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Relationship Between Ventilator Use Duration, Open Suction, and Ventilator-Associated Pneumonia in ICU Patients: A Cross Sectional Study

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ABSTRACT

Introduction: Ventilator-associated pneumonia (VAP) is a lung infection that occurs after 48 hours or > 2 days of using mechanical ventilation. Patients who use a ventilator will experience airway obstruction due to the accumulation of secretions in the Endotracheal Tube; therefore, suction of secretions is carried out by inserting a suction catheter through the nose/mouth/Endotracheal Tube (ETT). The method in this research is cross-sectional with prospective data collection

Aim: to analyze the relationship between the duration of mechanical ventilator use and the implementation of open suction with the incidence of ventilator-associated pneumonia (VAP) among patients receiving mechanical ventilation in the ICU

Method: This research uses a purposive sampling technique. The sample in this study comprised 37 patients receiving ventilatory support in the ICU. Data were analyzed using the Spearman rank test. The test results show that the duration of ventilator use has a p value (p=0.040) and the suction action has a p value (p=0.003), which means the results show a p value <0.05.

Result: Among 37 mechanically ventilated ICU patients, 4 (10.8%) developed VAP. Ventilator use duration was significantly associated with VAP incidence (r = 0.339; p = 0.040). Open suction implementation was also significantly associated with VAP incidence (r = -0.479; p = 0.003), with non-compliance to SOP associated with a higher risk of VAP.

Conclusion: This study concludes that the length of use of a mechanical ventilator and suction procedures in patients is related to the incidence of VAP in patients in the ICU

Keywords: Duration of Mechanical Ventilator Use; Modified Clinical Pulmonary Infection Score; Open Suction Procedure; Ventilator-associated pneumonia

Introduction

Ventilator-Associated Pneumonia (VAP) is a lung infection that occurs 48 hours or more than 2 days after mechanical ventilation, either through an endotracheal tube or tracheostomy (Fischa Awalin et al., 2019). VAP is divided into two categories: early-onset VAP, which occurs on the first day, typically 2-5 days after ventilator use, and late-onset VAP, which occurs after 5 days (Panjaitan et al., 2021).

The incidence of nosocomial infections worldwide is quite high, at 5% per year, or 9 million out of 190 million hospitalized patients. National Nosocomial Infection Surveillance (NNIS) data show that VAP mortality generally ranges from 25% to 50%, but in some cases, it has increased to around 70% (Panjaitan et al., 2021). In Zolfagri's 2021 study, five countries, across 11 hospitals, accounted for the majority of VAP cases: Hong Kong (31%), Australia

(25%), India (23%), the United States (12%), and Canada (10%). According to data from the International Nosocomial Infection Control Consortium (INICC), the number of VAP cases in Intensive Care Units (ICUs) reached 100,660 in 2016. Due to this high incidence of VAP, the INICC developed guidelines for VAP prevention in 2017. In 2019, there were 32,216 cases of VAP in ICUs, and in 2021, there were 24,170 cases. Therefore, approximately 450 million people in developing countries develop pneumonia annually (Fatmawati et al., 2023).

Based on the Indonesian Basic Health Research (RISKESDAS) data from 2007 to 2018, the incidence of pneumonia in Indonesia increased significantly, reaching 1,017,290 cases. Previous research reported that East Java ranked fourth among eight provinces in the incidence of ventilator-associated pneumonia (VAP), with a rate of 11.7%. ((Fatmawati et al., 2023)). Furthermore, at Jember Lung Hospital in 2019, of the 254 patients admitted to the ICU, 41 required mechanical ventilation for ≥96 hours (Rahmawati, 2021). Several risk factors have been associated with the development of VAP, including age, impaired consciousness, burns, comorbidities, duration of mechanical ventilator use, invasive procedures, previous antibiotic therapy, and other contributing factors such as smoking, hyperoxemia, and intra-abdominal hypertension.

