

ORIGINAL ARTICLE

Comparison of wiping and rinsing techniques after oral care procedures in critically ill patients during endotracheal intubation and after extubation: A prospective cross-over trial

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Abstract

Aim: Endotracheal intubation of critically ill patients increases the risk of aspiration pneumonia, which can be reduced by regular oral care. However, the rinsing of the residual oral contaminants after mechanical cleaning carries the risk of aspirating the residue during the intubation period. Removing the contaminants by wiping with mouth wipes could be an alternative to rinsing with water because of no additional fluid. This study tested: (i) the amount of oral bacteria during endotracheal intubation and after extubation; and (ii) the changes in the bacterial count during oral care procedures.

Methods: Thirty-five mechanically ventilated patients in the intensive care unit were enrolled. The amount of bacteria on the dorsal tongue surface was counted before and following oral care and then after the elimination of contaminants either by rinsing with water and suctioning or by wiping with mouth wipes. The oral bacterial amount was compared statistically between the intubation and extubation status and among set time points during the oral care procedure.

Results: The oral bacterial count was significantly decreased after extubation. During the oral care procedure, the oral bacterial amount was significantly lower after eliminating the contaminants either by rinsing or wiping, with no remarkable difference between the elimination techniques.

Conclusions: The findings suggest that the oral bacterial amount is elevated during endotracheal intubation, which could increase the risk of aspiration pneumonia. The significant reduction in the bacterial count by wiping indicates that it might be a suitable alternative to rinsing for mechanically ventilated patients.

Key words: critical care, oral bacteria, oral care, oral contaminants, ventilator-associated pneumonia.

INTRODUCTION

The incidence of pneumonia is increased in patients who receive mechanical ventilation because bacterial

colonization of the oral cavity is considered to be the reservoir for respiratory pathogens (El-Solh *et al.*, 2004). Such individuals also have a risk of aspirating secretions that have pooled in the oral cavity or pharynx. The microorganisms that are contained in the biofilm forming on the endotracheal tube during intubation have been associated with the onset of ventilator-associated pneumonia (VAP) (De Souza, De Andrade, Cabral, & Watanabe, 2014).

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In order to mitigate the risk of VAP, it is important to halt the passage of pathogenic bacteria into the lower airway: oral hygiene care reduces respiratory pathogens in the oral cavity and thus decreases the risk of VAP (Ames *et al.*, 2011; Lam, McMillan, Samaranayake, Li, & McGrath, 2013; Prendergast, Kleiman, & King, 2013; Shi *et al.*, 2013). The risk of oropharyngeal dysphagia often remains after the removal of the endotracheal tube, however (Brodsky *et al.*, 2014; Skoretz, Flowers, & Martino, 2010). Thus, the maintenance of oral health is also important after extubation in order to prevent aspiration of the oral pathogenic bacteria.

The procedures of mechanical dental plaque removal have been broadly introduced in many regimens (Lam *et al.*, 2013; Prendergast *et al.*, 2013; Sumi, Nakamura, & Michiwaki, 2002). However, studies on oral care protocols typically have focused more on cleaning and less on the elimination of contaminants afterwards (Lam *et al.*; Tashiro *et al.*, 2011). The amount of displaced contaminants temporally increases in the oral cavity following the mechanical removal of dental plaque (Ikeda *et al.*, 2014). In order to eliminate the residue, the rinsing and suctioning technique is widely used for patients who are intubated or not fully conscious (Munro, Grap, Jones, McClish, & Sessler, 2009; Prendergast *et al.*, 2013). In such cases, however, rinsing water can easily reach the pharynx due to its rheological properties, the patient's diminished consciousness, and gravity. As the rinsing water is often contaminated with the removed dental plaque from the dental and soft tissue surfaces, it must be promptly suctioned before becoming aspirated. Therefore, the avoidance of rinsing with additional fluid would seem to eliminate this risk altogether.

