

Comparison of Oropharyngeal and Respiratory Nosocomial Bacteria between Two Methods of Oral Care: A Randomized Control Trial

Porównanie występowania bakterii szpitalnej w gardle środkowym i górnych drogach oddechowych przy zastosowaniu dwóch metod pielęgnacji jamy ustnej: badania na próbie losowej

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Abstract

Introduction. To compare changes in oral and respiratory nosocomial colonization during the first week of mechanical ventilation in adult Neuroscience ICU patients randomized to a standard or comprehensive oral care protocol. Development of ventilator associated pneumonia (VAP) within each protocol was also investigated.

Material and methods. Patients were randomized to one of two groups. The standard oral care protocol included a manual pediatric toothbrush, toothpaste, and water-soluble lubricant. The comprehensive protocol consisted of tongue scraping, an electric toothbrush with a non-foaming toothpaste, followed by a moisturizing agent. Both groups received the assigned oral care protocol twice daily, with tooth brushing lasting two minutes per occasion. Oral and sputum cultures were obtained on admission and every 48 hours while intubated.

Results. Data from a total of 78 patients were analyzed. The standard protocol included 40 patients (mean age 51 ± 18 years); the comprehensive protocol 38 patients (mean age 51 ± 18 years). No significant differences in Glasgow Coma Score, diagnosis, or co-morbidities were found on admission. Oral colonization on admission was noted in 25% of patients in each protocol. There was a trend of reduced oral and respiratory nosocomial colonization among those in the comprehensive protocol but no significant differences were noted between groups. Incidence of VAP was equivalent (p=0.61) for the standard and comprehensive groups at day six.

Conclusions. Use of a tongue scraper, electric toothbrush, and oral gel resulted in less oral and respiratory colonization by known nosocomial pathogens. Larger studies are necessary to further investigate comprehensive oral care. (PNN 2012;1(1):10-18)

Key words: neuroscience intensive care patients, nosocomial bacteria, ventilator associated pneumonia

Streszczenie

Wprowadzenie. Porównanie zmian wywołanych bakterią szpitalną w obrębie jamy ustnej i górnych dróg oddechowych podczas pierwszego tygodnia wentylowania u dorosłych pacjentów neurologicznych, przebywających na oddziale intensywnej opieki medycznej, losowo wybranych do pielęgnacji jamy ustnej w sposób standardowy lub rozszerzony. Zbadanie przypadków odrespiratorowego zapalenia płuc w obu metodach zachowania higieny jamy ustnej.

Materiał i metody. Pacjenci zostali losowo przydzieleni do jednej z dwóch grup. Standardowy sposób postępowania w pielęgnacji jamy ustnej polegał na zastosowaniu tradycyjnej dziecięcej szczoteczki do zębów, pasty do zębów i rozpuszczalnego w wodzie środka nawilżającego. Metoda rozszerzona polegała na szczotkowaniu języka, z zastosowaniem elektrycznej szczoteczki do zębów niepieniącą się pastą oraz środka nawilżającego. U każdej z grup przypisaną metodę stosowano dwa razy dziennie, każdorazowo szczotkując zęby przez 2 minuty. Przy przyjęciu na oddział oraz co 48 godzin pobierano od zaintubowanych pacjentów próbki śliny i wymaz z jamy ustnej w celu zbadania kultur bakterii.

Wyniki. Analizie poddano wyniki 78 pacjentów. Standardowy sposób postępowania w higienie jamy ustnej zastosowano u 40 pacjentów (średni wiek 51-18 lat), natomiast rozszerzony u 38 pacjentów (średni wiek 51-18 lat). W chwili przyjęcia na oddział nie zaobserwowano statystycznie istotnych różnic w skali śpiączki Glasgow (*Glasgow Coma Scale*), diagnozie ani współwystępujących chorobach. Bakterie w jamie ustnej w chwili przyjęcia na oddział zaobserwowano u 25 % pacjentów w każdej z dwóch grup. Zauważono tendencję spadkową w odniesieniu do liczby szpitalnych bakterii w jamie ustnej i układzie oddechowym u pacjentów przypisanych do metody rozszerzonej, ale nie znaleziono znaczących różnic pomiędzy grupami. W szóstym dniu odsetek odrespiratorowego zapalenia płuc w obu grupach (standardowej i rozszerzonej) był taki sam ($p=0,61$).

