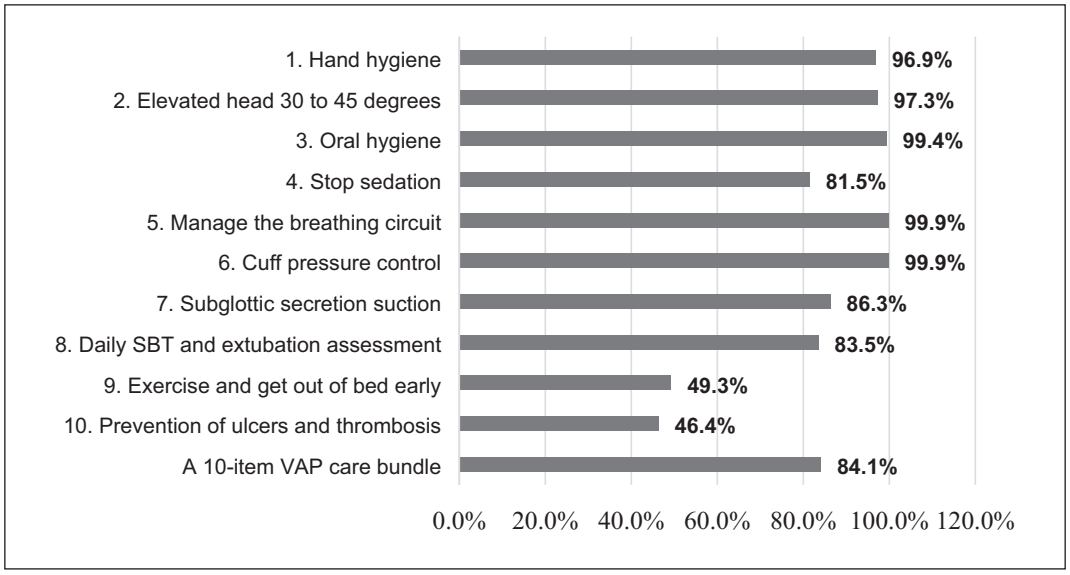

Figure 2. The compliance rate of the care bundle according to each solution.

Discussion

One hundred seventy patients on mechanical ventilation for 48 h at the ICU department were enrolled in the study, of which 22 patients were diagnosed with VAP (12.9%). According to Rosenthal VD et al. (2023), collecting data from 42 countries, Vietnam had a VAP rate of 23.83%. Our results also show that the VAP rate is higher than in some areas, such as Thailand at 2.71%, China at 8.37%, but lower than the Philippines at 24.59%, Russia at 24.59%, and Turkey at 16.88%.[2] The frequency of VAP was 15.56 cases of 1000 days, which was higher than some developed countries such as Japan (2018) at 6.4 of 1000 days,[20] and North America at 1–2.5 cases of 1000 days.[21] In our ICU, comparing the VAP rate from previous years to the present time shows that the VAP rate tends to decrease. This result is because our infection control has received more attention and investment in recent years. The department has strict regulations for medical staff, such as regularly evaluating hand hygiene compliance rates and developing checklists for care procedures for patients on ventilators. These are the result of the cooperation with Japanese experts to create a 10-item VAP care bundle several years ago, especially in warning patients infected with multidrug-resistant bacteria.

According to our results (Figure 2), hand hygiene has a compliance rate of 96.9%, lower than the study by the Japanese author (100%),[16] and higher than the Jordan author (94.2%).[22] Hand hygiene is also one of the solutions that many authors include in care bundles. However, studies have different compliance rates; Soni KC's[23] study is 86.8%, Okgün Alcan et al.[13] Türkiye from 76.8% before employee training to 97.6% after training with $p < 0.001$. Our results showed that the high compliance rate is due to the excellent infection control network, including groups of doctors and nurses who monitor daily via cameras discretely. The department board would immediately remind their staff to retrain if their hand hygiene is incorrect or incompliant. There will be warnings for teams who violate once in front of the department. Subsequent breaches will have separate penalties. The results show that the compliance rate with hand hygiene solutions is high. Still, when analyzing the group of fully compliant (100%) and not fully compliant (<100%), it shows that there are still 31.8% of patients whose medical staff still do not fully comply with hand hygiene solutions. This result indicates that we require more appropriate regulations to attain better rates of full compliance (Figure 3).