Mechanical ventilation is a supportive device used to assist respiratory function by delivering positive or negative pressure to the airways to maintain ventilation and ensure adequate oxygenation over a prolonged period (Yuliana et al., 2021). However, patients receiving mechanical ventilation are at increased risk of developing nosocomial pneumonia because of their underlying critical condition and impaired immune response (Riatsa A et al., 2018). In addition, inappropriate nursing care may promote microbial colonization in the oropharynx, thereby increasing the risk of ventilator-associated pneumonia (VAP). Prolonged use of mechanical ventilation further elevates this risk, making the duration of ventilator use an important factor in the development of VAP.

Patients on mechanical ventilation will experience a buildup of secretions in the airways, which can lead to the growth of Pseudomonas or Acinetobacter bacteria in the trachea. Therefore, special medical intervention is required to help clear secretions in the respiratory tract by performing suction through the nose/mouth/endotracheal tube (ETT) (Sari et al., 2019). If suction is not performed, the patient will experience hypoxemia and permanent brain damage. Open suction is a procedure to remove mucus by opening the ventilator circuit connector connected to the endotracheal tube. The open suction method

increases the heart rate immediately after suctioning. This procedure aims to clear the airway or maintain airway patency, reduce phlegm retention, and prevent lung infections. The frequency of suctioning depends on the patient's health (Buston & Hariadi, 2020).

To reduce the incidence of ventilator-associated pneumonia (VAP), preventive measures are implemented through the VAP bundle, which includes six-step hand hygiene, head-of-bed elevation when not contraindicated, oral hygiene, and secretion management through suctioning. Proper implementation of the VAP bundle has been shown to reduce VAP incidence, whereas poor adherence may increase the risk. The risk of VAP can be assessed using the Clinical Pulmonary Infection Score (CPIS), which ranges from 0 to 12 and is based on six variables: temperature, leukocyte count, tracheal secretions, oxygenation, chest radiograph findings, and tracheal aspirate culture. A meta-analysis of 13 studies reported that CPIS has a sensitivity of 65% and a specificity of 64% (Maria & Syarif, 2022). Based on these considerations, the researchers were interested in examining the relationship between the duration of ventilator use, the implementation of open suction, and the incidence of VAP in mechanically ventilated patients in the ICU.

Method

Design

This study employed an analytic observational design with a cross-sectional approach to examine the relationship between the duration of ventilator use, the implementation of open suction, and the incidence of ventilator-associated pneumonia (VAP) in mechanically ventilated patients.

Setting and Time

The study was conducted in the Intensive Care Unit (ICU) of Jember Lung Hospital, Jember, Indonesia. Data were collected during the study period from patients who had been mechanically ventilated for at least 48 hours.

Population, Sample, and Sampling

The target population consisted of ICU patients who used a mechanical ventilator for ≥48 hours (2 days) and underwent suction procedures at Jember Lung Hospital. A total of 37 patients were included in this study. Respondents were selected using a purposive sampling technique based on predetermined inclusion and exclusion criteria established by the researchers.

Instrument and Measurement Properties

Data were collected using three observation-based instruments: (1) an observation sheet to record the duration of mechanical ventilator use, (2) an observation checklist to assess the implementation of open suction, and (3) an observation sheet based on the Modified Clinical Pulmonary Infection Score (MCPIS) to identify the incidence of VAP. The duration of ventilator use was categorized according to the length of mechanical ventilation, while suction implementation was assessed based on compliance with the applicable standard operating procedure (SOP). VAP incidence was determined using the MCPIS criteria.

Data Collection Procedure

Data were collected through direct observation and review of patient-related clinical information during ICU care. The researcher recorded the duration of ventilator use, observed the implementation of suction procedures, and assessed VAP incidence using the MCPIS observation sheet. All collected data were checked for completeness before being entered into the analysis.