In the authors' previous study on hospitalized patients with neurological diseases, the effect of oral cavity wiping on the elimination of contaminants following oral care, as compared with rinsing, was examined (Ikeda *et al.*, 2014). Although the amount of oral bacteria was significantly increased after mechanical oral cleaning, a significant and comparable decrease was achieved either by wiping with mouth wipes or water rinsing with suctioning. As wiping also avoided the risk of rinsing water aspiration, it was considered to be an alternative for contaminant elimination after oral care. The present study evaluated wiping as a method for contaminant removal following oral care in a cohort of critically ill patients in the intensive care unit (ICU).

METHODS

Research objectives

The objectives of the present study were as follows:

- 1 To compare the bacterial count in the oral cavity between the intubated and extubated states in critically ill patients.
- 2 To examine the changes in the bacterial amount on the dorsal tongue surface from before oral care to after eliminating contaminants, either by rinsing or wiping.

Study design

This study's protocol was approved by the institutional review board at Fujita Health University (Approval ID: 14-258). The sample size was calculated based on the authors' previous study (Ikeda *et al.*, 2014) for a two-tailed significance level, a type I error of 0.05, and a type II error of 0.10 (power = 0.90). A prospective cross-over trial was conducted in the ICU of Fujita Health University from January to April, 2015. Before commencement, informed consent was obtained from the primary caregiver of each participant.

Participants and setting

Patients who were admitted to the ICU and who had undergone endotracheal intubation were recruited. Patients were excluded if they were edentulous, of unstable general physical condition, had a bleeding tendency, or a history of tracheostomy.

A total of 35 patients (24 men, 11 women; mean \pm standard deviation [SD] age: 66.5 ± 11.5 years) participated in this study. The mean \pm SD duration of the intubated period and stay in the ICU was 6.7 ± 8.5 and 11.8 ± 12.1 days, respectively. The cohort's characteristics are summarized in Table 1. The most frequent reason for admission to the ICU was postcardiovascular surgery (15 patients, 42.9%), followed by cardiopulmonary resuscitation (four patients, 11.4%). Ventilator-associated condition and possible VAP were defined based on the VAE surveillance criteria of the Centers for Disease Control and Prevention (Magill *et al.*, 2013). Possible VAP did not occur in any participant during the study period.

Procedures

The ICU nurses carried out oral care three times per day for each patient at 06:00 hours, 14:00 hours, and 18:00 hours according to a set of oral care protocols that had been developed by the ICU nursing staff, dentists, and dental hygienists. Oral moisturizing gel (Oral Plus

Table 1 Characteristics of the study population

Characteristic	Mean \pm SD or N (%)
Age (years)	66.5 \pm 11.5
Intensive care unit (ICU) stay (days)	11.8 \pm 12.1
Ventilation (days)	6.7 \pm 8.5
Sex	
Male	24 (69.0)
Female	11 (31.0)
Admission reason	
Postcardiovascular surgery	15 (43.0)
Cardiopulmonary resuscitation	4 (11.0)
Other	16 (46.0)
Ventilator-associated condition	
Among all ICU patients during the study period	4/153 (2.6)
Among the study participants during the study period	2/35 (5.7)
Possible ventilator-associated pneumonia	
Among all the ICU patients during the study period	0/154 (0.0)
Among the study participants during the study period	0/35 (0.0)

moisturizing gel for oral care; Wakodo Company, Ltd., Tokyo, Japan) first was applied to the soft surfaces of the oral cavity to soften any dried or hard secretions. The gel contains hyaluronic acid and trehalose and has a high water content ($\geq 75\%$) in order to prevent transpiration and to moisten the inside of the mouth. Afterwards, the teeth were brushed without dentifrice with a hand toothbrush. The toothbrush was dipped into a cup of tap water before brushing and was rinsed occasionally when needed. The palate, tongue, and other soft tissues were mechanically cleaned with a sponge swab. The intubation tube also was cleaned with a sponge swab while the fixing tapes were removed. Salivary secretions were suctioned

during oral care if necessary. Afterwards, the residual contaminants in the oral cavity were eliminated by using one of the two procedures described below. The fixed side of the intubation tube position was changed daily at the time of cleaning at 06:00 hours as it remained intubated. Chlorhexidine was not used for the oral care procedure because of the prohibition of high concentrations of chlorhexidine in Japan.