The solution of head elevation from 30–45 degrees has a general compliance rate of 97.3% (Figure 2). This rate is higher than Mohamad,[22] Jadot,[24] Joong Sik Eom 72.9%,[25] Pisitsak 70.3%,[26] and Seikihara 56.5%, but it is lower than Abad et al in the Philippines.[16]

Regarding oral care solution using 0.12% chlorhexidine solution at least once every 3 days, the compliance rate is 99.4%, and only 10 patients, accounting for 5.9%, still need to comply with this method fully (Figure 2). This rate is lower than the three studies of Cybele, Seikihara K., and Klompas 100%,[16,27,28] but higher than other studies such as Pisitsak and Chaiwat,[26] Eom et al.,[29] Silva et al.[30] 84.7%.

The solution of stopping daily sedation to assess consciousness had a compliance rate of 81.5% (Figure 2). The rate of patients with full compliance with this solution is 55.3%. We found that most patients have absolute contraindications to stopping sedation, such as extracorporeal membrane oxygenation (ECMO) patients or those with medical conditions in the advanced stages, so they need to lie sedated entirely. Okgün Alcan et al.[13] had an absolute 100% sedation compliance rate. Some authors also have very different results, ranging from 27% to over 95%.[26,28,31]

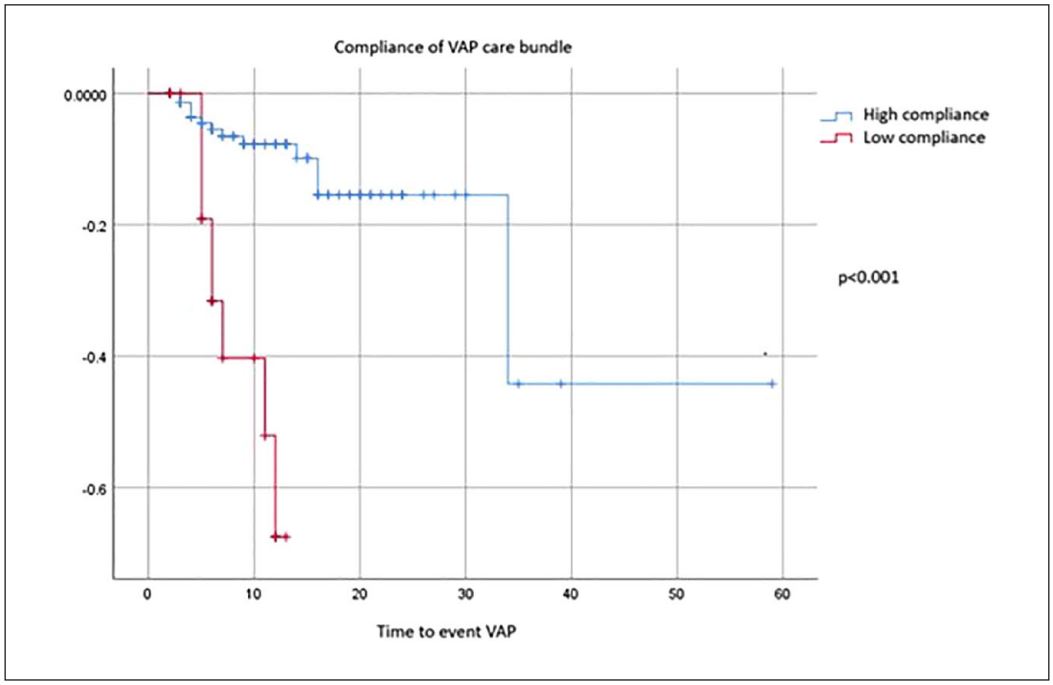

Figure 3. The time of occurrence of VAP depends on the level of compliance with a 10-item VAP care bundle.

