Crit Care Shock (2025) 28:83-90

The effectiveness of 0.12% chlorhexidine compared to fluoride toothpaste as an oral hygiene agent in reducing the incidence of VAP and BAL microorganisms in patients with MV in the ICU of Dr. Wahidin Sudirohusodo Hospital

Dodi Franata[1], Faisal Muchtar[2], Ari Santri Palinrungi[2], Muhammad Rum[1], Andi Adil[2], Hisbullah[2]

Abstract

***Background*: One of the serious complications in patients undergoing mechanical ventilation is called ventilator-associated pneumonia (VAP). Effective oral hygiene agents are essential to reduce the colonization of pathogenic microorganisms in the oral cavity and prevent VAP. Toothbrushing with 0.12% chlorhexidine and fluoride toothpaste are commonly used agents, but their effectiveness in reducing microorganism colonization still needs further investigation.**

***Methods*: The study design was a single-blind randomized clinical trial involving 20 patients undergoing mechanical ventilation, divided into two groups: one group received 0.12% chlorhexidine, and the other group used fluoride-based toothpaste. Measurement of microorganism colonies in non-bronchoscopy bronchoalveolar lavage (NBBAL) rinses was performed before and after the intervention on day 4. An independent samples t-test was used to analyze the data. Small sample sizes are limited by low statistical power, restricted generalizability, and a high risk of bias. Therefore, researchers must acknowledge these limitations and recommend further studies with larger samples for stronger and more generalizable results.**

***Results*: The results showed that using 0.12% chlorhexidine significantly reduced the number of colonies of microorganisms in bronchoalveolar lavage (BAL) compared with fluoride-based toothpaste. Chlorhexidine showed a greater reduction in microorganism colonies and was more effective in reducing Clinical Pulmonary Infection Score (CPIS).**

***Conclusion*: In patients on mechanical ventilation, 0.12% chlorhexidine is more efficient than fluoride toothpaste at lowering the colonies of microorganisms, which could help avoid VAP.**

Key words: Ventilator-associated pneumonia, chlorhexidine, fluoride toothpaste, microorganism colonization, mechanical ventilation.

[1.] Department of Anesthesiology, Intensive Care, and Pain Management, Faculty of Medicine, Hasanuddin University
[2.] Department of Anesthesiology, Intensive Care, and Pain Management, Dr. Wahidin Sudirohusodo Hospital, Makassar, South Sulawesi, Indonesia

Address for correspondence:
Faisal Muchtar
Department of Anesthesiology, Intensive Care, and Pain Management, Dr. Wahidin Sudirohusodo Hospital, Makassar, South Sulawesi, Indonesia
Email: Faisalmuchtar7@gmail.com

Introduction

Ventilator-associated pneumonia (VAP) represents a significant complication frequently seen in individuals receiving mechanical ventilation within the intensive care unit (ICU). VAP is described as a hospital-acquired infection that arises and progresses beyond 48 hours following the initiation of mechanical ventilation assistance. The prevalence rate of VAP in mechanically ventilated patients ranges from 9% to 68%, with a reported mortality rate of 30% to 70%. In addition, VAP can prolong hospital stays, increase healthcare costs,

