

PREVENTION OF PNEUMONIA DUE TO VENTILATOR IN CRITICAL PATIENTS WITH U SHAPE ORAL HYGIENE MODEL: A SYSTEMATIC REVIEW

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Abstract

In critical patients, generally, microorganisms originating from nasal cause Ventilator-Associated Pneumonia (VAP). This systematic review was aimed to identify the toothbrush U shape model usage, in potentially decrease the prevalence of ventilator-associated pneumonia among patients in intensive care units. Search strategy identified 15 potentially eligible articles, were 7 RCTs, 4 Meta-analysis, and 4 Observational studies. A total of 15 studies demonstrated the use of toothbrushing and chlorhexidine in mechanically ventilator patients in preventing VAP. Ten studies found positive association between toothbrushing and the use of chlorhexidine in preventing VAP. However, there were 5 studies that did not reveal an additional decrease of VAP incidence either of CHX and only toothbrushing or combination thereof. We cautiously assumed that toothbrushing and chlorhexidine might reduce VAP but the implementation of brushing should be taken into reconsideration in the terms of maintaining it.

Keywords

Toothbrushing • Ventilator-Associated Pneumonia (VAP) • Chlorhexidine • Intensive Care Unit

Introduction

Pneumonia is a possible infectious complication in the hospital due to the installation of a ventilator. Ventilator-associated Pneumonia (VAP) is an infection that takes a place in the intensive care unit (ICU) in ventilated patients. Almost 90% of infections in hospitals 48 hours after ventilator installation are caused by VAP. Therefore, it has been a significant problem, with increasing ventilator use, and increases duration of stay in the ICU [1]. In America, VAP is the second major source of hospital-acquired infection (HAI) and triggers 25% of infections in the ICU [2]. Meanwhile, in Europe, VAP is a frequent nosocomial infection, ranking second after urinary tract infections [3]. In 76% of cases of VAP, bacteria that accumulate in the oral cavity and lungs are similar [4]. Scannapieco found that *streptococcus aureus* and *pseudomonas aeruginosa* were the potential pathogens causing VAP in the oral cavity of ICU patients [5].

There are several ways to prevent VAP infection in ICU patients, such as subglottic suction, toothbrushing, chlorhexidine mouthwash, and herbal mouthwash. Several studies have

evaluated the effectiveness of oral decontamination to prevent nosocomial pneumonia. The policy is to prevent VAP through oral hygiene techniques such as subglottic suctioning, cleaning dental plaque, and mechanical interventions such as brushing teeth and rinsing the oral cavity. Besides that, there are also pharmacological interventions, such as antimicrobial agents. The most effective procedure to prevent VAP is to reduce the total of microorganisms in the oral cavity. In a clinical study, Yao et al. found that brushing with clean water two times a day for seven days significantly lowered the cumulative VAP level in the treatment group compared to the control group. They suggest that brushing the teeth twice a day can decrease the risk of VAP infection [6].

Previous research has underlined that oral hygiene methods can reduce VAP risk. The methods included brushing teeth using 0.12% chlorhexidine, swabs to clean the surface of the teeth and gingiva, mouthwash, suction, and combination therapy [6]. This study purposed to critically review the effectiveness of toothbrushing in reducing VAP incidence.

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To achieve the aim of the research, the reviewers consider a question: Can toothbrushing reduce ventilator-associated pneumonia (VAP) incidence in ventilated critically ill patients?

Material and methods

This review was created in compliance with the standards for particular items for reporting in systematic reviews. The authors searched PubMed, EBSCO, Science Direct, and ProQuest for randomised controlled trials, observational studies, and meta-analyses published in English from 2011 to 2021. Search terms were *oral care*, *oral hygiene*, *toothbrushing*, and *VAP*, with a prospecting limit of 10 years for publications, clinical trials, observational studies, and meta-analysis. Two researchers worked independently to find and screen titles and abstracts. A consistent data extraction methodology was utilised to analyse RCTs, observational studies, and meta-analyses according to the full text.

Selection criteria

Before reviewing the abstracts and papers, our inclusion and exclusion criteria were established. Patients on ventilators received oral hygiene toothbrushing in the treatment group, while patients in the control group received a placebo: a variation on oral care approach. Randomised controlled trials, observational studies, observational articles, and meta-analyses published in English were used to investigate the role of toothbrushing to minimise the risk of VAP in ventilated patients. The research participants had to be mechanically ventilated, admitted to a critical care unit, and critically ill. VAP must have been diagnosed via a positive culture following intubation.