Wnioski. W wyniku zastosowania szczoteczki do języka, szczoteczki elektrycznej oraz żelu do higieny jamy ustnej liczba bakterii szpitalnych atakujących jamę ustną i układ oddechowy była mniejsza. Potrzebne są szersze badania w celu dalszego zbadania działania rozszerzonej metody zachowania higieny jamy ustnej. (PNN 2012;1(1):10-18)

Słowa kluczowe: neurologiczni pacjenci oddziału intensywnej terapii, bakterie szpitalne, odrespiratorowe zapalenie płuc

Introduction

Acutely ill neuroscience intensive care patients (NICU), unable to protect their airway due to underlying pathology, paralytic agents, or both, require intubation and ventilation. Ventilator associated pneumonia (VAP) may develop within 48 hours of intubation and mechanical ventilation and is frequently associated with aspiration of colonized oropharyngeal secretions [1,2]. The aspiration of colonized oropharyngeal secretions has been identified as a key component in the early onset of VAP, i.e., developing within days of mechanical ventilation [3]. Among patients with VAP, the estimated mortality rate is between 20% and 70% with an estimated median hospital cost of \$76,730 to \$135,795 per case of VAP [4,5]. Therefore, strategies to reduce the incidence of VAP play an important role in patient care and health care consumption costs.

Oral health deteriorates during intubation [2,6,7]. While oral endotracheal intubation is often required for patients as a lifesaving measure, the presence of the artificial airway predisposes the patient to complications from poor oral hygiene such as the proliferation of oral pathogenic bacteria [8-10]. Epidemiological studies have addressed the role of oral bacteria in respiratory infections and suggest that nosocomial pathogens colonize the oral cavity prior to entering the lower respiratory tract [11]. Within 48 hours of admission to health care facilities, the composition of oropharyngeal flora changes to predominately gram-negative organisms, including potential VAP pathogens [12,13]. Dental plaque has been identified as a key site for growth of pathogenic nosocomial bacteria and disruption of such plaque via oral care may reduce oral bacteria prevalence [13].

Left untreated, accumulation of dental plaque results in gingival inflammation [14,15] and together with accumulation of debris along the dorsum of the tongue, such changes have been identified as risk factors in the development of pneumonia [16,17]. The mouth, having to remain open and exposed to ambient air during intubation, quickly becomes xerostomic due to lack of normal salivary flow and lubrication of tissues with a conversion from healthy mixed flora to nosocomial flora [3,18]. With increasing recognition of good oral health, methods of oral care have come under increased scrutiny as a means to prevent the occurrence of VAP and promote patient comfort.

Intubated patients present a nursing challenge in performing oral care because of the physical barriers and limited access to the oral cavity [7]. Given the deterioration in oral health during intubation and the associated complications such as pneumonia, investigations to determine best oral care practices are necessary [19]. Development and implementation of a comprehensive oral care protocol was recommended by the Center for Disease Control [20] for improving oral hygiene for patients who are at high risk for health-care associated pneumonia, but gave little guidance for the development of such protocols. The deterioration of oral health and resulting pathogenic consequences have spawned a number of clinical investigations aimed at reducing VAP through interventions such as oral decontamination, the use of silver-coated endotracheal tubes, and suggested standard protocols for oral care [21-23]. However, the role of oral care protocols on changes in microbial flora over time of intubation remains unclear. Understanding the impact of oral care interventions on the composition and changes in oral flora may have a role in preventing or reducing the development of nosocomial pneumonia.