and increase patient morbidity and mortality. (1)
Poor oral hygiene is a significant risk factor for VAP. ICU patients are more prone to oral health problems due to several factors, such as malnutrition, reduced saliva production due to the use of certain medications, and the presence of tracheal and nasogastric tubes. These conditions promote rapid dental plaque formation in oral flora to a predominance of Gram-negative organisms within 48 hours of hospitalization. The dental plaque becomes a reservoir of pathogens that can migrate to the lower respiratory tract through aspiration, thus contributing to the pathogenesis of VAP. (2)
Chlorhexidine has been recognized as a broad-spectrum antiseptic that is effective in reducing oral bacterial colonization as well as the migration of microorganisms to the lungs. The mechanism of action of chlorhexidine involves the binding of bacterial extracellular polysaccharides, thereby preventing bacterial adhesion to the cell membrane and reducing the risk of caries and periodontal disease. Based on previous research conducted by Kes et al., it was shown that the use of 0.12% chlorhexidine significantly reduced oropharyngeal colonization and the prevalence of pathogenic microorganisms such as Staphylococcus aureus, Enterobacter cloacae, Klebsiella pneumoniae, Pseudomonas aeruginosa, and Acinetobacter baumannii in patients undergoing mechanical ventilation. (3,4)
In addition to chlorhexidine, fluoride toothpaste is also a focus in VAP prevention. Fluoride toothpaste is known to make tooth enamel more resistant to decay and has antibacterial properties that help prevent bacterial colonization. A study by Scannapieco et al. revealed that fluoride administration could reduce the risk of aspiration of pathogenic bacteria into the lungs, while a study by Brailsford et al. showed a significant difference in the number and proportion of Gram-positive bacteria between the use of fluoridated and non-fluoridated toothpaste. (5,6)
In diagnosing and monitoring VAP, the Clinical Pulmonary Infection Score (CPIS) is commonly utilized to evaluate the intensity of pneumonia by examining clinical indicators like fever and reduced oxygen levels. A CPIS score >6 is usually associated with a probable diagnosis of VAP. In addition, diagnostic techniques such as non bronchoscopy bronchoalveolar lavage (NBBAL) can provide more accurate information about the causative pathogen, thus helping to determine specific antibiotic therapy. (7,8)
This study aimed to compare the effectiveness of 0.12% chlorhexidine and fluoride toothpaste in maintaining oral hygiene and reducing microbial colonization in mechanically ventilated patients. By understanding the different effects of these two agents, it is hoped that more effective strategies can be found in preventing VAP, thus contributing to improving the quality of patient care in the ICU.

Methods
This study was an experimental study with a randomized controlled trial design that aimed to compare the effectiveness of 0.12% chlorhexidine and fluoride toothpaste as oral hygiene agents in patients undergoing mechanical ventilation in the ICU of Dr. Wahidin Sudirohusodo Hospital. The study population consisted of patients aged 18-65 years, with normal/overweight body mass index (BMI), without prior pneumonia, who were undergoing mechanical ventilation and willing to consent to participate. Samples were obtained based on predetermined inclusion criteria, and patients were randomly divided into two groups: Group 1 received 0.12% chlorhexidine, and Group 2 used fluoride toothpaste.
The intervention was performed by providing oral hygiene care twice daily for three days, performed by ICU nurses. In Group 1, patients received 0.12% chlorhexidine applied orally, while Group 2 used fluoride toothpaste. The effectiveness of the intervention was measured using the CPIS and colony analysis of bronchoalveolar microorganisms taken through bronchoscopy. CPIS was calculated based on various signs and symptoms of pneumonia, where a CPIS score>6 indicated the likelihood of VAP. In addition, NBBAL sampling was performed to identify and count colonies of pathogenic microorganisms in the patient's respiratory tract. The independent samples t-test was used to compare the mean microorganism colony counted from two independent groups (chlorhexidine and fluoride toothpaste) measured on numerical data (colony counts) to determine if there was a statistically significant difference between them.
The information gathered underwent analysis through statistical tools to identify meaningful variations between the two groups. The analytical methods applied consist of the t-test for data that followed a normal distribution, and the Mann-Whitney test for data that did not, with a significance threshold established at $p<0.05$. Approval for this research was granted by the Ethics Committee at Dr. Wahidin Sudirohusodo Hospital, and every participant received a detailed explanation regarding the study's aims and processes, along with signing a consent form to join voluntarily. Statistical signifi-

cance was a measure that determines whether research results were likely to have occurred by chance or reflect a genuine effect, as measured by the p; a p less than 0.05 was generally considered significant.

