

Development and Implementation of a Chlorhexidine-Based Oral Hygiene Protocol to Prevent Ventilator-Associated Pneumonia in ICU Patients: A Quasi-Experimental Study

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) represents a major complication in mechanically ventilated ICU patients, driven by poor oral hygiene that promotes oropharyngeal pathogenic colonization. Standardized protocols are essential for effective VAP prevention in nursing care. This study developed and implemented a chlorhexidine-based oral hygiene protocol and evaluated its effectiveness against eucalyptol in reducing VAP risk.

Methods: A quasi-experimental nonequivalent control group posttest-only design was conducted in the ICU of Prof. Dr. Chairuddin P. Lubis University Hospital (September 2024). Thirty-two patients underwent purposive sampling and were allocated to intervention (n=16; 0.12% chlorhexidine oral care every shift for 48 hours) or control (n=16; eucalyptol) groups. VAP risk was measured via Clinical Pulmonary Infection Score (CPIS), with bacterial colonization assessed through sputum/bronchoalveolar lavage cultures. Independent t-tests analyzed differences ($p < 0.05$).

Results: The chlorhexidine group had a lower mean CPIS of 2.63 ± 1.31 compared to eucalyptol, which had a mean of 3.25 ± 2.24 ($p = 0.032$). Acinetobacter baumannii carbapenemase-producers were the most common isolates.

Conclusion: The 0.12% chlorhexidine protocol was better than eucalyptol at reducing VAP risk. It should be regularly used in ICU nursing practice.

Introduction

Mechanical ventilation is a life-saving treatment for patients with respiratory failure and other serious illnesses. However, using it for a long time can lead to complications. One major issue is ventilator-associated pneumonia (VAP), which is one of the most common infections linked to healthcare in intensive care units (ICUs). VAP is connected to higher rates of illness and death, longer ICU stays, and increased healthcare costs [1-2].

A key factor in developing VAP is the growth of harmful microorganisms in the mouth and throat. In critically ill patients who are intubated, normal mouth bacteria can be replaced within 48 hours by harmful bacteria like Staphylococcus aureus, Acinetobacter baumannii, and other Gram-negative organisms. These pathogens can move to the lower respiratory tract through microaspiration, leading to pneumonia [2-3].

Maintaining good oral hygiene is an important part of preventing VAP and plays a significant role in lowering bacterial growth in patients on mechanical ventilation. Chlorhexidine has been extensively studied as an oral antiseptic because it effectively kills a wide range of

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microbes and has a good safety record. Various studies and meta-analyses have shown that chlorhexidine oral care can reduce oral bacterial growth and the rate of VAP in ICU patients [4–6].

Despite having evidence-based recommendations, oral care practices in many ICUs vary and often use non-standardized antiseptic agents like eucalyptol-based mouthwashes, which may be less effective at preventing VAP [7-8].

At Prof. Dr. Chairuddin P. Lubis University Hospital, the rate of VAP in 2023 was higher than the target, highlighting the need for better preventive strategies. Therefore, this study developed and implemented a standardized 0.12% chlorhexidine oral hygiene protocol and compared its effectiveness to routine eucalyptol care. This supports evidence-based nursing practices and improves patient safety in the ICU [1].

Background of the Study

The absence of a standardized oral hygiene protocol in ICU nursing practice may contribute to variability in oral care quality and VAP prevention outcomes. Establishing an evidence-based chlorhexidine protocol is expected to optimize nursing interventions and enhance patient safety in mechanically ventilated patients.

Methods

Study Design and Setting

This study employed a quasi-experimental, nonequivalent control group, posttest-only design. The study was conducted in the Intensive Care Unit of Prof. Dr. Chairuddin P. Lubis University Hospital, Universitas Sumatera Utara, Medan, Indonesia, in September 2024.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of Universitas Sumatera Utara (No. 18702/UN5.4.10.S/PPM/2024). Written informed consent was obtained from patients' legal representatives prior to participation.

Clinical trial registration was not required due to the quasi-experimental design and the implementation-focused nature of the study.

Participants and Sampling

Purposive sampling was used to select the participants. Adult patients who were admitted to ICU and required mechanical ventilation ≥ 48 hours. Patients with previous intubation referred from other hospitals were excluded to minimize the baseline risk of VAP. Thirty-two patients were recruited and assigned to an intervention group ($n = 16$) or a comparison group ($n = 16$).

Development and Implementation of the Oral Hygiene Protocol

An oral hygiene protocol using chlorhexidine was developed from current literature and tailored to local ICU guidelines. ICU nurses were educated on the protocol before implementation. Chlorhexidine oral hygiene using 0.12% chlorhexidine was performed every shift for 48 hours. The control group received routine oral hygiene containing eucalyptol, which was the current standard of care for oral hygiene in the ICU at the time of the study and served as an active control.

Outcome Measures

Clinical outcomes were assessed by measuring Clinical Pulmonary Infection Score (CPIS). Bacterial colonization was determined by sputum cultures obtained on day 3.