Data Analysis

Data processing included editing, coding, and tabulation. Descriptive statistics were used to summarize respondent characteristics and study variables. Bivariate analysis was performed using Spearman's rho correlation test to examine the relationship between the duration of ventilator use and VAP incidence, as well as between open suction implementation and VAP incidence. A p-value <0.05 was considered statistically significant.

Ethical Declaration

This study was conducted after obtaining permission from the relevant institution and hospital. All data were collected and analyzed while maintaining the confidentiality of patient information.

Result

A total of 37 mechanically ventilated patients admitted to the intensive care unit (ICU) of Jember Lung Hospital were included in this study. The results are presented according to participant characteristics, VAP-related clinical indicators, duration of mechanical ventilation, and the relationship of ventilator duration and open suction implementation with ventilator-associated pneumonia (VAP).

Most participants were male (67.5%, n = 25), while female patients accounted for 32.5% (n = 12). The mean age of the participants was 49.84 ± 18.20 years, with a median age of 52 years and an age range of 18–86 years. Regarding primary diagnosis, the most frequent conditions were post-trepanation surgery (10.8%, n = 4), meningioma (8.1%, n = 3), post-laparotomy (8.1%, n = 3), and pulmonary tuberculosis (8.1%, n = 3). The remaining diagnoses consisted of a variety of neurological, respiratory, trauma, and postoperative conditions.

Table 1. Demographic and clinical characteristics of mechanically ventilated ICU patients (n = 37)

Variable	Category	n (%) / Value
Sex	Male	25 (67.5)
	Female	12 (32.5)
Age (years)	Mean ± SD	49.84 ± 18.20
	Median (min–max)	52 (18–86)
Primary diagnosis	Post-trepanation surgery	4 (10.8)
	Meningioma	3 (8.1)
	Post-laparotomy	3 (8.1)
	Pulmonary tuberculosis	3 (8.1)
	Rib fracture with subcutaneous emphysema	2 (5.4)
	Respiratory failure + sepsis + ascites	2 (5.4)
	Other diagnoses*	20 (54.1)

Other diagnoses included laminectomy, typhoid fever, dyspnea with respiratory failure and lung tumor with pleural effusion, maxillofacial and cruris fracture, brain tumor, spinal stenosis, lung tumor, moderate traumatic brain injury with acute subdural hematoma, post-craniotomy, pleural effusion, cerebral edema syndrome, frontal trepanation, right parietal tumor, blunt abdominal trauma, cervical cancer, post-tumor excision, chronic obstructive pulmonary disease, apnea with congenital heart disease and hematemesis, and intracerebral hemorrhage with intraventricular hemorrhage.

The distribution of VAP-related clinical indicators based on the Modified Clinical Pulmonary Infection Score (MCPIS) is presented in Table 2. Most patients had a body temperature of 36.5–38.4°C (86.4%, n = 32). Leukocyte abnormalities (<4,000 or >11,000/mm^3) were found in 64.9% (n = 24) of patients. More than half of the patients had no tracheal secretions (51.4%, n = 19), while 10.8% (n = 4) had purulent tracheal secretions. In terms of oxygenation, 83.8% (n = 31) had an MCPIS oxygenation score of 0, and 81.1% (n = 30) had no infiltrates on chest radiography.

Table 2. Distribution of VAP-related clinical indicators based on MCPIS among mechanically ventilated ICU patients (n = 37)

Variable	Category	n (%)
Body temperature	36.5–38.4°C	32 (86.4)
	38.5–38.9°C	2 (5.4)
	>39°C or <36°C	3 (8.1)
Leukocyte count	4,000–11,000/mm³	13 (35.1)
	<4,000 or >11,000/mm³	24 (64.9)
Tracheal secretions	No tracheal secretions	19 (51.4)
	Non-purulent secretions	14 (37.8)
	Purulent secretions	4 (10.8)
Oxygenation	Score 0 (>240 or ARDS)	31 (83.8)
	Score 2 (<240 or non-ARDS)	6 (16.2)
Chest radiograph	No infiltrate	30 (81.1)
	Diffuse infiltrate	6 (16.2)
	Localized infiltrate	1 (2.7)