Given the deterioration in oral health during intubation, an analysis of nosocomial colonization of the oropharynx and respiratory secretions among patients receiving different oral care protocols is needed. Implementation of a comprehensive oral care protocol that supports dental, mucosal, and tongue hygiene may prove beneficial in reducing pathogenic oral bacteria during the time of intubation. Therefore, we compared changes in nosocomial oral and respiratory bacteria during intubation from admission through the first week of hospitalization in adult NICU patients randomized to a standard or comprehensive oral care protocol. The frequency of VAP within each protocol was also investigated.

Material and methods

This was a randomized controlled trial (RCT) comparing the effects of two oral care protocols on oral and respiratory nosocomial flora and VAP rates during the first week of intubation among patients in a NICU. The study was approved by the Institutional Review Board of St. Joseph's Hospital and Medical Center, Phoenix, Arizona. It was conducted in accordance with the Helsinki Declaration of 2008 and registered at ClinicalTrials.gov (NCT 00518752). Informed consent was obtained from each patient's next-of-kin.

Sample and setting

All patients aged 18 years and older, intubated within 24 hours of admission to the NICU between August 2007 and August 2009 at a tertiary medical center in the southwestern United States were eligible for study inclusion. Exclusion criteria were pregnancy, age under 18 years old, an edentulous state, facial fractures or trauma affecting the oral cavity, unstable cervical fractures, anticipated extubation within 24 hours, or a grim prognosis. We also excluded patients transferred from health care facilities where they had been admitted for more than 24 hours.

Patients were randomized into one of two oral care methods, standard or comprehensive, using a computer-generated randomization list maintained in a separate locked cabinet from enrollment forms to prevent manipulation of eligibility judgments. After obtaining consent, patients were assigned the next available number for enrollment from the randomization list. Patients analyzed were those with documented oral and sputum samples upon enrollment and every 48 hours thereafter during the first six days of hospitalization or until extubation, whichever came first.

Procedure

The products used in the standard oral care group consisted of a manual pediatric toothbrush, toothpaste

containing standard 1000 parts per million fluoride with sodium lauryl sulfate (a common detergent agent), and a biologically inert, water-based, water-soluble lubricant as the moisturizing agent for oral mucosa and lips (K-Y Jelly®, Johnson & Johnson, New Brunswick, New Jersey, USA). Patients randomized to the comprehensive oral care method underwent tongue scraping using a low-profile tongue scraper with a posterior to anterior sweeping motion across the dorsal surface of the tongue. Scraping was followed by tooth brushing with an electric toothbrush (Oral B Vitality® toothbrush, Newark, New Jersey, USA). Teeth were brushed with Biotene® toothpaste, a non-foaming toothpaste containing Sodium Monofluorophosphate. Following brushing, a liberal application of Oral Balance® was applied as the moisturizing agent for oral mucosa and lips (Biotene® and Oral Balance® are products from Glaxo-SmithKline, Moon Township, Pennsylvania, USA). For both groups, the assigned toothbrush protocol was performed twice daily and tooth brushing lasted two minutes on each occasion. Educational sessions teaching each protocol were provided for all staff nurses of the NICU.

Oral microbial samples were obtained upon patient enrollment within 24 hours of admission to the NICU by one of the nurse research assistants. A sterile, cotton-tipped applicator was rubbed along the buccal gingival margin of posterior teeth of the lower jaw. Sputum samples were obtained by a respiratory therapist at the corresponding time of oral cultures in standard fashion. Oral and sputum cultures were obtained every 48 hours while intubated.

Reliability testing for chest x-ray interpretation was established by a pre-trial pilot of 20 chest x-rays with two board certified pulmonary critical care physicians. During the trial, these same two physicians, blinded to group assignment, interpreted all chest radiographs. All chest x-ray interpretations were conducted in a darkened room and viewed on the hospital's radiographic data base. At each viewing, each subject's radiograph was judged on a yes/no category on the presence of the following criteria: clear, infiltrate, atelectasis, and effusion. Infiltrate occurring more than 48 hours after admission was the only radiographic criterion used for the diagnosis of pneumonia [20,24].