Result and discussion

Table 1 shows a comparison of characteristics between two groups of research subjects. Group 1 used 0.12% chlorhexidine (n=10), and Group 2 used fluoride toothpaste (n=10). The table compares several variables between the two groups. The average age of Group 1 was 39.20±16.17 years, while Group 2 was 48.50±14.17 years. The p-value (0.188) indicated no statistically significant difference between the ages of the two groups. The average BMI of Group 1 was 22.69±2.88, while Group 2 was 25.01±2.93. The p-value (0.094) indicated no statistically significant difference between the BMI of the two groups. The average duration of time on the ventilator for Group 1 was 2.20±0.91 days, while Group 2 was 2.30±0.94 days. The p-value (0.813) indicated no statistically significant difference between the durations of time on the ventilator for the two groups. The average BAL colony count for Group 1 was (1.73±1.38) x 10^3 CFU/ml, while Group 2 was (2.78±2.27) x 10^3 CFU/ml. The p-value (0.243) indicated no statistically significant difference between the BAL colony counts of the two groups. The statistical test used was the unpaired t-test. Based on the data presented, there was no statistically significant difference between the group using 0.12% chlorhexidine and the group using fluoride toothpaste regarding age, BMI, duration of ventilator use, and number of BAL colonies on day 1.

Table 2 compares the colony counts of microorganisms in BAL between two intervention groups at two measurement time points. The measurement time was before intervention and after the intervention. BAL microorganism colony count (CFU/ml) presented as mean±standard deviation. Before the intervention, Group 1 revealed (1.73±1.38) x 10^3 CFU/ml, while Group 2 revealed (2.74±2.27) x 10^3 CFU/ml, with a p-value of 0.243 (not significant). After the intervention, Group 1 revealed (0.57±1) x 10^3 CFU/ml, while Group 2 was (2.37±2.01) x 10^3 CFU/ml. Comparison between groups at the same time point used an independent samples t-test, while comparison within groups (before vs after) used a paired sample t-test. These results indicated that 0.12% chlorhexidine was more effective in reducing the number of microorganism colonies than fluoride toothpaste after the intervention.

Table 3 compares the reduction in the number of colonies of BAL between the two intervention groups (presented as mean±standard deviation). The decrease in BAL microorganism colony count in Group 1 was (1.16±7.21) x 10^3 CFU/ml, while in Group 2 was (3.80±3.39) x 10^3 CFU/ml. The statistical test used was the independent samples t-test. Group 1 showed a statistically significant decrease in BAL microorganism colony counts compared to Group 2. These results indicated that 0.12% chlorhexidine was more effective in reducing the number of BAL microorganism colonies compared to fluoride toothpaste. This finding was consistent with Kes et al.'s study, which reported that 0.12% chlorhexidine could significantly reduce oropharyngeal colonization and prevent VAP in patients undergoing mechanical ventilation. (4)

Figure 1 shows the average number of BAL colonies between two intervention groups at two-time points. Group 1 used 0.12% chlorhexidine (blue bar), and Group 2 used fluoride toothpaste (green bar). Before the intervention (baseline), the colony count for Group 1 was approximately 1750 colonies, and for Group 2, it was approximately 2350. On day four, the colony count for Group 1 was approximately 580 colonies, and for Group 2, it was approximately 1950. After 4 days of intervention, both groups showed a decrease in BAL colony counts. However, the decrease was more drastic in Group 1 compared to Group 2. This graph shows that 0.12% chlorhexidine was more effective in reducing the number of BAL colonies than fluoride toothpaste after 4 days of intervention. It supports the findings presented in **Tables 2** and **3**, which show that 0.12% chlorhexidine was more effective in reducing the number of BAL colonies compared to fluoride toothpaste.

