Original Article

Ventilator-associated Pneumonia Risk Decreased by Use of Oral Moisture Gel in Oral Health Care

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Abstract

Although oral health care has a preventive effect against ventilator-associated pneumonia (VAP), the most effective method of oral health care in this respect remains to be established. The objective of this single-center, randomized, controlled trial was to investigate the relationship between VAP and various methods of oral health care. All patients included in the study (n=142) were on mechanical ventilation with oral intubation at the intensive care unit of the Tokyo Dental College Ichikawa General Hospital. They were divided into two groups, one receiving standard oral health care (Standard group), and the other receiving oral health care using an oral moisture gel instead of water (Gel group). After removal of the intubation tube, biofilm on cuff of the tube was stained with a disclosing agent to determine the contamination level. Factors investigated included sex, age, number of remaining teeth, intubation time, fever $\geq 38.5^{\circ}\text{C}$, VAP, cuff contamination level, and time required for one oral health care session. No VAP occurred in either group during the study period. The level of cuff contamination was significantly lower in the Gel group than the Standard group, and the time required for one session of oral health care was shorter ($p < 0.001$). Multivariate analysis revealed use of the oral moisture gel as a factor affecting cuff contamination level. Use of an oral moisture gel decreased invasion of the pharynx by bacteria and

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contaminants together with biofilm formation on the intubation tube cuff. These results suggest that oral health care using an oral moisture gel is effective in preventing cuff contamination.

Key words: Ventilator-associated pneumonia—Oral health—Biofilm—Critical care—Respiratory aspiration

Introduction

Pneumonia accounts for 15% of nosocomial infections, with approximately 25% of such infections occurring in the emergency room¹⁹. Tracheal intubation is the largest risk factor for nosocomial bacterial pneumonia¹⁹. Ventilator-associated pneumonia (VAP) can occur within 48 hrs of attachment of a mechanical ventilator¹³, and has a reported incidence of 15–60%^{5,20} and associated mortality rate of 70%⁵. The prevention of VAP is, therefore, a major issue in respiratory management.

One infection route for VAP is thought to be the silent aspiration of secretions from around the intubation tube in the trachea⁸. First, bacteria adhere to and proliferate in the oral cavity and pharynx. A biofilm then forms, particularly on the teeth and external wall of the trachea, and on the intubation tube. Large amounts of bacteria in this biofilm can then enter any saliva or blood that comes into contact with these surfaces. This saliva or blood may then be silently aspirated into the open respiratory tract, accumulate on the cuff of the intubation tube, leak into the trachea from gaps between the cuff and the tracheal wall, and then flow into the peripheral airway. This sequence of events results in VAP.

Maintaining oral hygiene is important for both oral and general health^{1,10,22}. Oral health care has always been thought to be important in preventing aspiration pneumonia, although no clinical evidence for this was published until 1994 in a study on subclinical aspiration using radioisotopes by Kikuchi *et al.*¹⁴. Another study then suggested subclinical aspiration of oral bacteria during sleep to be

a cause of pneumonia¹⁶. The effect of oral health care was further demonstrated in a bacteriological study in which oral health care was provided to residents of nursing homes for the aged¹¹. In follow-up studies, patients receiving professional oral health care by dentists or dental hygienists showed a 14% decrease in the incidence of fever, an 8% decrease in pneumonia, and 9% fewer deaths from pneumonia than patients who did not receive oral health care^{24–26}. Taken together, these studies indicate that oral health care is effective in preventing aspiration pneumonia.

The 2003 Guidelines for Prevention of Nosocomial Pneumonia issued by the Centers for Disease Control and Prevention in the United States recommend creating and implementing a comprehensive oral hygiene program³, but do not recommend any specific oral health care methods.

In this study, the relationship between VAP and type of oral health care was investigated, focusing on objectively measuring contamination of the intubation tube. Our goal was to determine which method of health care provided the strongest preventive effect.

