

The Effect of Brushing with a Soft Toothbrush and Distilled Water on the Incidence of Ventilator-Associated Pneumonia in the Intensive Care Unit

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Background: Ventilator-associated pneumonia (VAP) is a common nosocomial infection, which results in longer hospitalization, increased treatment costs, and higher mortality rates. One major cause of VAP is colonization and microaspiration of oropharyngeal secretions following the formation of dental plaque, which is due to poor oral hygiene and failure to mechanically remove these microorganisms from the teeth. This study was conducted to determine the effect of brushing teeth with distilled water on the incidence of VAP in patients admitted to intensive care unit (ICU).

Materials and Methods: In this randomized clinical trial, 168 intubated patients, who had at least 20 teeth were randomly assigned to two groups. In the experimental group, the patients' teeth were brushed twice a day with a children's toothbrush and distilled water in addition to the routine oral care. The clinical pulmonary infection score (CPIS) was used to diagnose VAP. The data were analyzed using SPSS version 16 software.

Results: A total of 38.6% of the patients in each group developed VAP. There was a significant difference in incidence of VAP on day five between the two groups ($P < 0.05$). The incidence of VAP had a significant relationship with smoking ($P < 0.001$), underlying diseases ($P < 0.001$), duration of hospitalization ($P = 0.002$), and age ($P < 0.001$). Enterobacter was the most common microorganism identified in both groups.

Conclusion: According to our results, tooth brushing twice daily with distilled water reduced the incidence of VAP in patients admitted to the ICU. Therefore, it is recommended that nurses caring for ventilator-dependent patients brush the patients' teeth with distilled water as a part of their routine oral care.

Key words: Distilled water, Oral hygiene, Ventilator associated pneumonia (VAP), Tooth brushing.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a type of nosocomial infection that develops in mechanically ventilated patients. It is the second most common nosocomial infection and the first most common ICU acquired infection and occurs in patients who are mechanically ventilated for more than 48 hours (1,2). Its

prevalence is 10%-65% and it is 5-10 times more common in ICUs than in other wards (3,4). The risk of VAP increases by 1%-3% for every additional day of mechanical ventilation (5). Ventilator associated pneumonia is associated with increased mortality (30%-70%), disability, longer ICU stays (by 7%-9%), longer hospitalization, longer

duration of mechanical ventilation, and higher costs of treatment (e.g., \$30,000 per patient stay)(6-8). Colonization of the oropharynx and microaspiration of oropharyngeal secretions, which directly introduce bacteria and other pathogens to the lower respiratory tract, are the most important risk factors for development of VAP (9-10). The risk of pneumonia increases in intubated patients by 6%-21% due to easier accessibility of the lower respiratory tract by the colonizing bacteria at the end of the pharynx (11,12). The oral bacterial flora usually changes from gram positive to gram negative bacteria after 48 hours of ICU admission, which leads to bacterial colonization of the pharynx and increased accumulation of dental plaques (13). These dental plaques form at a higher rate in patients admitted to the ICU compared to other patients due to immune dysfunction, underlying diseases, the presence of endotracheal tubes, difficulty with swallowing, side effects of drugs, and decreased oral fluid intake. However, the most important causes of dental plaque formation are poor oral hygiene and the failure to mechanically remove the plaques, which result in growth of bacteria on the plaques. Moreover, there is a strong relationship between the bacteria found in cultures from dental plaques and the bacteria found in tracheal aspirate cultures, which result in VAP (14,15).

The most important strategy for reducing VAP is improving oral hygiene (9). Techniques suggested for removing dental plaques and oral pathogens include mechanical interventions such as brushing and swabbing, and pharmacological interventions such as rinsing with mouthwashes. However, dental plaques are removed only through brushing (16-18). While antibacterial mouthwashes have been shown to improve oral hygiene, they are not routinely used due to development of bacterial resistance, associated complications, and the higher cost associated with them (17). For instance, chlorhexidine is one of the most commonly used solutions in intubated patients, but it is both costly and irritating (17, 19). Therefore, it seems that brushing is more cost-effective and

causes less irritation compared to chlorhexidine (20). While water is safe and useful for cleaning the teeth and gums, and preventing xerostomia, it water is a potential source for growth of pseudomonas. Therefore, it is best to use distilled water (19).