Table 4 presents a comparison of BAL germs on day 4, comparing the types of bacteria in BAL between Group 1 and Group 2 after the intervention. The results show that Group 1 had fewer Proteus mirabilis (p=0.02). More subjects in Group 1 had no germ growth. Overall, Group 1 showed lower bacterial growth. These results indicated that 0.12% chlorhexidine was more effective in reducing bacterial growth in BAL on day 4 and were in line with Paque et al.'s study, which found that fluoride toothpaste has high antimicrobial efficacy in a multispecies biofilm model, so it can help reduce the risk of VAP. (9)

Table 5 compares the CPIS in BAL between two intervention groups before and after the intervention. The CPIS scores were presented as mean±standard deviation. Before the intervention,

the CPIS score for Group 1 was 2.4±0.69, and for Group 2 was 2.8±1.03, with a p-value of 0.324. After the intervention, the CPIS score for Group 1 was 1.4±0.51, and for Group 2 was 2.2±0.91, with a p-value of 0.02.

The statistical test used to compare between groups at the same time was the independent samples t-test, while for comparisons within the same group (before vs after) was the paired samples t-test. Before the intervention, there was no significant difference in CPIS scores between the two groups. After the intervention, Group 1 showed a statistically significant decrease in CPIS scores compared to Group 2. Both groups showed a statistically significant decrease in CPIS scores after the intervention compared to before the intervention. These results indicated that 0.12% chlorhexidine was more effective in lowering CPIS scores, which indicated a reduction in pulmonary infection compared to fluoride toothpaste after the intervention. However, both interventions were effective in lowering CPIS scores overall.

Table 6 compares the reduction in the CPIS between the two groups (presented as mean±standard deviation). Group 1 showed a CPIS reduction of 1.10±0.56, while Group 2 reduced 0.50±0.52. Using an independent samples t-test, it was found that Group 1 experienced a statistically significant greater reduction in CPIS (p=0.025) compared to Group 2. This indicated that 0.12% chlorhexidine was more effective in lowering CPIS, which indicated a reduction in pulmonary infection, compared to fluoride toothpaste.

Table 7 demonstrates that no subjects in either group developed VAP, indicating no discernible difference between the two interventions in preventing VAP.

Conclusion

This research directly influences ICU protocols by recommending the replacement of fluoride toothpaste with 0.12% chlorhexidine as the primary oral hygiene agent for mechanically ventilated patients. 0.12% chlorhexidine potentially significantly reduces VAP incidence. By incorporating monitoring of temperature, leukocytes, and BAL cultures, the protocol can more proactively prevent VAP, enhance care quality, and lessen the burden on the healthcare system.

Using 0.12% chlorhexidine as an oral hygiene agent was shown to be more effective than fluoride toothpaste in reducing NBBAL microorganism colony counts and CPIS in mechanically ventilated patients in the ICU. Although both agents can significantly reduce the risk of lower airway infections, the broad-spectrum bactericidal and bacteriostatic effects of chlorhexidine provide a more pronounced advantage. Therefore, the use of 0.12% chlorhexidine is recommended as the primary oral hygiene agent. Further research with a larger sample size and longer durations is necessary to strengthen these findings and evaluate long-term effects. Implementing appropriate oral hygiene protocols in hospitals is crucial. Further research with other antiseptics is also needed.

Table1. Characteristics of research subjects

Variables	Groups		p
	0.12% chlorhexidine (n=10)	Fluoride toothpaste (n=10)	
Age (year)	39.20±16.17	48.50±14.17	0.188^{ns}
BMI (kg/m^2)	22.69±2.88	25.01±2.93	0.094^{ns}
Duration of time on ventilator at first sampling (days)	2.20±0.91	2.30±0.94	0.813^{ns}
BAL colony count day 1 (CFU/ml)	$(1.73±1.38)x10^3$	$(2.78±2.27)x10^3$	0.243^{ns}

Legend: BMI=body mass index; BAL=bronchoalveolar lavage; CFU=colony-forming unit.
^{ns}: not significant.
Data are mean±standard deviation and were tested by unpaired t-test.