Data collection

The demographic data collected from the patient's chart included age, gender, admission diagnosis, co-morbidities, and tobacco use. The Glasgow Coma Scale (GCS) score was used at enrollment as a global indicator of neurological impairment. The presence of an endotracheal tube with subglottic secretion suctioning was noted, with number of days intubated and ICU length of stay recorded. Oral and sputum culture

swabs were plated on the following agar media: blood, chocolate, and MacConkey. All three agar plates were incubated in CO₂ at 35° C. After 48 hours, technicians interpreted the plates using the Gram Stain technique and bacteria counts were expressed as colony forming units (cfu) and bacterial identification was reported.

Data Analysis

All data were analyzed with SPSS version 17.0 (SPSS Inc., Chicago, IL, USA). Variables were checked regarding assumptions underlying parametric and nonparametric statistics, described and analyzed accordingly. The Student's t test was used to compare mean scores. The Chi-square test with Fisher's Exact test was used for comparing between protocol differences in categorical variables. Friedman's test was used to analyze repeated measures of bacterial nosocomial colonization at each time point between and among the standard and comprehensive oral care groups. For hypothesis testing, the alpha level of significance was set at 0.05 (two-tailed).

The source of bacterial analyses, i.e., oral or respiratory, and group assignment, was noted from samples obtained on day of admission, followed by days two, four, and six while intubated. Nosocomial bacteria were categorized in the following four groups: *Staphylococcus aureus* (*S. aureus*); Klebsiella, Enterobacter, and Serratia (KES) were reported as one group; Pseudomonas; and other gram negative bacteria (GNB) was used if multiple species were detected.

Oral and sputum bacterial counts for each time point were performed by the microbiology department. Samples with none to 10² cfu bacteria were coded as non-colonized; samples with 10³⁻⁴ cfu were coded as colonized. Based on the admission oral culture, patients in each oral care protocol were further divided into colonized or non-colonized groups. With the oral care protocol and colonization as the assignment variable, each bac-

terial species was then compared every 48 hours thereafter during the first week of intubation. The interrater agreement between the two pulmonary critical care physicians was analyzed using the Kappa measure of agreement. VAP was defined with documentation of a new or progressive pulmonary infiltrate together with two or three of the following criteria: fever, leukocytosis, or purulent tracheobronchial secretions [20].

Results

There were 78 patients randomized to standard or comprehensive oral care with nosocomial bacterial analysis of oral and sputum cultures from admission through day six of intubation (Fig. 1).

The sample consisted of 40 patients aged 51 ± 18 years old (mean ± SD) in the standard protocol and 38 patients aged 54 ± 18 years old (mean ± SD)