There are inadequate data about improving oral hygiene and reducing VAP using nursing interventions such as tooth brushing. This study was conducted to determine the effect of brushing with distilled water on the incidence of VAP in mechanically ventilated patients admitted to the ICU.

MATERIALS AND METHODS

This randomized clinical trial was conducted on 168 ventilator-dependent patients hospitalized in the ICUs. Taking into account the confidence interval of 95% and statistical power of 75%, P1 and P2 were obtained as 0.54 and 0.71, respectively. Eligible patients were randomly assigned to two groups: 84 patients in the intervention group and 84 patients in the control group, using Random Allocation software (Figure 1). Inclusion criteria of this study were as follows: Endotracheal intubation, having at least 20 teeth, and being 20-85 years old. Exclusion criteria were as follows: extubation, signs/symptoms of aspiration, immune compromising conditions, debilitating diseases, coagulation disorders, and jaw fractures. We used a demographic and clinical information questionnaire (age, sex, kind of trauma, history of smoking, underlying diseases, and duration of hospitalization) as well as the standard scale of bacterial pneumonia to collect data.

In the intervention group, in addition to routine oral care, the anterior and posterior surfaces of the teeth and the surface of the tongue were brushed twice a day (in the morning and the afternoon) with a children's soft toothbrush and distilled water, making sure not to traumatize the teeth. Subsequently, chlorhexidine was applied to a swab and was rubbed on the surface of the tongue, followed by 20 mL of normal saline, and the mouth

was deeply suctioned subsequently. The first intervention was performed during the first 24 hours of intubation, and thereafter, oral care was delivered twice daily for the next five days. Oral care was performed by three trained nurses. The patients in the control group received routine oral care per the ICU protocol (control of endotracheal tube cuff, rinsing the mouth with normal saline, applying chlorhexidine to a swab and rubbing it on the surface of the tongue, and oropharyngeal suction) three times a day (in the morning, afternoon, and at night). The treating physician and the data analyst were blinded to patient allocation.

The incidence of VAP was determined using the clinical pulmonary infection score (CPIS). This score was developed by Pugin et al. in 1991 and confirmed by the National Center for Infectious Diseases (21). Clinical pulmonary infection score includes body temperature, white cell count, tracheal aspirates in terms of color and smell, oxygenation (PaO₂/FiO₂), radiographic findings (chest X-ray), and positive tracheal aspirate culture. A score of six or higher shows the presence of pneumonia (CPIS ≥ 6). To determine the incidence of VAP, CPIS was first calculated after two days of intervention, that is, on day three of ICU stay. This was repeated on the fourth and fifth days of the intervention. Test results and chest X-rays were interpreted by the attending physician on daily basis. Data were collected by interviews, observation, inspection, and document analysis by the physician and nurse. In intervention group patients with scores higher than 6, a sterile sample of tracheal aspirate culture was obtained and delivered to the laboratory.

This study was approved by the Research Ethics Committee of Shahid Sadoughi University of Medical Sciences (registered clinical trial IRCT2013102115101N1). Informed consent was obtained from the patients' guardian after briefing them about the objectives of the study.

Data were analyzed using SPSS v. 16 software. We performed descriptive statistics (mean, standard deviation,

and frequency percentage) and inferential statistics (Independent T-test, chi-squared test, and if necessary, Fisher's exact test). For continuous variables (age and duration of length of hospitalization), independent t-tests were used. For categorical variables (sex, kind of trauma, history of smoking, underlying diseases), chi-squared test was used.

RESULTS

Of the 168 patients, 84 patients were assigned to the control group, and the other 84 patients were assigned to the intervention group. 13 patients in the control group and 9 patients in the intervention group were excluded because of death or extubation. However, new patients were selected again as advised by the statistician to replace them.

At baseline there were no differences in demographic (age, sex) or clinical information (duration of hospitalization, type of trauma, underlying disease, history of smoking) between the patients in the control and the intervention group ($P > 0.05$) (Table 1).