Table 2. Comparison of colony counts of bronchoalveolar lavage microorganisms by measurement time and intervention group

Measurement time	Colony of bronchoalveolar lavage microorganisms (CFU/ml)		p^a
	0.12% chlorhexidine	Fluoride toothpaste	
Before intervention	$(1.73±1.38)x10^3$	$(2.74±2.27)x10^3$	0.243^{ns}
After intervention	$(0.57±1)x10^3$	$(2.37±2.01)x10^3$	0.02*
p^b	0.001*	0.003*	

Legend: CFU=colony-forming unit.
^{a}: independent samples t-test; ^{b}: paired sample t-test; ^{ns}: not significant; *: significant.
Data are mean±standard deviation.

Table 3. Comparison of the reduction in the number of colonies of bronchoalveolar rinse microorganisms between 0.12% chlorhexidine and fluoride toothpaste

Colonies	0.12% chlorhexidine	Fluoride toothpaste	p
Decrease in oral microorganism colonies (CFU/ml)	$(1.16±7.21)x10^3$	$(3.80±3.39)x10^3$	<0.01*

Legend: CFU=colony-forming unit.
*: significant (tested by independent samples t-test).
Data are mean±standard deviation.

Table 4. Comparison of colony and germ type of bronchoalveolar rinses between two groups on day 4 after intervention

Bacteria	0.12% chlorhexidine (n=10)	Fluoride toothpaste (n=10)	p
Staphylococcus aureus	1	2	0.02*
Escherchia coli	2	3	
Proteus mirabilis	0	1	
Pseudomonas aeruginosa	0	2	
No germ growth found	7	2	

Legend: *: significant (tested by independent samples t-test).

Table 5. Comparison of colony counts of bronchoalveolar lavage microorganisms by measurement time and intervention groups

Measurement time	CPIS		p^a
	0.12% chlorhexidine	Fluoride toothpaste	
Before intervention	2.4±0.69	2.8±1.03	0.324^{ns}
After the intervention	1.4±0.51	2.2±0.91	0.02*
p^b	0.04*	0.005*	

Legend: CPIS=Clinical Pulmonary Infection Score.
[a]: tested with paired sample t-test; [b]: tested with independent sample t-test; [ns]: not significant; *: significant.
Data are mean±standard deviation.

Table 6. Comparison of CPIS reduction between 0.12% chlorhexidine and fluoride toothpaste groups

CPIS	0.12% chlorhexidine	Fluoride toothpaste	p
CPIS reduction	1.10±0.56	0.50±0.52	0.025*

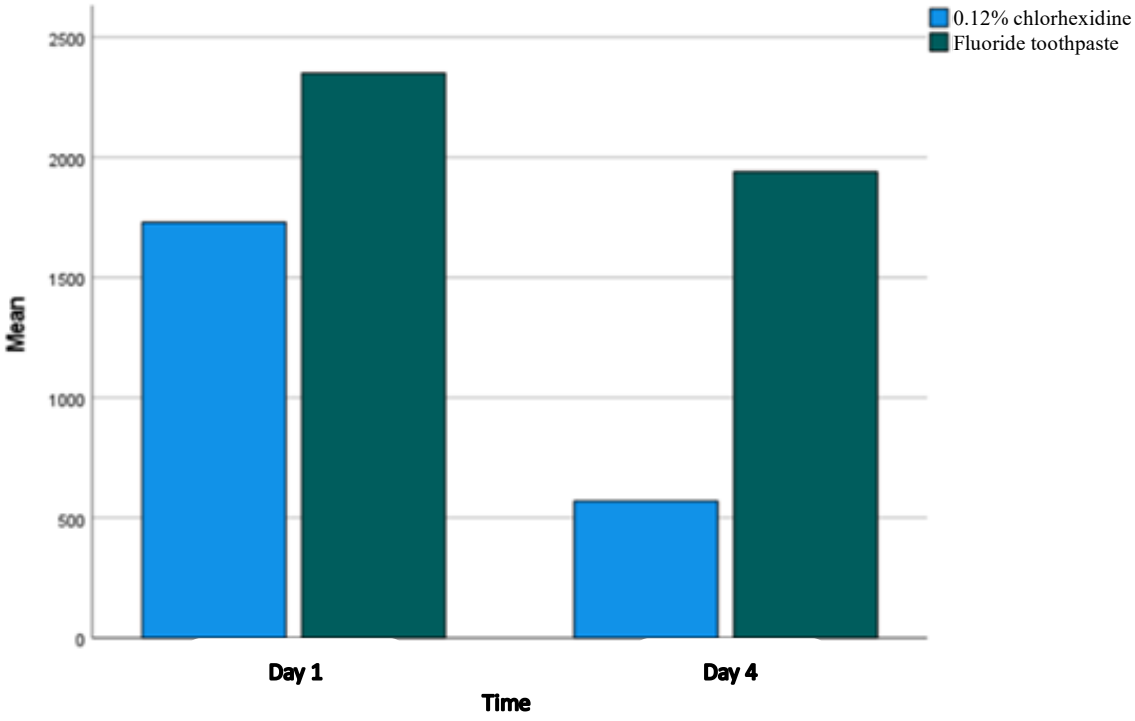
Legend: CPIS=Clinical Pulmonary Infection Score.
*significant (tested by independent samples t-test).
Data are mean±standard deviation.