Two procedures for eliminating the contaminants were adopted after mechanical cleaning of the teeth, palate, tongue, and gums: (i) rinsing: the mouth was rinsed with 30 mL of tap water that was delivered by using an irrigating syringe and suctioned with an oral suction handle; and (ii) wiping: the entire mouth, including the teeth, palate, tongue, gums, and intubation tube, was wiped with an oral care mouth wipe (Oral Plus; Wakodo Company, Ltd.). The mouth wipe has a texture similar to that of a baby wipe and was designed to clean the soft tissues of the mouth. The sheet is composed mainly of cellulose fibers, with a small amount of plastic fibers to bind them. It contains hyaluronic acid and trehalose for moisturization but no alcohol or antimicrobial compounds. Both procedures were conducted on each participant on different days at least 24 h apart whenever possible.

The procedure order was fixed in this study design to maximize the number of trials. Wiping always served as the first eliminating procedure because the patients often were extubated within 24 h after ICU admission. In such cases, although comparisons could not be made between wiping and rinsing during endotracheal intubation, those of the oral bacteria before and after extubating were possible with wiping.

The measurements of the bacterial amount were conducted at the timing of oral care at 14:00 hours. The amount of bacteria on the left and right sides of the dorsal tongue surface was measured by a bacterial detection apparatus (Bacteria counter; Panasonic Healthcare, Tokyo, Japan) before oral care, just after oral care,

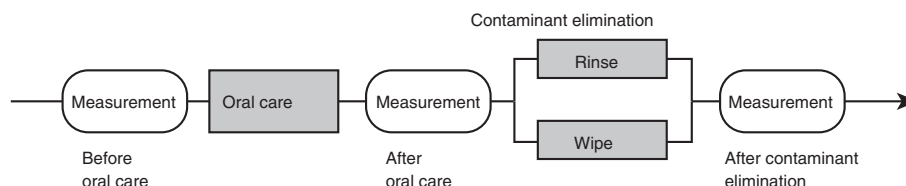


Figure 1 Schematic flow of bacterial measurement. The amount of bacteria on the dorsal tongue surface was measured at three time points: before oral care, just after oral care, and after eliminating the contaminants. During intubation, water rinsing and suctioning (rinsing) or wiping with oral care wipes (wiping) were adopted as procedures for eliminating the contaminants after oral care. Both procedures were carried out on each participant whenever possible on different days and at least 24 h apart. Following extubation, wiping only was used for eliminating the contaminants after oral care.

and after eliminating the contaminants (Fig. 1). The bacterial counts in the oral cavity were determined in a standardized way based on previous studies (Hamada, Suehiro, Nakano, Kikutani, & Konishi, 2011; Ikeda *et al.*, 2014). A sterilized swab first was inserted into a measuring device with a constant 20 g pressure because the measurement pressure affects the acquired amount of bacteria. The swab then was pressed on the sampling area with a constant pressure and was swiped three times in a 10 mm swath. The swab next was placed in distilled water in the apparatus for counting. The bacterial quantification used the dielectrophoretic impedance measurement technique (Hamada *et al.*, 2011). The calculated numbers of bacteria (cfu/mL) were stored in the apparatus until computer analysis.

Data analysis

As a preliminary trial, differences in the bacterial amount before oral care, just after oral care, and after eliminating contaminants between the endotracheal tube side and the non-tube side of the dorsal surface of the tongue during intubation was tested first by using the Wilcoxon signed-rank test. No statistically significant difference in the amount of oral bacteria was found at all the timings between the tube and non-tube sides of the dorsal tongue surface for wiping or rinsing, respectively. The mean value of the oral bacteria on the tube and non-tube sides (or left and right sides after extubation) were calculated and these were adopted as the representative values for each measurement.