Search method for identification

An extensive review study of published clinical trials which reported on VAP precautions with toothbrushing in oral care was carried out. Between December 2021 and January 2022, the articles were searched. The following databases were used to find relevant studies: PubMed, EBSCO, Science Direct, and ProQuest. For the study, the following keywords were implemented: *VAP*, *toothbrush*, *oral care*, and *oral hygiene*. The MEDLINE strategy was as follows. The keywords that connected to or concerned the treatment were included in the search method. The modified seeking keywords for use with other library databases were linked to data system criteria for RCTs, observational studies, and meta-analysis.

Data extraction

The papers discovered using the search technique as well as those obtained from external inputs were autonomously reviewed by the authors. By accessing the complete text of these possibly eligible papers, members of the review team separately evaluated their eligibility. Any differences

they had about the eligibility of specific studies were settled with the help of a third reviewer. The following data were extracted: study environment; study population, demographic information, and baseline characteristics; specific treatment and conditions; research method; findings and interval of analysis; potential mechanisms of the treatment; and data for assessing the critical appraisal. The reviewers extracted data on their own, identify conflicts, and resolve them through discussion. The study's authors requested that the missing data be provided.

Results

Results of search

The results are shown in Figure 1. We found 1,574 articles, of which 784 articles were rejected. The reviewers excluded 784 articles because the articles were duplicated in the electronic search engine. Screening the abstracts yielded 790 articles, of which 671 articles were excluded from abstract screening. One hundred and three studies were excluded: 78 due to irrelevant results, 10 due to irrelevant subjects, 8 due to irrelevant interventions, 7 non-English articles, and 1 ongoing study. The full-text articles for the 15 studies were revealed and evaluated for analysis.

Description of selected studies

Studies selected in this review (n=15) were 7 RCTs, 4 meta-analyses, and 4 observational studies. The RCT enrolled a total of 1,547 patients, observational 2,603 patients, and meta-analysis 8,027 patients. Overall, the interventions studied within the included trials were as follows: (1) Toothbrushing [7–10], (2) Chlorohexidine [11–13], (3) mouthwash, (4) toothbrushing combined with another oral care [14–20]. Mostly the patients were adults, but one study investigated oral care for children with a ventilator [17]. Particulars concerning the approach of selected trials are outlined in Table 1. Of the studies that examined the effects of toothbrushing combined with chlorohexidine, only 2 studies were able to demonstrate a significant impact on minimising the prevalence of VAP in ventilated patients. Only two studies mentioned that the use of toothbrushing may reduce the risk of VAP [9, 10]. Four studies failed to find any significant effect on risk-reduction from toothbrushing or the use of chlorohexidine [7, 8, 17, 18]. Only chlorohexidine was found to decrease the risk of VAP in ventilated patients [11–13].

The effect of toothbrushing on minimising VAP was reported by four papers, but only two papers demonstrated its effectiveness. Several studies showed that toothbrushing combined with other oral care—for example, chlorohexidine—has a positive effect in decreasing VAP rates. Sankaran and Sonis mentioned that toothbrushing stands in the top three methods in oral care procedures to reduce VAP [10].