The intubation cuff pressure is one of the critical components of the prophylactic care bundle because ensuring pressure by the cuff reduces the risk of upper respiratory tract secretions flowing to the lower respiratory tract and lungs. Cuff pressure should be continuously maintained between 20 and 30 cm H_2O and measured at least four times daily. Many studies have included this solution in the preventive care bundle and demonstrated that maintaining continuous cuff pressure reduces VAP.[32–34] In our study, the compliance rate for this solution reached 99.9% (Figure 2). Our research results are equivalent to those of Seikihara K., with a compliance rate of 99.8%. However, much higher than research by other authors such as Sachetti et al.,[35] reaching from 29.8% before intervention to 51.5% after intervention, DeLuca et al.[12] with ratio of 45%.

Subglottic secretion suction also has a compliance rate of 86.3% (Figure 2). At first, the hospital could not provide materials such as Hi-lo Evac endotracheal tubes in the early stages. In the following period, the number of patients using endotracheal lines with suction ports on the cuff increased significantly, so only 25 patients still needed to comply with the solution entirely. This reason was similar to other studies with low compliance rates, such as Jadot et al.[24] 24.7%, Eom et al.[29] 10.9%, and Darawad et al.[22] 61.5. Compared to them, our study has a much higher compliance rate but is still lower than Seikihara K.'s (2023). With our daily mechanical ventilation weaning assessment solution, the compliance rate of doctors is 83.5%, but only 60.6% of patients fully applied this solution. This rate is lower than Pisisak and Chaiwat's[26] study of 95% but higher than some studies such as Abad et al.'s[27] 34.6%, Seikihara et al.'s[16] 49.5%, and Klompas et al.'s[36] 82%.

Very few studies have included early mobilization solutions for patients in evaluating compliance levels. When looking for studies on the compliance rate of medical staff, we only found studies about the effectiveness of early mobilization for patients in the ICU, such as Liu et al.,[37] Zang et al.,[38] and Wang et al.[39] Our study results achieved a meager compliance rate of 49.3%, with over 30% of patients fully complying with the solution. This measure is challenging to implement in the ICU due to the patient's unstable condition and numerous invasive procedures. Furthermore, the number of medical staff in our ICU department is humble. The bed-leaving technique requires a concentration of human resources to move the patient, so achieving a high compliance rate with the solution is more complicated. Our results are much higher than those of Seikihara et al.,[16] only 5.8%.

Preventing peptic ulcers and deep vein thrombosis in our study had a shallow compliance rate of only 46.4% (Figure 2). Our research is lower than the study of Seikihara et al.[16] and Okgün Alcan et al.[13] 100%. In other studies, we found that the authors separated these two solutions, so they had different compliance rates, such as Mohamed KEA (2014), which prevented deep vein thrombosis at 78% and duodenal ulcer at 87%.[40] Similarly, many studies show compliance results of both solutions are much higher than ours.[29,41]

Our research results showed that among the 10 solutions in the care bundle, there are five solutions with a compliance rate of less than 90%: daily stopping sedation and assessing consciousness (81.5%), aspiration of fluid on the

Table 3. Association between ventilator pneumonia and compliance level of solutions with low compliance rate ($n = 170$).

Characteristic		OR (95% CI)	p
Stop sedation	Compliance	1	**0.018**
	Non-compliance	3.1 (1.2–7.9)	
Subglottic secretion suction	Compliance	1	<**0.001**
	Non-compliance	16.4 (5.8–46.1)	
Daily SBT and extubation assessment	Compliance	1	**0.013**
	Non-compliance	3.1 (1.2–8.0)	
Exercise and get out of bed early	Compliance	1	**0.024**
	Non-compliance	5.1 (1.1–22.7)	
Prevention of ulcers and thrombosis	Compliance	1	>0.05
	Non-compliance	2.9 (0.6–12.9)	

Table 4. Association between VAP and level of compliance with a 10-item VAP care bundle.