In each group 38.6% of the patients developed VAP. The incidence VAP in the intervention group and the control group were respectively 4.8% and 6% ($P=0.5$) on the third day, 14.3% and 20.2% ($P=0.31$) on the fourth day, and 29.8% and 47.6% on the fifth day ($p=0.02$) (Table 2).

The following microorganisms were isolated from the endotracheal tube aspirates: enterobacter was found in 14 patients in the experimental group (56%) and 20 patients in the control group (50%). Acinetobacter was found in seven patients in the intervention group (28%) and 12 patients in the control group (30%). Klebsiella was found in four patients in the intervention group (16%) and eight patients in the control group (20%). There were no significant differences between the two groups in this regard ($X = 0.69$, $P = 0.71$). Table 3 shows a significant relationship between the incidence of VAP on the fifth day and smoking ($P < 0.001$), underlying diseases ($P < 0.001$), duration of hospitalization ($P = 0.002$), and age ($P < 0.001$) (Table 3).

Table 1. Comparison of the baseline clinical and demographic data between the two groups

Variables	Experimental group		Control group		Statistical test	
	Mean	SD ^a	Mean	SD ^a	T ^a	P value
Age (year)	44.9	13.9	44.2	14	0.33	0.74
Duration of hospitalization (day)	12.6	4.1	12.4	4	0.4	0.69
Sex	N ^a	%	N ^a	%	χ^2 ^a	P value
Male	56	66.7	57	67.9		
Female	28	33.2	27	32.1	0.027	0.87
Total	84	100	84	100		
Type of trauma	N ^a	%	N ^a	%	χ^2 ^a	P value
General Organ damage	21	25	21	25		
Neurological damage	39	46.4	38	45.2		
General & Neurological damage	24	28.6	25	29.8	0.033	0.98
Total	84	100	84	100		
Underlying disease (yes)	33	39.3	37	44	0.39	0.53
Smoking (yes)	30	35.7	33	39.3	0.229	0.63

^a Abbreviations: SD, Standard deviation; N: number; χ^2 , Chi-square test; T: Independent T-test

Table 2. The frequency distribution of VAP in the experimental and the control group on the fifth day

Groups		Experimental group		Control group		χ^2 ^a	P value
		N ^a	%	N ^a	%		
VAP on the fifth day	Infected	25	29.8	40	47.6	5.65	0.02
	Uninfected	59	70.2	44	52.4		

^a Abbreviations: χ^2 : Chi-square test, N: number

Table 3. The incidence of ventilator associated pneumonia on clinical and demographic characteristics of the fifth day

Variables		Total samples	Ventilator associated pneumonia		P value
			N ^a	%	
Sex	Male	113	48	42.5	P=0.149
	Female		17	30.9	
Type of trauma	General Organ damage	42	21	25	P<0.65
	Neurological damage	77	38	45.2	
	General & Neurological damage	49	25	29.8	
Underlying disease	Positive	70	48	68.6	P<0.001
	Negative	98	17	17.3	
Smoking	Yes	63	42	66.7	P<0.002
	No	105	23	21.9	
variables			Ventilator associated pneumonia		P value
			Infected	Uninfected	
			M \pm SD ^a	M \pm SD ^a	
Age (year)			48.8 \pm 12.5	41.9 \pm 14.2	P<0.002
Duration of hospitalization			13.9 \pm 4	11.6 \pm 3.8	P<0.001