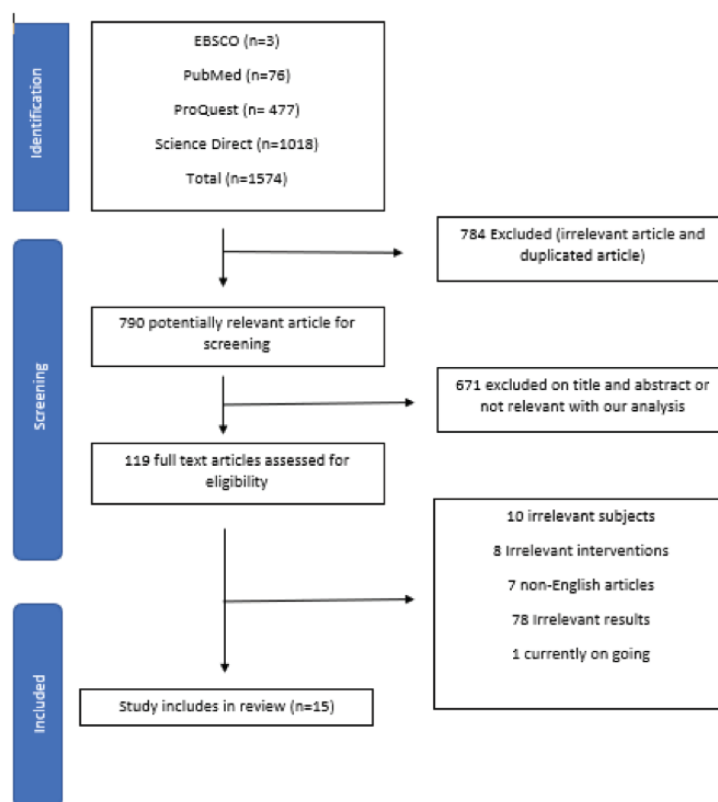


Figure 1. Data extraction chart.

Toothbrushing

The four studies reviewed were meta-analyses [7, 10] ($n = 2$), a randomised controlled trial [9] ($n = 1$), and an observational study ($n = 1$) [8]. According to our results, a randomised controlled trial study found that the experimental group on day 5 had a lower risk of VAP ($p < 0.05$) than the comparison group: the intervention in this review was to apply a soft toothbrush with distilled water twice per day [9]. Nasiriani *et al.* also mentioned that sex and kind of trauma did not show any significant relationship with the incidence of VAP [9]. A meta-analysis using NMA reported that chlorohexidine is identified as the better oral hygiene treatment for the reduction of VAP, but NMA contrasted that toothbrushing or mechanical cleaning was superior. When toothbrushing competed with mouthwash, toothbrushing is superior than mouthwash alone (furacilin) [10].

Gu *et al.* and Nasiriani *et al.* mentioned there was a negative effect of toothbrushing to reduce VAP [7, 9]. A study conducted by Gu *et al.* using a randomised controlled trial found toothbrushing was unrelated to minimising the incidence of VAP significantly. The other study also reported similar findings: that toothbrushing did not have significance in minimising the risk of VAP. Hayashida *et al.* reported that oral care using toothbrushing and mucosal cleaning did not decrease the number of

bacteria that cause VAP, but watering of the oral cavity and oropharynx with topical antibiotics may minimise oral bacteria in ventilated critically ill participants.

The use of chlorohexidine

In this systematic review, the reviewer found three studies that mentioned the use of chlorohexidine for oral care. Grap *et al.* and Tuon *et al.* implemented a randomised controlled trial, and Snyders *et al.* used meta-analysis [11, 12, 13]. All three studies have positive results regarding the use of chlorohexidine for oral care in preventing VAP. A randomised controlled trial using the Clinical Pulmonary Infection Score (CIPS) reported that there was a significant treatment influence on CIPS either from enrolment within 48 hours or 72 hours. Chlorohexidine also minimises the prevalence of spared methicillin-resistant *staphylococcus aureus* (MRSA) [13]. The other study used meta-analysis and reported that chlorohexidine proved beneficial to prevent VAP, and 2% chlorohexidine had the most potential in preventing the prevalence of VAP [12].

Toothbrushing combined with chlorohexidine

We found six studies regarding the use of toothbrushing combined with chlorohexidine for oral care to prevent VAP. Four of the six studies have positive results regarding the use of

Table 1: A summary of the characteristic result of the included studies on the use of toothbrushing in oral care for ventilated patients.