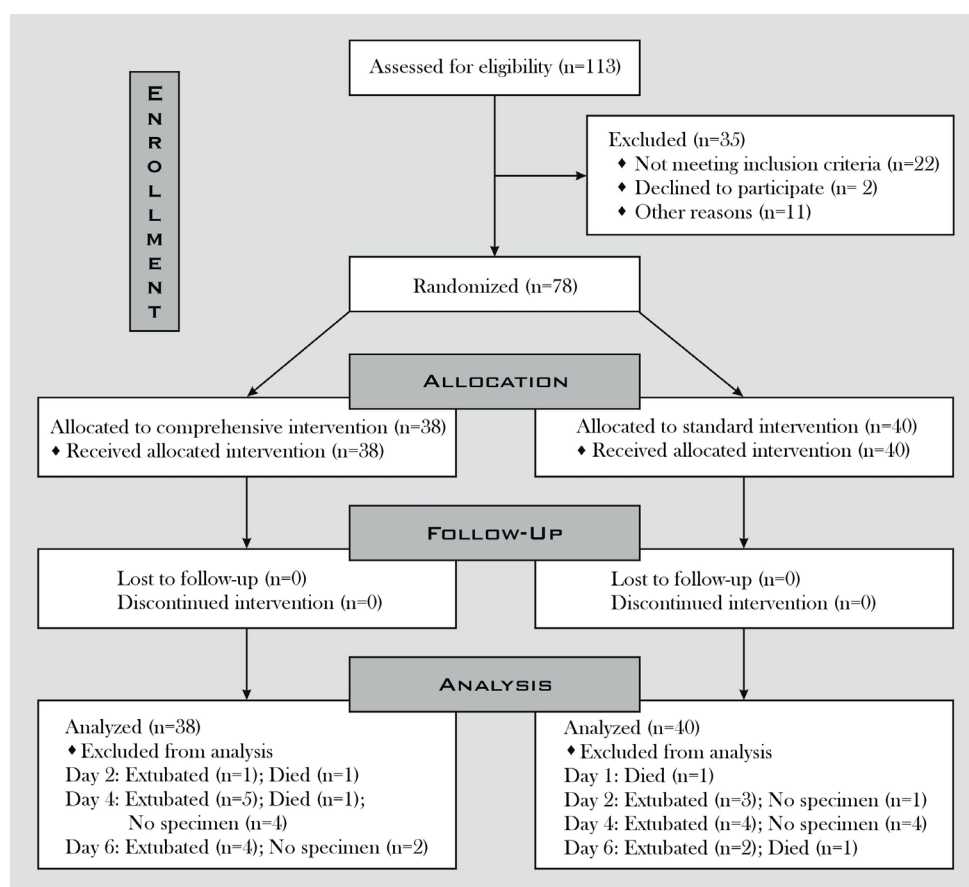


Figure 1. CONSORT Flow Diagram of Study Participants

in the comprehensive protocol (Table 1). Baseline demographics of gender, admission diagnosis, and admission GCS were similar in both groups. There were no significant differences in co-morbidities of cardiac, respiratory, diabetes, or other secondary diagnoses ($p=0.41$). No significant differences in tobacco use were detected. Total number of days intubated was the

same for patients in both groups ($p=0.62$). The length of stay in the ICU was not significantly different for either group ($p=0.70$). There was no difference in disposition between groups, i.e., less than 10% in each group discharged to home; 70% to acute or sub-acute rehabilitation; approx 20% died or transferred to hospice ($p=0.90$). Protocol compliance was monitored daily by research assistants not involved in the bedside care and exceeded 91% for both groups. The Kappa coefficient, used as the measure of agreement between the two physicians, was 0.84. The prevalence of oral

nosocomial colonization was approximately 25% on admission for patients in both oral care protocols.

On admission, the non-colonized oral cultures of patients in both protocols exhibited conversion to nosocomial colonization for all bacterial species on days two, four, and six (Table 2). While there were no significant differences between groups for any bacterial species over time, we observed a trend towards greater oral and respiratory colonization in patients treated with the standard oral care protocol compared to the comprehensive protocol group for all bacterial counts.

Table 1. Clinical Summary of Patients at enrollment, $n=78$

Variable	Comprehensive $n=38$		Standard $n=40$		P value
Age (years), mean (SD; min–max)	54	(17.8; 19-87)	51	(18.4; 18-85)	0.55 ^a
Gender					0.50 ^b
Male, n	19		23		
Female, n	19		17		
Smoking					0.89 ^b
No, n	28		30		
Yes, n	10		10		
Admission Diagnosis					0.26 ^b
Hemorrhagic Stroke	13		20		
Closed Head Injury	8		6		
Other*	17		14		
Co-morbidity					0.41 ^b
None	9		8		
Diabetes	7		3		
Cardiac disease	17		18		
Respiratory	1		3		
Other**	4		7		
Admission GCS ^c					0.28 ^b
Severe, n	24		27		
Moderate, n	14		11		
Mild, n	0		2		
Hi-Lo Evac [®] ^d endotracheal tube					0.97 ^b
No, n	22		23		
Yes, n	16		17		
Total number of days intubated, mean (SD; min–max)	8	(4; 2-19)	8	(4; 3-18)	0.62 ^a
Length of stay in the ICU (days), mean (SD; min–max)	16	(8.3; 4-39)	18	(9.4; 3-39)	0.70 ^a