^a Abbreviations: N: number, M: Mean, SD: Standard deviation

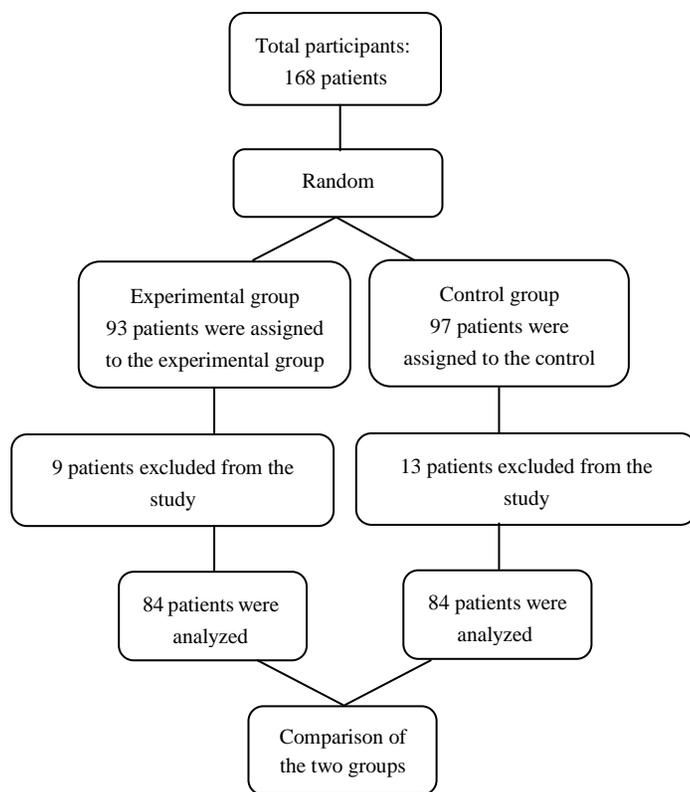


Figure 1. Consort flow diagram of study

DISCUSSION

Our results show that 38.6% of the patients in each group developed VAP. Numerous studies have reported different results on the prevalence of VAP. Pneumonia is the most frequent infection in the ICU with an incidence of 9-68% (7, 22-24). These different results might be attributed to the use of different diagnostic criteria and different study populations.

According to our results, the incidence of VAP in the experimental group on the fifth day was lower than that in the control group, which could be attributed to tooth brushing with distilled water twice day. This is in accordance with results from YAO's study. YAO et al. showed that tooth brushing twice a day with distilled water reduced the incidence of VAP by 17% (19). In a study by Hutchins et al. a protocol of changing catheters, oral suction every 24 hours, tooth brushing twice a day, mouth washing with 0.12% chlorhexidine and hydrogen peroxide

swabs every 4 hours, wetting the mouth and lips, deep oral suction every 12 hours, reduced VAP by 89.7% (1).

Based on our results, there were no differences between the two groups in terms of the type of microorganisms, and the most frequent microorganisms were enterobacter, acinetobacter, and Klebsiella, respectively. While some researchers have reported enterobacter and staphylococcus aureus as the most common bacterial agents causing VAP (25,26), others have reported pseudomonas and acinetobacter, respectively, as the most common bacterial agents which cause VAP (27-29). In studies by Afkhamzadeh et al and Peleg and Hooper, the most frequent microorganisms were Klebsiella and enterobacter (30-31). These different results might be attributed to the impact of different geographical locations, types of prophylactic antibiotics, and different methods of oral care used in those studies.

Moreover, our results showed no significant difference in the incidence of VAP on the fifth day based on sex and kind of trauma. Similarly, studies by Buczko and Nadi et al. did not show any significant relationship between patient sex and VAP (32, 33). Sabery et al. did not find a significant differences between cause of hospitalization and incidence of VAP ($P=0.58$)(34). However, history of smoking, age, underlying diseases, and duration of hospitalization were significantly related with VAP. The relationship between smoking and pulmonary diseases and VAP has been proven in clinical and epidemiological studies (35, 36). Arvanitis et al, also found significant correlations between the incidence of VAP and age (37). Furthermore, Chao et al. revealed a significant relationship between the incidence of VAP and duration of hospitalization ($P=0.000$) (38).

Given the physiological complications and psychological, social, and economic effects of VAP, it is necessary to perform interventions to reduce its incidence. According to the hypothesis confirmed in this study, tooth brushing twice a day with distilled water, in addition to performing routine oral hygiene, reduces the incidence of VAP in patients and is recommended as a part of the

routine care provided to patients. Moreover, it should be noted that one of the inclusion criteria in this study was the possession of at least 20 teeth, which has not been studied in other studies and is considered the strength of this study. Further studies are also needed to compare the effect of tooth brushing with distilled water with that of tooth brushing with chlorhexidine, on the incidence of VAP in patients admitted to the ICU.

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