No.	Author & Date	Treatment	Subject	Methodology	Intervention	Control Group	Outcome
1	Snyders et al., (2011)	Oral care with chlorhexidine	1930 adult patients with ventilator	Meta-analysis	Chlorhexidine 0.12% and chlorhexidine 2% concentration	Placebo, toothbrushing, oral rinse, Listerine	Chlorhexidine showed a beneficial effect in preventing VAP with a 2% dose being the most effective
2	Grap et al. (2011)	Chlorhexidine	145 trauma patients with ventilator	Randomised controlled trial	5 ml chlorhexidine	Oral care without chlorhexidine	In trauma patients, chlorhexidine may significantly reduce VAP and a single swab can be useful as an alternative way to reduce VAP
3	Tuon et al. (2016)	Chlorhexidine	16 patients with ventilator	Randomised controlled trial (double-blind)	Oral washing with 15 ml of 2% chlorhexidine gluconate	Placebo (mouth washing using 0.9% NaCl solution)	When compared to the control group, the intervention group had a minimal incidence of methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)
4	Cutler & Sluman (2014)	Toothbrushing and chlorhexidine	528 ventilated patients	A historical controlled study	Toothbrushing and 1% chlorhexidine	-	The expected and observed incidence of VAP after a change in oral care indicated a statistically significant difference ($p < 0.01$)
5	Kusahara et al. (2012)	Chlorhexidine	96 paediatric patients with ventilator	Prospective, RCT, double-blind clinical trial	46 participants used a toothbrush and antibacterial gel twice daily (chlorhexidine)	50 placebo samples were brushed with non-antiseptic gel for 12 hours.	In a sample of children on mechanical ventilation, 0.12% chlorhexidine revealed insignificance to reduce the prevalence of VAP
6	Silva et al. (2021)	Toothbrushing and chlorhexidine	796 patients	Meta-analysis	Chlorhexidine with toothbrushing	Chlorhexidine	Based on meta-analysis, chlorhexidine effects a lower risk of VAP incidence than chlorhexidine alone
7	Ory et al. (2016)	Toothbrushing	2,030 ventilated patients in ICU	Cohort study	Caregiver using foam stick in period 1 (chlorhexidine)	Caregiver using stick and toothbrushing with aspiration (chlorhexidine)	Oral health improved considerably from the third day of intervention with a toothbrush in period 2. The probability of VAP decreased significantly between the two periods
8	Conley et al., (2013)	Toothbrushing using toothpaste and CHG	75 patients with ventilator	Prospective study RCT	Brushing teeth with toothpaste and using 0.12% chlorhexidine gluconate solution every 12 hours	-	Toothbrushing with toothpaste and applying chlorhexidine gluconate may be effective in reducing the VAP rate

(Continued)

Table 1. Continued

No.	Author & Date	Treatment	Subject	Methodology	Intervention	Control Group	Outcome
9	de Lacerda Vidal et al. (2017)	Toothbrushing and chlorhexidine	213 patients with ventilator	Prospective RCT	Toothbrushing with 0.12% chlorohexidine gel every 12 hours	0.12% chlorohexidine every 12 hours	The brushing combined with 0.12% chlorhexidine gel minimised the prevalence of VAP during the follow-up period, however, the deviation was statistically insignificant ($p=0.084$)
10	Sankaran & Sonis (2021)	Toothbrushing	4473 patients	Meta-analysis	0.12% Chlorohexidine, bicarbonate rinse + toothbrushing, Listerine, furacilin, povidone-iodine	Placebo/usual	The result showed that toothbrushing, brushing teeth with povidone-iodine, and were three oral care interventions that can prevent VAP
11	Nasiriani et al. (2016)	Toothbrushing	168 patients with ventilator	Randomised controlled trial	Brushing teeth twice a day with distilled water and a child's toothbrush	Routine oral care	The findings revealed a substantial difference in the prevalence of VAP on day 5 of intervention between both of the groups
12	Gu et al. (2012)	Toothbrushing	828 patients with ventilator	Meta-analysis	Toothbrushing	Without toothbrushing	The intervention was an insignificant effect on minimising mortality of VAP or intensive care unit
13	Hayashida et al. (2016)	Toothbrushing and cleaning the mucosa	45 patients with ventilator	Observation with intervention	Toothbrushing, interdental brushing, tongue mucosal surface cleaning, and also irrigation	-	Brushing and washing the mucosa did not minimise oral bacteria, but watering the oral cavity and oropharynx dramatically reduced it to 105 cfu/ml ($p < 0.001$)
14	Lorente et al. (2012)	Toothbrushing and CHX	436 patients with ventilator	Randomised controlled trial	0.12% chlorohexidine injection into the oral cavity and manual brushing	Injection of 0.12% chlorohexidine into the oral cavity	Statistically, there was an insignificant difference in the prevalence of VAP in both of the groups with brushing vs. without brushing
15	Berry et al. (2013)	Oral care with mouthwash (Listerine, natrium bicarbonate)	398 patients with ventilator	A prospective randomised controlled trial	Group B (6.5 g of sodium bicarbonate and 1 L mouthwash in 20 ml sterile water) Group C (20 ml Listerine mouthwash instilled twice a day and sterile water)	Every two hours, rinse your mouth with 20 ml of water	On day 4, there was an insignificant difference in dental plaque colonisation in both the control and intervention groups ($p = 0.243$).