^a Student's t-test

^b Chi-square test

*Other = brain tumor, seizure

**Other = renal, metabolic, misc

^c Glasgow Coma Scale: possible score range 3–15 (15 = no impairment of consciousness) Severe (sum score 3–8) Moderate (sum score 9–12) Mild (sum score 13-15)

^d The Hi-Lo Evac[®] endotracheal tube has a separate dorsal lumen for continuous aspiration of subglottic secretions

For example, *S. aureus* was detected in all oral cultures in both groups except day six for the comprehensive group. Moreover, no lower respiratory tract colonization of *S. aureus* was detected in the comprehensive group at any time point. While the oral prevalence of KES organisms was equivalent in both groups, there

on admission and days two, four, and six (Table 3). Despite the lack of statistically significant differences between protocol assignments at any time point for oral or respiratory colonization, there were a number of important clinical observations. Colonization of *S. aureus* was detected in the standard protocol group

Table 2. Admission Non-colonized Oral Specimens with Conversion to Nosocomial Colonization *

		Standard				Comprehensive			
		Admission	Day 2	Day 4	Day 6	Admission	Day 2	Day 4	Day 6
		No. positive samples n=29	No. positive samples n=26	No. positive samples n=20	No. positive samples n=18	No. Positive samples n=28	No. positive samples n=27	No. positive samples n=18	No. positive samples n=12
S. aureus, n	Oral	--	3	1	2	--	3	1	0
	Respiratory	--	2	1	0	--	0	0	0
KES, n	Oral	--	1	2	5	--	1	2	3
	Respiratory	--	0	1	0	--	1	0	2
Pseudo., n	Oral	--	2	2	2	--	1	1	1
	Respiratory	--	0	0	2	--	0	0	1
GNB, n	Oral	--	7	7	8	--	3	7	7
	Respiratory	--	1	1	3	--	2	0	4
VAP, n		--	2	4	7	--	3	4	5

*Some patients had more than one organism

S. aureus = *Staphylococcus aureus*; KES = Klebsiella, Enterobacter, and Serratia; Pseudo = pseudomonas; GNB = gram negative bacteria

VAP= ventilator associated pneumonia

was a trend of fewer reported oral bacteria in the comprehensive group with fewer respiratory bacteria in the standard oral care group. Similarly, oral colonization with pseudomonas was detected in both oral care groups with a trend of fewer bacteria in the comprehensive oral care group. Despite the oral colonization with pseudomonas, the organism was not detected in the respiratory samples for patients in either group

in both oral and respiratory samples from admission through day six. In comparison, within the comprehensive oral care protocol, *S. aureus* was present in the admission oral culture only, and respiratory samples from admission revealed a trend of decreasing frequency through day four with none detected at day six. While KES appeared more prevalent in the oral samples within the comprehensive care group compared to

Table 3. Admission Nosocomial Colonized Oral Specimens *†

		Standard				Comprehensive			
		Admission	Day 2	Day 4	Day 6	Admission	Day 2	Day 4	Day 6
		No. positive samples n=10	No. positive samples n=9	No. positive samples n=7	No. positive samples n=6	No. Positive samples n=10	No. positive samples n=9	No. positive samples n=8	No. positive samples n=8
S. aureus, n	Oral	5	1	2	1	2	0	0	0
	Respiratory	5	2	2	1	4	2	2	0
KES, n	Oral	3	1	0	1	4	3	4	3
	Respiratory	0	0	0	0	0	0	0	0
Pseudo., n	Oral	0	0	0	0	0	0	0	1
	Respiratory	0	0	0	0	0	1	0	0
GNB, n	Oral	7	5	2	2	8	4	4	4
	Respiratory	3	0	0	0	8	1	2	0
VAP, n		--	3	4	3	--	2	4	3

*Moderate to heavy growth on admission oral culture

†Some patients had more than one organism

S. aureus = *Staphylococcus aureus*; KES = Klebsiella, Enterobacter, and Serratia; Pseudo = pseudomonas; GNB = gram negative bacteria

VAP= ventilator associated pneumonia

protocol until day six. Gram negative bacteria, present in oral samples from day two through day six in both groups, was not found to be significantly different between groups at any time.