Changes in the oral bacterial amount at each time point from before oral care to after elimination with rinsing or wiping were analyzed by using Friedman's rank test. The Wilcoxon signed-rank test with Bonferroni correction was adopted for multiple comparisons. The amount of oral bacteria was compared between before and after extubation and between the elimination procedures with the Wilcoxon signed-rank test. The critical value for rejecting the null hypothesis was $P < 0.05$. The statistical analyses were carried out by using SPSS v. 20.0 software (IBM Corporation, Armonk, NY, USA).

RESULTS

Overall, 35 patients received oral care, along with wiping, during endotracheal intubation. Of them, 21 underwent oral care with rinsing for a mean \pm SD of 1.5 ± 0.75 days afterwards. Fourteen patients received oral care with wiping after extubation for 5.6 ± 9.2 days after the first oral care procedure (Fig. 2). Four patients

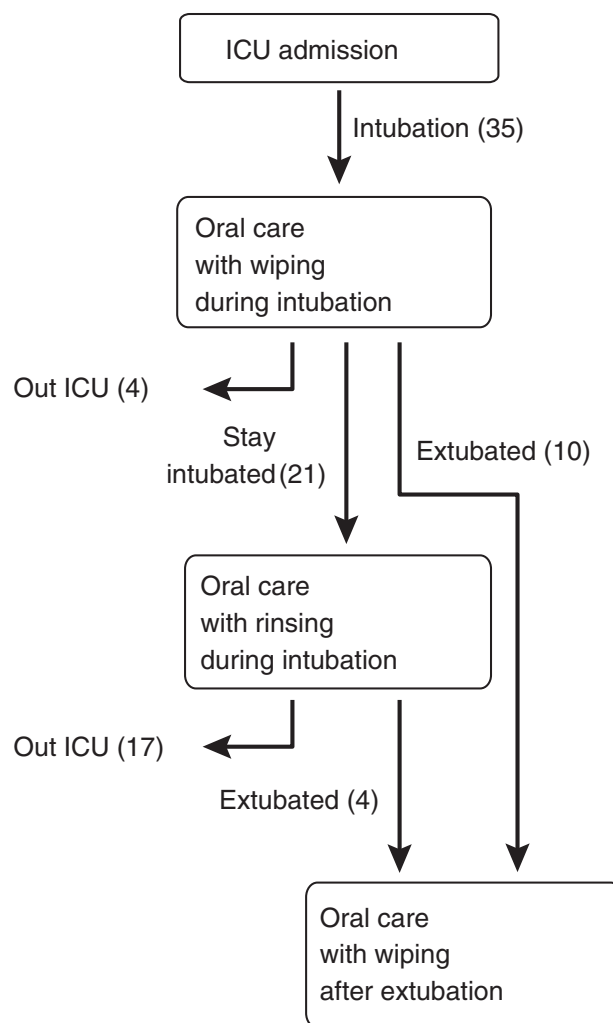


Figure 2 Schematic flow of data sampling. The first oral care procedure was conducted by using oral care wipes (wiping) on 35 patients with endotracheal intubation. Of these, oral care with water rinsing and suctioning (rinsing) was carried out on 21 patients on different days and at least 24 h apart. After extubation, oral care, along with wiping, was carried out on 14 patients. ICU, intensive care unit.

were excluded during the study: three had been discharged from the ICU and one had received a tracheotomy.

Tube side compared to the non-tube side

For both the wiping and rinsing trials, the amount of bacteria at all recorded time points was comparable between the endotracheal tube side and the non-tube side of the dorsal surface of the tongue during intubation. The oral bacterial counts on both sides were

therefore averaged and mean values were adopted for the ensuing analyses.