toothbrushing and chlorohexidine. Three of the six studies were randomised controlled trials [14, 16, 17]. One study was a meta-analysis, another is a historical study, and another of the six was an observational study [15, 19, 20]. Cutler et al. showed that their study demonstrated significance in reducing VAP by around

50% through oral care using 1% chlorhexidine gluconate [15]. An observational study conducted by Conley et al. showed that toothbrushing with chlorohexidine was statistically significant by opposing the ratio of VAPs per total ventilator per day in ICU patients [14]. The research organised by Ory et al. also found

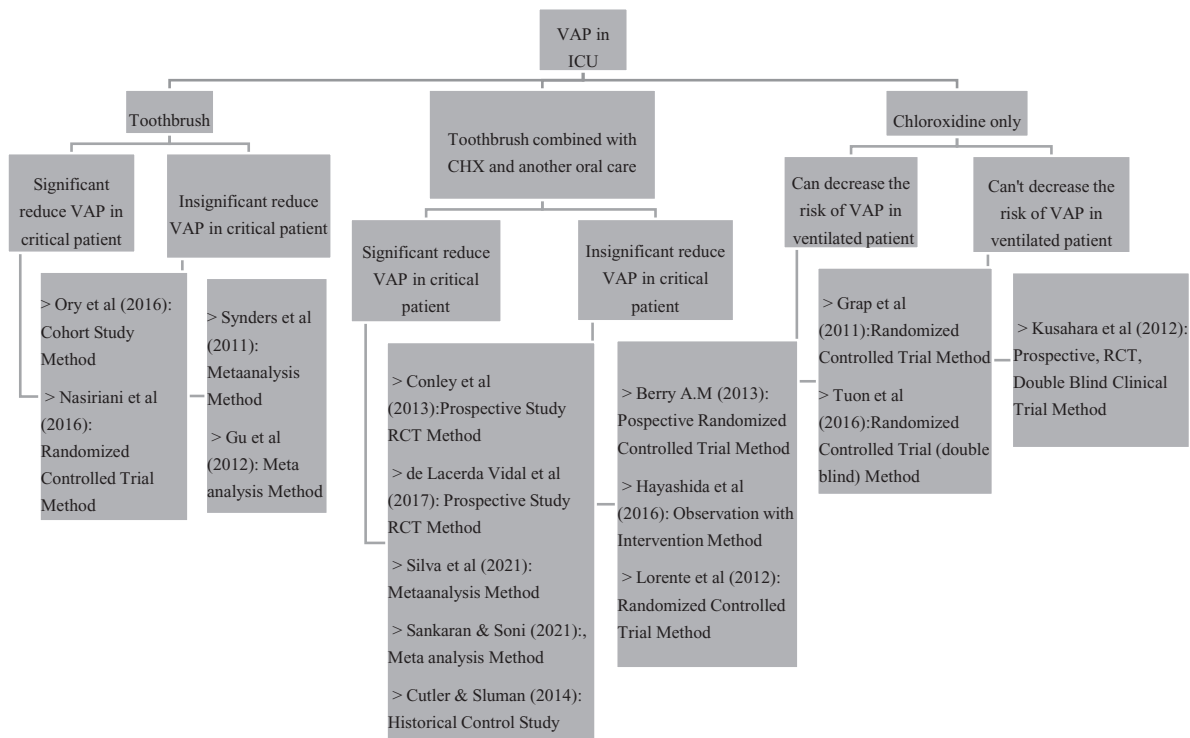


Figure 2. The effect of a toothbrush, toothbrush combined with CHX and other oral care, and CHX only on VAP transmission in ICU.

that a modest oral hygiene protocol may increase the oral health of ventilated patients [19]. Toothbrushing, chlorhexidine, and aspiration have significance in reducing VAP compared with chlorohexidine alone. de Lacerda Vidal et al. also supported the concept that toothbrushing combined with 0.12% chlorohexidine gel reduced VAP to minimal prevalence, but the difference was not significant statistically [16].

A meta-analysis mentioned that there is no one study reported that chlorohexidine versus chlorohexidine with toothbrushing has significantly different results [20]. Previous articles conducted by Kusahara et al. reported that oral care (toothbrushing) with 0.12% chlorohexidine did not have a beneficial effect on minimising VAP [17].