Materials and Methods

A total of 142 patients on mechanical ventilation with oral intubation for more than 10 hrs in the intensive care unit (ICU) at the Tokyo Dental College Ichikawa General Hospital between March and November 2010 were included in the study. After admission to the ICU, the patients were divided into two groups, one receiving standard oral health care (Standard group) and the other receiving oral health care using an oral moisture gel

Table 1 Oral health care manual for patients on tracheal intubation at Tokyo Dental College Ichikawa General Hospital

1) <u>Body position, confirmation of tracheal tube fixation and tube removal, regulation of cuff pressure</u>
<ul style="list-style-type: none"> • Check that the patient's upper body is inclined $\geq 30^\circ$, and adjust body position within the allowable range so that oral care is easy to perform. • Confirm fixation position of tracheal tube. At 14:00, remove the tape holding the tracheal tube in place. At 8:00 and 20:00, leave the tube fixed in position. • Use a cuff pressure gauge to adjust cuff pressure to 40 mmHg from the normal level of 25–30 mmHg.
2) <u>Wipe around the mouth and nasal cavity</u>
<ul style="list-style-type: none"> • Wipe the face around the mouth using gauze moistened with a 1% solution of external antiseptic Isodine[®] solution. • Wipe the nasal vestibule with a medium cotton swab moistened with Isodine[®]. The aim is to ensure air flow into the nasal cavity.
3) <u>Retain moisture on lips, ensure visual field</u>
<ul style="list-style-type: none"> • Wipe and moisten lips with a cotton swab wetted in a 1% solution of external antiseptic Isodine[®], and prevent damage during lip retraction.
4) <u>Wipe lips, buccal mucosa, roof of the mouth, tongue, tracheal tube</u>
<ul style="list-style-type: none"> • Using a sponge brush soaked in 1% solution of external antiseptic Isodine[®], wipe the lips, buccal mucosa, roof of the mouth, tongue and tracheal tube in the oral cavity. • When contaminants or tongue coat are strongly adherent, gently wipe and remove these materials with a sponge brush dipped in 2-fold diluted oxydol. • Suction within the mouth as necessary using the Yankauer Suction[®].
5) <u>Brush teeth</u>
<ul style="list-style-type: none"> • If the patient has teeth, brush using a toothbrush moistened with 1% solution of external antiseptic Isodine[®]. • Using the Yankauer Suction[®] connected to an aspirator, suction saliva and contaminant fluid from the mouth as needed.
6) <u>Wipe the lips, buccal mucosa, roof of the mouth, tongue, and tracheal tube within the oral cavity again with a sponge brush</u>
7) <u>Fix the tracheal tube in place, adjust body position and cuff pressure</u>
<ul style="list-style-type: none"> • At 14:00, fix the tracheal tube in place with tape, return the patient to the original body position, and adjust the cuff pressure to the normal 25–30 mmHg level using a cuff pressure gauge.
8) <u>Retain moisture in the mouth and lips</u>
<ul style="list-style-type: none"> • If the inside of the mouth is dry, spread oral moisture gel. • Spread vaseline on the lips.

(Gel group). Oral health care was provided to each patient 3 times/day, at 8:00, 14:00, and 20:00 by a nurse trained by a dentist or a dental hygienist. The patients were assigned to each group depending on which day they were hospitalized. A Hi-Lo EvacTM endotracheal intubation tube (Covidien Japan, JP) with a suction lumen on the cuff was used in both groups. Mouth and over cuff suctioning were performed manually every 2 hrs. Suctioning of the airway was done only as necessary when auscultation revealed the presence of secretions in the airway.

1. Oral health care methods

1) Standard group

Oral health care was performed according to the oral health care manual of Tokyo Dental College Ichikawa General Hospital (Table 1). The total volume of liquid used was approximately 30 cc.

2) Gel group

Here, the same procedure was used as for the Standard group, but with wiping with a 1% solution of external antiseptic Isodine[®] or 2-fold diluted oxydol being replaced with an oral moisture gel (3MTM OptreozTM; Sumitomo

3M Health Care Limited, JP) instead. The total amount of gel used for oral health care was 5g. The gel consisted of water, glycerolglycerin, sodium alginate, hydroxyethyl cellulose, cetylpyridinium chloride, sodium citrate, and sodium benzoate. The cetylpyridinium chloride and sodium benzoate are antibacterial ingredients, but their concentrations are very low. They were included as a preservative only, and any antibacterial effect can be disregarded.

2. Data collection

Information on sex, age, number of remaining teeth, intubation time, fever of $\geq 38.5^{\circ}\text{C}$, and VAP was obtained from patient medical records after extubation.