The duration of mechanical ventilator use was almost equally distributed between 72 hours and 96 hours. A total of 18 patients (48.6%) received mechanical ventilation for 72 hours, whereas 19 patients (51.4%) received ventilation for 96 hours. Among the four patients who developed VAP, all cases occurred in the group receiving ventilation for 96 hours, while no VAP cases were observed in patients ventilated for 72 hours. Spearman's rho analysis demonstrated a significant positive correlation between duration of ventilator use and VAP incidence ($r = 0.339$, $p = 0.040$), indicating that longer ventilator use was associated with a higher occurrence of VAP.

Table 3. Association between duration of mechanical ventilator use and VAP incidence in ICU patients (n = 37)

Variable	Category	VAP n (%)	Non-VAP n (%)	Total n (%)	Correlation coefficient (r)	p-value
Duration of mechanical ventilation	72 hours	0 (0.0)	18 (100.0)	18 (48.6)	0.339	0.040
	96 hours	4 (21.1)	15 (78.9)	19 (51.4)		

With regard to suction practice, most patients received open suction according to the standard operating procedure (SOP) (97.3%, n = 36), while only one patient (2.7%) underwent open suction not in accordance with the SOP. Among the four patients who developed VAP, three had undergone suction according to the SOP and one had undergone

suction not in accordance with the SOP. Spearman's rho analysis showed a significant association between open suction implementation and VAP incidence (r = −0.479, p = 0.003). The negative correlation indicates that poorer adherence to the suction SOP was associated with a greater likelihood of VAP.

Table 4. Association between open suction implementation and VAP incidence in ICU patients (n = 37)

Variable	Category	VAP n (%)	Non-VAP n (%)	Total n (%)	Correlation coefficient (r)	p-value
Open suction implementation	According to SOP	3 (8.3)	33 (91.7)	36 (97.3)	-0.479	0.003
	Not according to SOP	1 (100.0)	0 (0.0)	1 (2.7)		

Overall, 4 of 37 mechanically ventilated patients (10.8%) developed ventilator-associated pneumonia. The findings of this study demonstrated that both the duration of mechanical ventilator use and the implementation of open suction were significantly associated with VAP incidence. Patients receiving mechanical ventilation for a longer duration were more likely to develop VAP, and non-compliance with the open suction SOP was associated with a higher occurrence of VAP.

Discussion

This study examined the relationship between duration of mechanical ventilation, open suction implementation, and ventilator-associated pneumonia (VAP) among mechanically ventilated patients in the ICU of Jember Lung Hospital. Overall, 10.8% of patients developed VAP, and both duration of ventilator use and open suction implementation were significantly associated with VAP incidence. These findings underscore the importance of minimizing unnecessary ventilator exposure and maintaining strict adherence to suction procedures to reduce the risk of VAP in critically ill patients.

Most participants in this study were male, and the mean age was approximately 50 years. This finding is broadly consistent with previous ICU-based studies reporting a predominance of male patients among those receiving mechanical ventilation (Riatsa A et al., 2018). The age distribution is also clinically relevant, as increasing age has been recognized as a contributing factor to VAP due to declining immune function, the presence of comorbidities, and reduced physiological reserve (Susanti et al., 2015). In the present

study, the wide age range suggests that VAP risk should be interpreted within the broader context of critical illness and underlying disease severity rather than age alone.