Discussion

This review aimed to verify whether the use of toothbrushing reduced VAP in critically ill patients. VAP is a serious complication of ventilation. This study has the potential to suggest that oral care in ICU patients affects the improvement of health quality. Eight intervention studies explored the effects of chlorohexidine and toothbrushing, either combined or alone. Studies by Nasiriani et al., Grap et al., Tuon et al., Conley et al., Cutler & Suman, de Lacerda Vidal et al., and Ory et al. were successful in reducing VAP using chlorohexidine and toothbrushing [9, 11, 13–16, 19].

Because the assumptions are based on repeated comparisons, these results should be interpreted cautiously. Our research presents further intriguing indications that could be valuable for future research on the subject. A toothbrush is a tool that can be used to reduce VAP because a toothbrush serves to reduce plaque, bacteria, and mucus in the mouth area. This is in line with the findings of Singh et al., which are in agreement that toothbrushing along with oral care can be an advantage in preventing VAP in patients on mechanical ventilation [21]. To prevent microorganisms from colonising the oral cavity of ventilated critically ill patients in the ICU, oral hygiene should be performed according to proper methods. To avoid the occurrence of VAP, it is necessary to practice good oral hygiene. We identify three studies that mentioned toothbrushing can reduce VAP. According to Ory et al., oral health improved significantly after day 3 of oral treatment when a toothbrush was used in the second period [19]. The risk of VAP was reduced considerably between the two time periods. According to the NMA outcome by Sankaran and Sonis, brushing alone or in combination with a robust antiseptic mouthwash, povidone-iodine, was linked with the highest response rate in critically ill patients in preventing VAP, followed by furacilin and chlorhexidine, serially (0.2%) [10]. It was also shown that brushing with distilled water twice daily can minimise the prevalence of VAP in ICU patients [9]. Singh et al. agree and state that toothbrushing along with oral care can reduce the number of VAP patients, the length of ICU stays,

and the ventilator time [21]. Thus, the use of toothbrushing with oral care can reduce mortality in ICU patients. The solution for implementing oral care for mechanically ventilated patients is divided into two sections: mouthwash and moisturiser. The mouthwash solution with chlorhexidine is the most commonly recommended. Chlorhexidine is a bacteriostatic antiseptic and disinfectant that is bacteriostatic against both gram-positive and gram-negative bacteria. Chlorhexidine is an excellent anti-plaque formation agent with a broad spectrum. According to de Lacerda Vidal *et al.*, brushing with 0.12% chlorhexidine gluconate gel decreased VAP prevalence compared to the control group, though the result was not statistically meaningful [16]. Even the Singh *et al.* results compare patients getting toothbrushing with chlorhexidine mouthwash 0.2% combined with lubrication and getting only the mouthwash reduced VAP in a mechanically ventilated patients [21]. In another opinion, oral hygiene with chlorhexidine reduces the microorganisms in the oral cavity of ICU patients [22]. Patients with critical illness deserve special attention, although this requires extended hospitalisation and more frequent multiple contacts with healthcare providers [23]. Therefore, the use of 0.12% chlorhexidine solution can be a strategy to reduce hospital costs. But the systematic review from Buckley *et al.* showed mixed results, and the majority failed to demonstrate a significant reduction in the incidence of nosocomial pneumonia with the use of chlorhexidine. However, the cardiothoracic surgery ICU patient population may benefit from its use [24]. While chlorhexidine is safe, it does prompt mucosal irritation and desquamation, and perhaps dry mouth.

We found four studies that mentioned that chlorhexidine can reduce VAP. Chlorhexidine has been demonstrated to be effective in the minimisation of VAP, with 2% chlorhexidine being the most potent [12]. Snyders *et al.* also noted that there was no indication of a reduction in mortality when chlorhexidine was used [12]. Although 2% chlorhexidine may be the most beneficial in preventing VAP incidence. A study with 5 ml of chlorhexidine for oral care intervention can reduce Clinical Pulmonary Infection Score and VAP in ventilated patients [11]. Significant treatment effects were reported in CPIS for up to 48 hours and up to 72 hours after admission. Methicillin-resistant *Staphylococcus aureus* (MRSA) was less common in the chlorhexidine group than in the comparison group [13]. Cutler and Sluman revealed a meaningful difference in the incidence of VAP after an oral care change [15]. The enhanced oral care package, which included 1% chlorhexidine gluconate, was correlated to a considerable reduction in VAP.

Oral hygiene is a stand-alone nursing action that has a significant impact on the success of VAP prophylaxis in ventilated patients. Three papers showed that the risk of VAP is reduced when subjects use a toothbrush combined with chlorhexidine.