The level of contamination of the intubation tube cuffs was determined as follows (Fig. 1).

The endotracheal intubation tube was removed when the condition of the patient had improved and they no longer needed artificial respiratory management (mean, 64.1 hrs; minimum, 10 hrs; maximum, 294 hrs). Each intubation tube was carefully and slowly removed to avoid strong contact with the surrounding mucosa, with the air in the cuff completely discharged. Immediately after removal, the intubation tube cuff was expanded and the biofilm stained thoroughly using a spray-disclosing agent (2TONE[®]; Heraeus Kulzer Japan, JP). Excess dye was rinsed off with water and images of both sides of the cuff portion of the stained tube recorded using a digital camera. Images taken of the intubation tube cuffs were numbered to allow later matching with patients and stored on a personal computer. The stained areas of the cuffs were automatically selected by Adobe Photoshop[®] CS2 (Adobe Systems Inc., San Jose, CA) and the total number of pixels counted. The plaque stain was used to indicate the area for selection. This was performed automatically using the automatic selection tool and the number of pixels counted. The contamination level of each cuff was evaluated as the percentage (%) of pixels in the stained portion compared to the total

Fig. 1 Method of evaluating cuff contamination level
 A: Cuffs were stained using disclosing agents.
 B: Cuffs were selected using image software on computer.
 C: Using plaque stain as an indicator, selection was automatically performed using automatic selection tool and number of pixels counted.

pixel number (contamination level = number of stained pixels/total number of pixels).

The image analysis of each photograph of a stained cuff was performed by the same person, who was blind to which group each image belonged. The cuff contamination level was finally matched to the patient using this number and statistical tests performed in each group.

The time required for oral health care was the mean of the measured time required to provide oral health care by three nurses.

The protocol for this study was in accordance with provisions of the Helsinki Declaration, and the study was approved by the Ethic Committee of the Tokyo Dental College Ichikawa General Hospital (No.192, February 2, 2010). The purpose of the study was fully explained to each patient or their guardian before or after intubation. It was also made clear that participation was voluntary and that the patient would suffer no disadvantage if they refused to participate; the anonymity of the data was also guaranteed. Consent for survey participation was then obtained individually.

Table 2 Group comparison regarding use of oral moisture gel

χ^2 test	Sex	Male	Female	p value
	Standard group	64.3% (54)	35.7% (30)	0.71
	Gel group	67.2% (39)	32.8% (19)	
	Fever	<38.5°C	$\geq$ 38.5°C	p value
χ^2 test	Standard group	90.5% (76)	9.5% (8)	0.85
	Gel group	91.4% (53)	8.6% (5)	
Student's <i>t</i> -test		Standard group (n = 84)	Gel group (n = 58)	p value
	Age, yr	67.9 $\pm$ 12.8	67.9 $\pm$ 13.8	0.71
	Number of remaining teeth	11.7 $\pm$ 10.2	14.2 $\pm$ 9.8	0.13
	Intubation hours	49.8 $\pm$ 56.9	84.2 $\pm$ 67.3	<0.001
	Contamination level, %	25.0 $\pm$ 13.5	15.8 $\pm$ 12.6	<0.001
	Oral health care seconds	759.7 $\pm$ 340.8	466.8 $\pm$ 295.7	<0.001

3. Statistical analysis

The SPSS® statistics package, ver. 18 (IBM Corporation, US) was used for all the statistical analyses. For comparisons between the two groups, the χ^2 test was used for sex and the presence or absence of fever, and the Student's *t*-test for age, number of remaining teeth, number of intubation hour, cuff contamination level, and oral health care time. The parameters of factors related to cuff contamination were investigated using logistic regression analysis. In this analysis, the contamination level on the cuff ranged from 0 to 58.90. To use binomial logistic regression analysis, the continuous data were changed into category data. The cut-off point was set as the first quartile, and the contamination level at that point was 9.37. Between 0 and 9.37 was assigned a value of 0, while a contamination level on the cuff between 9.38 and 58.90 was assigned a value of 1. A value of $p < 0.05$ was taken to indicate a significant difference.