Characteristics	VAP		p
	Yes	No	
	(X ± SD)	(X ± SD)	
Hand hygiene	97.3 ± 11.0	96.8 ± 6.3	0.77
Elevated head 30–45 degrees	99.0 ± 1.8	97.1 ± 6.7	**0.005**
Oral hygiene	99.7 ± 1.5	99.4 ± 4.0	0.72
Stop sedation	70.1 ± 35.2	83.2 ± 25.3	0.11
Manage the breathing circuit	100.0 ± 0.0	99.9 ± 0.5	0.70
Cuff pressure control	100.0 ± 0.0	99.9 ± 1.4	0.70
Subglottic secretion suction	40.9 ± 50.3	93.0 ± 25.2	<0.001
Daily SBT and extubation assessment	71.1 ± 35.7	85.4 ± 24.3	0.08
Exercise and get out of bed early	28.9 ± 38.4	52.3 ± 39.8	**0.01**
Prevention of ulcers and thrombosis	58.8 ± 31.8	44.6 ± 42.8	0.07
A 10-item VAP care bundle	76.6 ± 10.2	85.2 ± 8.5	<**0.001**

cuff (86.3%), assessment of daily weaning from mechanical ventilation (83.5%), early mobilization to leave bed (49.3%), and prevention of peptic ulcer and venous thrombosis deep vein thrombosis (46.4%) (Figure 2). We conducted univariate analysis to find the risk of VAP arising from inadequate compliance with these solutions (Table 3). Four interventions raise the risk of VAP. These include ceasing sedation to evaluate consciousness and daily assessments to wean from mechanical ventilation, which increases the risk by 3.1 times, and early mobilization, which increases it by 5.1 times. The highest risk ratio, up to 16.4 times, is associated with aspirating during balloon tamponade. The significance level for all these results is less than 0.05. However, there is no meaningful difference in the solutions to prevent gastric and duodenal ulcers and deep vein thrombosis. Klompas et al.[28] is similar to our results in that the resolution of stopping sedation from assessing consciousness when fully complied with reduces VAP by 1.81 times (OR = 1.81; $p < 0.001$). They also concluded that peptic ulcer prophylaxis increases the risk of VAP up to 7.69 times (OR = 7.69; 95% CI: 1.44–41.10; $p = 0.02$). Pozuelo-Carrascosa et al. (2020) concluded that using an endotracheal tube with a suction port on the cuff reduces VAP by 0.56 times (OR = 0.56; 95% CI: 0.48) (Table 4).[42]

Table 5 shows that in most cases, the average duration of mechanical ventilation and length of hospital stay were higher in the group with incomplete compliance, as seen. In the hand hygiene solution group, the duration of mechanical ventilation in the group with incomplete compliance was 8.4 and 13.9 days, respectively, compared to 7.6 and 12.9 days in the fully compliant group. The elevated head 30–45 degrees solution had a duration of mechanical ventilation of 8.5 days in the noncompliant group, compared to 7.5 days in the fully compliant group. On the other hand, the oral hygiene solutions showed opposite results in all three evaluation criteria. Low compliance reduced mechanical ventilation time and hospital stay. However, the relationship between complete compliance (100%) or incomplete (<100%), high compliance (⩾75%) or low compliance (<75%) of each solution with the treatment results of patients is not statistically significant with p in all solutions being greater than 0.05.

Table 5. Relationship between level of compliance with solutions and duration of mechanical ventilation.