Wiping compared to rinsing

There was no statistical difference in the amount of oral bacteria prior to oral care between the rinse and wipe groups ($P = 0.57$) (Fig. 3). The bacterial count decreased significantly over the course of the oral care procedure in both the wipe ($P < 0.001$) and rinse ($P < 0.001$) groups. Before oral care, the median (interquartile range; IQR) amount of oral bacteria was 1.39×10^7 ($7.92 \times 10^6 - 2.29 \times 10^7$) cfu/mL in the wipe group and 1.27×10^7 ($6.59 \times 10^6 - 2.80 \times 10^7$) cfu/mL in the rinse group. After oral care, the median IQR amount of bacteria was 1.43×10^7 ($9.19 \times 10^6 - 3.23 \times 10^7$) cfu/mL in the wipe group and 1.34×10^7 ($5.67 \times 10^6 - 1.96 \times 10^7$) cfu/mL in the rinse group, which was not statistically different from that before oral care in either group. In contrast, the oral bacterial count was significantly decreased after

contaminant elimination by either wiping (4.01×10^6 [$1.54 \times 10^6 - 7.78 \times 10^6$] cfu/mL; $P < 0.001$) or rinsing (2.46×10^6 [$1.83 \times 10^6 - 8.38 \times 10^6$] cfu/mL; $P < 0.001$). The oral bacterial amount after contaminant elimination did not differ between the rinse and wipe groups ($P = 0.61$) (Fig. 3).

Intubated compared to extubated

After extubation, the amount of bacteria was significantly lower at all time points in the oral care procedure than that during intubation for trials using the wipe procedure ($P < 0.05$) (Fig. 4). Without the endotracheal tube, the bacterial count on the tongue tended to increase from before oral care (3.82×10^6 [$1.62 \times 10^6 - 9.91 \times 10^6$] cfu/mL) to after oral care (6.88×10^6 [$3.81 \times 10^6 - 1.49 \times 10^7$] cfu/mL), albeit not significantly ($P = 0.56$), and then decreased significantly to 1.57×10^6 ($5.01 \times 10^5 - 1.94 \times 10^6$) cfu/mL after wiping ($P < 0.001$) (Fig. 4).

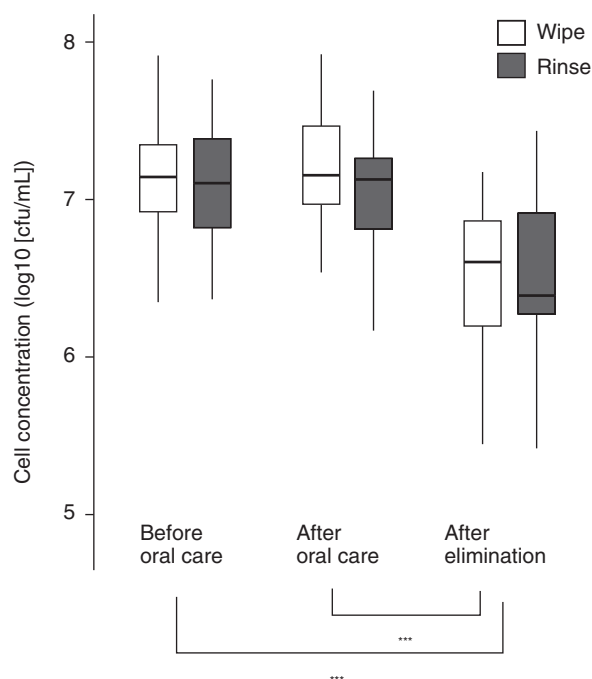


Figure 3 Changes in the amount of oral bacteria at the time points of before oral care, just after oral care, and after contaminant elimination during the intubation period. Rinse, rinsing with tap water and suctioning with an oral suction tip. Wipe, wiping with oral care mouth wipes. For both rinsing and wiping, the amount of oral bacteria had decreased significantly after the elimination of contaminants (*** $P < 0.001$), but was not different between the wipe and rinse groups at all the time points.