The MCPIS-related clinical indicators observed in this study further illustrate the complexity of diagnosing VAP in ICU patients. Although most patients had body temperatures within the normal range, a substantial proportion showed leukocyte abnormalities and tracheal secretion patterns suggestive of pulmonary infection. Leukocytosis was particularly evident among patients who developed VAP, which is consistent with previous evidence indicating that elevated leukocyte count is a common inflammatory marker in patients with pneumonia and postoperative pulmonary complications (Sotianingsih et al., 2019). However, fever and leukocyte abnormalities in ICU patients are not specific to VAP and may also result from postoperative inflammation, tissue injury, blood transfusion, or systemic infection ((Rahman et al., 2017)). Therefore, the use of a composite clinical tool such as the Modified Clinical Pulmonary Infection Score (MCPIS) is important because it integrates multiple clinical and laboratory parameters rather than relying on a single sign.

The first major finding of this study is that the duration of mechanical ventilation was significantly associated with VAP incidence ($r = 0.339$; $p = 0.040$). All VAP cases occurred in patients who had been mechanically ventilated for 96 hours, whereas no VAP cases were identified in those ventilated for 72 hours. Although the correlation was modest, the direction of the relationship is clinically meaningful and aligns with the pathophysiology of ventilator-associated infection. Endotracheal intubation bypasses the normal upper airway defense system, impairs mucociliary clearance, and facilitates microaspiration of contaminated secretions into the lower respiratory tract. The longer the artificial airway remains in place, the greater the opportunity for bacterial colonization, biofilm formation, and subsequent infection (Affanin et al., 2022).

Prolonged mechanical ventilation was significantly associated with a higher risk of VAP, consistent with previous studies showing that longer ventilator use increases exposure to airway instrumentation, secretion retention, and bacterial colonization, thereby predisposing patients to nosocomial infection (Abdelrazik Othman & Salah Abdelazim, 2017). Open suction implementation was also significantly associated with VAP incidence. Poor adherence to suction SOPs may increase the risk of infection because ineffective secretion removal can promote bacterial growth, airway obstruction, and pulmonary complications

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(Ariyani & Mulyati, 2018). In addition, open suction requires temporary ventilator disconnection, which may increase contamination risk if aseptic technique is not maintained (Buston & Hariadi, 2020).

These findings emphasize the importance of two key VAP prevention strategies in ICU practice: minimizing unnecessary ventilator duration and ensuring strict compliance with suction procedures. Together, these measures may strengthen the implementation of the VAP prevention bundle and reduce infection burden in mechanically ventilated patients (Affanin et al., 2022). This study has several limitations, including its cross-sectional design, small sample size, and single-center setting, which may limit causal interpretation and generalizability. In addition, MCPIS is a clinical tool rather than a definitive microbiological standard, and several potential confounding factors were not analyzed. Nevertheless, the findings provide useful evidence that prolonged ventilator use and suboptimal open suction practice are associated with VAP, highlighting the need for stronger adherence to ventilator care protocols and further multicenter studies with larger samples.

Conclusion

This study demonstrated that both the duration of mechanical ventilation and the implementation of open suction were significantly associated with the incidence of ventilator-associated pneumonia (VAP) among ICU patients at Jember Lung Hospital. Patients who received mechanical ventilation for a longer duration were more likely to develop VAP, while poor adherence to open suction procedures was associated with a higher risk of infection. These findings highlight the importance of minimizing unnecessary ventilator exposure and ensuring strict compliance with suction standard operating procedures as part of VAP prevention strategies in critically ill patients. Strengthening ventilator care practices and adherence to the VAP prevention bundle may help reduce the burden of VAP in ICU settings.

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Conflict of Interest

None.

Author Contributions

R.A. contributed to the study conception and design, data collection, data analysis, interpretation of findings, and manuscript drafting. R.H. contributed to the study design, supervision of the research process, interpretation of data, and critical revision of the manuscript. B.S. contributed to the study conceptualization, methodology development, supervision, data interpretation, and critical review and editing of the manuscript. All authors reviewed, approved, and agreed to the final version of the manuscript.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. Due to ethical and privacy considerations, the data are not publicly available as they contain information that could potentially compromise the confidentiality of the participants.

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