According to Silva *et al.*, a meta-analysis reported that the prevalence of VAP was decreased 24% more in participants who received chlorhexidine in combination with toothbrushing than in those who received only chlorhexidine [20]. De Lacerda Vidal *et al.* also stated that applying a toothbrush in combination with 0.12% chlorhexidine gel can minimise the prevalence of VAP during the performance period, notwithstanding the fact that the result was not statistically significant. The mean mechanical ventilation period was significantly reduced in the brushing group [16].

In contrast to the discussion above, one study mentioned that toothbrushing cannot decrease the risk of VAP. In the other research by Gu *et al.*, oral care with brushing teeth vs without brushing teeth did not significantly minimise the prevalence of VAP and transform other prominent clinical results in ventilated patients [7]. Hayashida *et al.* also found that oral bacteria numbers were not reduced by toothbrushing or mucosal washing, but watering of the oral cavity and oropharynx greatly reduced it to 105 cfu/ml [8]. We found that a study conducted by Unahalekhaka *et al.* mentioned that toothbrushing transmitted possibly pathogenic and antibiotic-resistant bacteria [25]. This research found the mean bacterial population of a toothbrush head was around $10^4 - 10^5$ CFU/toothbrush. This was comparable to the total bacteria growth of toothbrushes in healthy patients. They said that the growth of the bacteria did not change over a variety of toothbrush manufacturers [21]. Bacterial growth was also assessed in the grooves of the toothbrush handles that had rubber material. Butts *et al.* found that smooth grips had fewer bacterial transmissions than grooved grips [26]. According to Lorente *et al.*, there were insignificant variations in baseline characteristics between the two patient groups. The prevalence of VAP did not differ statistically significantly between the groups [18]. Children in the treatment group using chlorhexidine with no possibility of pathogenic microflora in their oropharynx 24 hours after ventilation had lower rates of ventilator-associated pneumonia [17]. In a simple cohort of mechanically ventilated children, the administration of 0.12% chlorhexidine had an insignificant effect on the prevalence of VAP. The study's use of minimal chlorhexidine, integrated with the children's characteristics, as well as the presence of multi-resistant Gram-negative organisms, could have affected the outcome [17]. According to one paper, the utilisation of mouthwash cannot reduce VAP because day 4 showed no considerable distinction in the colonisation of dental plaque between the control and study groups. Ventilator-associated pneumonia was identified in 18 individuals. Comparing Listerine or sodium bicarbonate oral care to the comparison group, neither reduced dental plaque growth nor the prevalence of VAP [4].

The American Association of Critical Care Nurses and the Centers for Disease Control and Prevention recommend using

chlorhexidine gluconate (0.12%) in oral treatment, and cleaning the patient's teeth for 3 to 4 minutes to reduce the incidence of VAP [27]. Brushing is an important part of implementing dental care in intubated patients. Most experts recommend a paediatric toothbrush because it has soft bristles and is small enough to access the oral cavity of tracheal intubated patients. For mechanically ventilated patients, the frequency of dental care varies. De Lacerda Vidal et al. suggest that oral treatment be performed every 12 hours [16]. However, it must be done with caution to avoid dislocation of the ETT tube and bleeding. Chlorhexidine has been demonstrated to be healthy; however, it has adverse effects such as inflammation of the mucosal lining [16]. Oral treatment and brushing are important to reduce the incidence of VAP.

We also found that the use of U-shape toothbrush did not appear during the analysis of the study. Most of the studies did not mention the type of toothbrush.

Conclusion

In conclusion, the analysis indicated that among ventilated patients who received toothbrushing, there was a substantial decrease during mechanical ventilation, and also a potential to minimise the risk of VAP. We assumed with caution from a few studies that toothbrushing and chlorhexidine might reduce VAP, but the practice of toothbrushing care should be reconsidered in relation to maintaining it. We also found that the U-shape model was not used in the studies.

Limitation

One limitation of this research was the nonrandomised study design used for analysis (observational post-intervention). In this review, the reviewer did not find the use of U-shape toothbrushing in oral treatment to prevent the risk of VAP in critically ill patients. So, this review only reported the evidence that toothbrushing (without specific brush shape) can perhaps reduce the risk of VAP for ventilated patients.

Conflict of Interest

We declare that there is no potential conflict of interest in this research.

Acknowledgment

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