DISCUSSION

In the present study, it was examined if the amount of bacteria in the oral cavity differed between the intubated and the extubated status in critically ill patients, as well as how the bacterial count was affected by different elimination procedures after oral care. This study's results demonstrated that the level of oral bacteria was significantly lower after extubation of the endotracheal tube. Furthermore, after oral contaminant elimination, either by the wiping or rinsing technique, the bacterial amount decreased significantly during intubation, with no statistical difference between the elimination procedures. These findings indicate that the oral bacteria level is elevated in intubated patients. They also suggest that wiping might be an alternative to rinsing for eliminating the contaminants after oral care. The wiping technique can mitigate the risk of rinsing water aspiration by requiring no additional fluid.

Changes in the oral bacterial amount during the oral care procedures

This investigation examined the bacterial count after oral care and after eliminating the contaminants and assessed the effectiveness of two elimination procedures (i.e. wiping *vs* rinsing) in intubated patients. The amount of oral bacteria was significantly decreased after elimination in both the wipe and rinse groups. Pooled oropharyngeal secretions are one of the risk

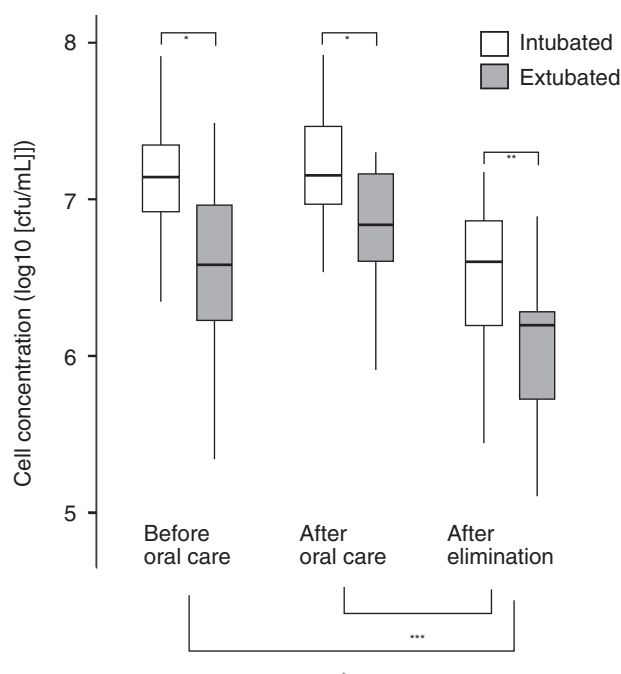


Figure 4 Changes in the amount of oral bacteria at the time points of before oral care, just after oral care, and after contaminant elimination by wiping during the intubated and extubated periods. At all time points, the oral bacterial count was significantly higher in the intubated participants. The amount of oral bacteria had decreased significantly after elimination of the contaminants for both the intubated and extubated participants. * $P < 0.05$, ** $P < 0.01$, and *** $P < 0.001$.

factors for VAP in patients with endotracheal intubation (Mietto, Pincioli, Patel, & Berra, 2013). This study's results showed that the median number of oral bacteria on the dorsal surface of the tongue tended to be higher after oral care than of that beforehand. However, the bacterial number decreased significantly after wiping the tongue surface, indicating the importance of eliminating contaminants after oral care. These findings were consistent with those obtained using healthy volunteers (Ikeda *et al.*, 2013) and unintubated patients who were hospitalized in a neurology inpatient unit (Ikeda *et al.*, 2014). In earlier studies, oral bacterial amounts on the tongue surface were not increased after oral care but were elevated on the buccal vestibule of the mandible. The bacterial count varied with the location in the oral cavity. Sachdeo, Haffajee, and Socransky (2008) reported that the bacterial amount was highest on the dorsal surface of the tongue and lower on the labial vestibules and palate. Thus, wiping the tongue surface should be a minimum requirement in oral care protocols.

There were no significant differences in the oral bacterial count at any time point between the wipe and rinse groups. Wiping reduces excess fluid entry into the lower airway. With a significant drop in oral bacteria and no significant difference from the rinsing and suctioning procedure, wiping might be an applicable method to eliminate the contaminants after oral care.