Results

1. Age and sex

The age and sex of each patient are shown in Table 2. The 142 patients (93 men, 65.5%; 49 women, 34.5%) on mechanical ventilation

in this study had a mean age of 67.9 ± 13.2 years.

2. Tests between groups using χ^2 and Student's *t*-test

In comparisons between the two groups, significant differences were seen in cuff contamination levels and intubation and oral health care times. No significant differences were seen in sex, age, number of remaining teeth, or presence or absence of fever (Table 2). No VAP occurred in either of the groups during the study period.

3. Logistic multivariate analysis

Multivariate analysis of sex, age, number of remaining teeth, intubation time, and oral moisture gel tested against the cuff contamination level in the Standard and Gel groups showed that the number of remaining teeth and the use of an oral moisture gel were factors influencing cuff contamination (Table 3). Cuff contamination was significantly lower when patients had more teeth or an oral moisture gel was applied.

Discussion

The purpose of the present study was to investigate the relationship between oral

Table 3 Binomial logistic regression analysis for factors related to cuff contamination

	OR	95% CI		p value
Sex (Female = 0, Male = 1)	0.843	0.344	2.068	0.709
Age (Continuous quantity)	0.982	0.948	1.018	0.326
Teeth (Continuous quantity)	0.945	0.899	0.994	0.027
Intubation hours (Continuous quantity)	0.994	0.988	1.001	0.085
Using oral moisture gel (yes = 0, no = 1)	4.237	1.763	10.181	0.001

health care and VAP. However, as there was no incidence of VAP during the study period, the contamination level of the incubation cuffs was determined instead as an objective indicator of a cause of VAP.

Currently, in an acute medicine setting, oral health care is usually viewed as a form of disease control focused on preventing infections of the airway and other structures, and many hospitals have developed oral health care manuals and introduced clinical paths. Oral health care for patients on mechanical ventilation is allotted much time among nursing tasks^{2,21)}. However the methods, materials, tools, time, and frequency of oral health care vary among hospitals, with a standardized program remaining to be developed. A number of studies have investigated the use of chlorhexidine in oral health care for patients on mechanical ventilation^{4,7,9,12,15,16,18)}; others have reported on the additional use of electric toothbrushes^{7,17)}. Consistent and significant results, however, remain elusive. In this study, we hypothesized that oral contaminants flushed into the pharynx during oral health care would constitute a risk factor for VAP. Use of a toothbrush or a sponge means that water carrying oral bacteria may accidentally flow into the pharynx and increase risk of VAP. Here, an oral moisture gel was used instead. Such gel, however, does not contain effective levels of antibacterial or anti-inflammatory agents, allowing us to focus solely on the effect of reducing the flow of

contaminants into the pharynx during oral health care. This method was then compared with conventional care using Isodine[®] antiseptic. The results showed a significant decrease in contamination of the cuff with use of an oral moisture gel. This may be explained by the lower fluidity of the gel reducing its potential to scatter during use and flow into the pharynx. In addition, the action of the gel retains moisture in the mouth, which may prevent bacterial colonization⁶⁾. The lubricating properties of the gel also play a role, protecting the oral mucosa while facilitating the elimination of hard contaminants such as encrustations from bleeding or dried phlegm and reducing the need for suctioning, as less material flows into the throat. Significant differences were observed in cuff contamination levels and time needed for oral health care. Oral health care with oral moisture gel made it possible to significantly shorten the time required compared to the conventional method of oral health care. This not only reduces the burden on nurses, but also affects medical economics by reducing medical and staff costs arising from the occurrence of VAP²³⁾.

While use of an oral moisture gel showed the greatest effect on level of contamination of the cuff, the number of existing teeth also showed some influence. These results indicate that a greater number of present teeth may have an adverse effect on oral health, which in turn will affect the contamination level of

the cuff. Further large-scale cohort studies are needed to investigate the effect of various methods of oral health care in preventing VAP and determine the best comprehensive oral hygiene program.

Conclusions

None of the patients in this study developed VAP in either the general oral care or moisture gel method groups. However, evaluation of the contamination of the cuff of the intubation tube using disclosing agents revealed that the contamination level decreased with use of an oral moisture gel. These findings suggest that oral health care using an oral moisture gel prevents VAP in patients on mechanical ventilation.

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Disclosure Statement

None of the authors has a conflict of interest to declare.

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