Table 7. Frequency distribution of study subjects based on the incidence of VAP

Variables	Groups				Total (n=20)
	0.12% chlorhexidine (n=10)		Fluoride toothpaste (n=10)		
	F	%	F	%	n
VAP	0	0	0	0	0
No VAP	10	50	10	50	20

Legend: VAP=ventilator-associated pneumonia; F=frequency.

Figure 1. Comparison of bronchoalveolar lavage colonies in both groups



References

1. Atashi V, Yousefi H, Mahjobipoor H, Bekhradi R, Yazdannik A. Effect of oral care program on prevention of ventilator-associated pneumonia in intensive care unit patients: A randomized controlled trial. Iran J Nurs Midwifery Res 2018;23:486-90.
2. Roberts N, Moule P. Chlorhexidine and tooth-brushing as prevention strategies in reducing ventilator-associated pneumonia rates. Nurs Crit Care 2011;16:295-302.
3. Retracted: Meta-Analysis of the Efficacy and Safety of Chlorhexidine for Ventilator-Associated Pneumonia Prevention in Mechanically Ventilated Patients. Evid Based Complement Alternat Med 2023;2023: 9873478.
4. Kes D, Yildirim TA, Kuru C, Pazarlioglu F, Ciftci T, Ozdemir M. Effect of 0.12% Chlorhexidine Use for Oral Care on Ventilator-Associated Respiratory Infections: A Randomized Controlled Trial. J Trauma Nurs 2021;28: 228-34.
5. Scannapieco FA, Binkley CJ. Modest reduction in risk for ventilator-associated pneumonia in critically ill patients receiving mechanical ventilation following topical oral chlorhexidine. J Evid Based Dent Pract 2012;12:103-6.
6. Brailsford SR, Kidd EAM, Gilbert SC, Clark DT, Beighton D. Effect of withdrawal of fluoride-containing toothpaste on the inter-proximal plaque microflora. Caries Res 2005; 39:231-5.
7. Dewanti RI, Ciptaningtyas VR, Halleyantoro R, Wibobo GW. Comparison Of Antibacterial Effectiveness Of Herbal Toothpaste And Fluoride On The Growth Of Streptococcus mutans. Diponegoro Medical Journal 2022;11: 253-6.
8. Zilberberg MD, Shorr AF. Ventilator-associated pneumonia: The clinical pulmonary infection score as a surrogate for diagnostics and outcome. Clin Infect Dis 2010;51 Suppl 1:S131-5.
9. Paqué PN, Karygianni L, Kneubuehler J, Fiscalini L, Wiedemeier DB, Müller M, et al. Microbial approaches for the assessment of toothpaste efficacy against oral species: A method comparison. Microbiologyopen 2022; 11:e1271.