Characteristics		Ventilation time X ± SD	Time in hospital X ± SD
Hand hygiene	Compliance (*n* = 116)	7.6 ± 10.4	12.9 ± 11.3
	Non-compliance (*n* = 54)	8.4 ± 8.9	13.9 ± 11.0
	P	>0.05	>0.05
Elevated head 30–45 degrees	Compliance (*n* = 120)	7.5 ± 10.8	13.4 ± 12.2
	Non-compliance (*n* = 50)	8.5 ± 7.8	12.8 ± 8.7
	P	>0.05	>0.05
Oral hygiene	Compliance (*n* = 160)	8.0 ± 10.2	13.4 ± 11.5
	Non-compliance (*n* = 10)	5.5 ± 4.0	10.7 ± 4.6
	P	>0.05	>0.05
Stop sedation	Compliance (*n* = 94)	7.0 ± 6.8	12.6 ± 8.0
	Non-compliance (*n* = 76)	8.9 ± 12.8	14.1 ± 14.3
	p	>0.05	>0.05
Manage the breathing circuit	Compliance (*n* = 169)	7.8 ± 10.0	13.3 ± 11.3
	Non-compliance (*n* = 1)	12.0	12.0
	p	—	—
Cuff pressure control	Compliance (*n* = 169)	7.8 ± 10.0	13.3 ± 11.2
	Non-compliance (*n* = 1)	5.0	5.0
	p	—	—
Subglottic secretion suction	Compliance (*n* = 145)	7.0 ± 8.9	12.8 ± 11.0
	Non-compliance (*n* = 25)	12.7 ± 13.8	16.0 ± 12.4
	p	>0.05	>0.05
Daily SBT and extubation assessment	Compliance (*n* = 103)	7.5 ± 10.2	13.1 ± 10.6
	Non-compliance (*n* = 67)	8.3 ± 9.6	13.5 ± 12.2
	p	>0.05	>0.05
Exercise and get out of bed early	Compliance (*n* = 52)	6.6 ± 5.6	13.8 ± 10.5
	Non-compliance (*n* = 118)	8.4 ± 11.3	13.0 ± 11.6
	p	>0.05	>0.05
Prevention of ulcers and thrombosis	Compliance (*n* = 35)	6.5 ± 4.6	16.4 ± 10.7
	Non-compliance (*n* = 135)	8.2 ± 10.9	12.4 ± 11.3
	p	>0.05	>0.05
A 10-item VAP care bundle	High (*n* = 141)	7.6 ± 10.2	13.5 ± 11.3
	Low (*n* = 29)	9.0 ± 8.7	12.2 ± 11.1
	p	>0.05	>0.05

Our study has significant limitations that need to be acknowledged. Firstly, although we applied a VAP prevention package, the study was conducted during the COVID-19 outbreak, which meant that we faced a shortage of both human resources and equipment to serve the patients. Secondly, the practice of applying preventive measures is a combination of efforts from both doctors and nurses. However, our coordination was limited due to differences in work location and job assignments. Thirdly, during the course of the study, several patients were intubated from other departments in the hospital, making it difficult to accurately assess the results over time.

Conclusion

A 10-item VAP care bundle has helped reduce the incidence of VAP. To further decrease the risk of VAP and shorten ICU and hospital stays, full adherence to subglottic secretion suction, daily SBT, early mobilization, and bed-leaving are essential. Moreover, to ensure the effectiveness of these solutions, it is essential to continuously train the medical staff, strengthen supervision, and improve self-assessment of compliance levels.

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Author's contribution

Hoan Minh Hoang, Co Xuan Dao, and Hoang Huy Ngo designed, collected, and analyzed the study. Hoan Minh Hoang and Kham Van Vu assisted with data collection and analysis. Tatsuya Okamoto, Chieko Matsubara, Son Ngoc Do, Giang Thi-Huong Bui, Han Quang Bui, Nguyen Thi Duong, Ngoan Thi Nguyen, Toan Xuan Vuong, Thach The Pham, Cuong Van Bui contributed to the

study design and helped interpret the results. All authors contributed to writing the manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics approval

The Institutional Review Board of Bach Mai Hospital waived this study's ethical approval with number 1435/BVBM-HĐĐĐ.

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Informed consent

Written informed consent was obtained from all subjects before the study.

Trial registration

Not applicable.

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