Changes in the oral bacteria after endotracheal tube extubation

The median number of oral bacteria was decreased significantly after extubation, suggesting that the bacterial count was elevated during intubation. Intubated patients have a reduced level of consciousness, dull swallowing reflex, and pooling of saliva (Chastre & Fagon, 2002). These factors could impair oral clearance, leading to an increased number of oral bacteria. The risk of pneumonia is 6–20-fold higher during intubation in critically ill patients (Chastre & Fagon), which probably is related to the pooled oropharyngeal secretions, declined cough reflex, and biofilm development on the endotracheal tube (Mietto *et al.*, 2013; Vandecandelaere *et al.*, 2012). It was witnessed that the amount of oral bacteria was increased during the endotracheal intubation period, which could contribute to VAP susceptibility.

During the endotracheal intubation period, the ICU unit nurses carried out oral care three times daily. The improvement of oral hygiene by daily oral care during the intubation period might have an impact on the significant decrease of the bacterial count after extubation. The amount of oral bacteria was not counted every day during intubation. Further studies are needed to clarify the effect of daily oral care on the change in the amount of bacteria after extubation.

Lateralization of the oral bacterial amount on the dorsal surface of the tongue

Biofilm formation on the inside and outside surfaces of intubated endotracheal tubes is the one of the pathophysiological mechanisms of VAP development (De Souza *et al.*, 2014; Mietto *et al.*, 2013; Vandecandelaere & Coenye, 2015). Endotracheal tube biofilm is composed primarily of oral aerobic and anaerobic bacteria (Vandecandelaere & Coenye). Although it had been hypothesized that a higher amount of oral bacteria would be detected on the tongue surface of the endotracheal tube side, this study's results revealed no significant difference between the tube and non-tube sides. In the study's ICU, oral care is carried out by the nurses three times per day and the fixation position of the

endotracheal tube is changed routinely, which might have accounted for this finding. Tube cleaning also was conducted in this oral care protocol in order to reduce the amount of external surface bacteria. Further studies are needed to characterize the amount of bacteria on the tube surfaces.

Limitations of the study

This study had several limitations. First, it was a cross-over trial that was not randomized: the elimination procedure order was fixed, with wiping as the first technique during the endotracheal intubation period in order to maximize the sample size. Although the second trial usually was done on the following day of ICU admission, it was presumed that the oral conditions were similar between the sampling points. In support of this, the average oral bacterial count before oral care during intubation was not significantly different between the wipe and rinse trials. On both days, the results showed that oral contaminant elimination by either wiping or rinsing reduced the oral bacterial count significantly after oral care. Lastly, the present study demonstrated the short-term effect of wiping on the reduction of the oral bacteria. As the incidence of VAP was too low, further studies with a large sample size and longer observation period will be needed in order to examine the long-term merits of wiping as an elimination procedure of the oral contaminants as a way of reducing the risk of VAP.

CONCLUSION

In critically ill ICU patients, the amount of bacteria was significantly decreased after extubation, which suggested that the oral bacterial level was elevated during intubation and might be associated with the risk of VAP. In the current examination of the effectiveness of mouth wiping as a means of reducing the oral bacteria after oral care, a significant decrease was detected in the bacterial level with wiping to a degree that was comparable with that of rinsing with water and suctioning. These findings indicate that wiping is an effective procedure to eliminate the contaminants after oral care. The wiping technique can mitigate the risk of rinsing water aspiration by requiring no additional fluid.

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DISCLOSURE

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

K. M.⁽¹⁾, Y. K., and T. Y. conducted the investigation; K. M.⁽²⁾ carried out the statistical analysis; K. M.⁽¹⁾, K. M.⁽²⁾, H. Y., Y. S., C. Y., and O. N. conceived the study, participated in its design, and helped to draft the manuscript. All the authors read and approved the final manuscript.

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