Data Analysis

Participant characteristics and bacterial profiles were summarized using descriptive statistics. Associations between variables were examined using independent t-tests to assess differences in CPIS scores between groups. Significance was accepted at $p < 0.05$.

Results

(Table 1) summarizes participant characteristics and bacterial isolates ($n=32$).

The bacterial culture results showed that *Acinetobacter baumannii* carbapenemase-producing strains (CRAB) were the most frequent isolates in the intervention group (62.5%). In the control group, *Acinetobacter baumannii* carbapenemase (CRAB, 25%) and *Klebsiella pneumoniae* carbapenemase (CRKP, 25%) dominated the pathogen profile.

Table 1- Baseline characteristics of participants and distribution of bacterial isolates ($n = 32$)

Characteristic	Intervention ($n=16$)	Control ($n=16$)
Gender (Female, %)	56.3	62.5
Age (most common group, %)	65–73 (56.3)	47–55 (43.8)
Education (most common, %)	High school (50.0)	Elementary (43.8)
Specimen type (sputum, %)	87.5	75.0
Main bacterial isolates	A. baumannii CRAB (62.5%)	A. baumannii CRAB (25%), K. pneumoniae CRKP (25%)

Effectiveness of the Oral Hygiene Protocol

Effectiveness of the oral hygiene protocol. Independent t-test analysis demonstrated a statistically significant

difference between groups in CPIS scores (Table 2, $p = 0.032$).

Table 2- Comparison of CPIS scores between groups

Group	Mean CPIS (SD)	Mean Difference	P value (t-test)
Intervention	2.63 (1.31)		
Control	3.25 (2.24)	-0.625	0.032

Discussion

This study demonstrates that the development and implementation of a standardized oral hygiene protocol using 0.12% chlorhexidine significantly reduced the risk of ventilator-associated pneumonia compared with routine oral care using eucalyptol.

This finding is reflected in the significantly lower CPIS scores observed in the intervention group, supporting the effectiveness of protocol-based nursing interventions in ICU settings [1].

The predominance of elderly patients among patients in both groups demonstrates age-related immunosuppression as a risk factor for VAP development. Due to age-related dysregulation of the immune system along with increased colonization with respiratory tract pathogenic bacteria, older patients experience a higher incidence of nosocomial infections [3]. Standardized prevention bundles should be consistently applied among patients who are at risk.

The microbiology outcomes demonstrated that multidrug resistant gram-negative bacteria, predominately *Acinetobacter baumannii* (CARBAPENEM-PRODUCERS), were most prevalent among both patients with and without VAP. This is consistent with previous research that has reported *Acinetobacter baumannii*, along with *Klebsiella pneumoniae*, as the most common organism associated with VAP in ICUs [2].

We also identified biofilm-forming organisms (*Pseudomonas aeruginosa*) and extended-spectrum beta-lactamases (ESBL)-producing *Escherichia coli*, among our patients which further supports implementation to prevent early oral colonizers [5].

Our outcomes are consistent with previous nursing and clinical research that support chlorhexidine oral care, when used consistently and correctly as part of a standardized order set, is associated with decreased colonization and incidence of VAP [4,6]. Variation in outcomes have been published among studies with different patient populations and compliance with the protocol [8].

In conclusion, our study showed how evidence can be brought to nursing practice by creating and implementing

a standardized oral hygiene protocol. Protocol driven care improves patient safety and the efficacy of VAP prevention bundles allowing nursing to excel in quality improvement within the critical care setting [8].

Conclusion

From this quasi-experimental study, the standardized oral hygiene protocol with chlorhexidine effectively lowers VAP biomarkers among mechanically ventilated ICU patients.

There was a presence of multidrug-resistant bacteria, especially *Acinetobacter baumannii* and *Klebsiella pneumoniae*, necessitating early intervention to address oral colonization.

The 0.12% chlorhexidine protocol yielded significantly reduced average CPIS scores compared to standard eucalyptus mouthwash, thus its adoption as part of VAP prevention bundles.

Implications for Nursing Practice

Nursing practice requires nurses to adhere to the standardized oral hygiene procedures and receive training and support from their institutions to ensure their success. Frequent oral hygiene during shifts, proper documentation, and monitoring improve patient safety.

Recommendations

Further studies need to be conducted regarding the sustainability of the protocol, effects on VAP cases, patient outcomes, and applicability in different ICUs.

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Ethics approval

This study was approved by the Health Research Ethics Committee of Prof. Dr. Chairuddin P. Lubis University Hospital, Universitas Sumatera Utara, as stated in the ethical clearance document. The study was conducted in accordance with ethical principles for medical research involving human subjects.

Informed Consent

Written informed consent was obtained from the patients' legal representatives prior to participation in the study.

Authors' contributions

All authors contributed to the conception and design of the study. Data collection was conducted in the intensive care unit setting. Data analysis and interpretation were performed collaboratively. All authors participated in manuscript drafting, critically revised the content, and approved the final version of the manuscript.

Data availability

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

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