Patients with oral nosocomial colonization on admission were compared for between group differences

the standard group, no detection of KES was noted in the sputum of either oral care group. Pseudomonas was not detected in any samples from the standard oral care group. Pseudomonas was reported once in the sputum sample (day two) and once in the oral specimen (day six) within the comprehensive oral care protocol group.

Oral samples were colonized with GNB in both protocol groups through day six and in sputum samples through day four of the comprehensive care group.

There was no significant difference in the development of VAP and oral colonization between oral care protocols at any time point for days two through six ($p=0.61$). Among those not colonized on admission, VAP rates on days two, four, and six were 8, 20, and 39% respectively in the standard group and 11, 22, and 42% in the comprehensive group. This is in contrast to the colonized group where VAP rates on days two, four, and six for the standard protocol were 33, 57, 50% for the standard group and 22, 50, and 38% for the comprehensive protocol. There were less than 11 patients in either group at each time point. Administration of antibiotics was analyzed for a possible relationship to colonization trends for both groups with a VAP diagnosis. No significant differences were detected in the number of patients with VAP receiving antibiotics and oral nosocomial colonization between groups on days two, four, or six (data not shown).

Discussion

In this study, the standard and comprehensive oral care groups were evenly matched on salient demographic characteristics. Furthermore, both groups underwent episodes of tooth brushing for two minute twice daily as an intervention. A key finding from the study suggests that among those randomized to the comprehensive oral care protocol, there was no respiratory colonization of *S. aureus* over time. This finding is intriguing since *S. aureus* is common in patients with neurological diseases [11]. In addition, fewer patients in the comprehensive protocol developed nosocomial oral colonization over time, and while not statistically significant, this trend suggests that intubated patients may benefit from a comprehensive oral care protocol including mechanical cleansing. Needleman et al. [25] reported significant decrease in dental plaque with a powered toothbrush used four times a day compared to foam swabs soaked in Chlorhexidine (CHX) and suggested further studies with mechanical debridement as part of VAP reduction strategies be conducted. Furthermore, the mechanical removal of dental plaque and tongue coating debris may allow for future refinements in oral care protocol interventions such as the use of antiseptic rinses [26].

While no significant differences were found in oral nosocomial colonization between groups, two minute episodes of toothbrushing twice daily in both protocols may have contributed to the reduction of respiratory colonization noted in both groups over time. Since the presence of nosocomial oral colonization

has been associated with development of nosocomial pneumonia [27] efforts to delay or minimize such conversion seem logical, as nosocomial colonization of the oropharynx has been identified as a risk factor for early occurrence of VAP [28]. While there was no significant difference in VAP rates in our investigation, the study was underpowered due to limited resources and no conclusions can safely be made due to the small sample size.

Mechanical debridement of the tongue and tooth surfaces is not the only intervention explored as a means to reduce the oral bioburden of pathogenic bacteria. The concept of oral decontamination to decrease VAP with such products as CHX, providone-iodine and other antiseptic rinses has been studied with mixed results on duration of ventilation and survival. In a meta-analysis by Pineda & Saliba et al. [29], the use of CHX did not significantly reduce the rate of VAP nor the mortality rate. However, in a multifaceted VAP reduction trial of 112 ICUs, a significant decrease of VAP rates was sustained for a two year period yet no oral care protocol was identified as one of the variables investigated [30]. Few studies have explored various oral care protocols that highlight the actual care methodology.

The findings from this analysis must be interpreted with caution given the sample size. Furthermore, limitations include the neuroscience patient population which may not reflect patients in surgical, medical, cardiac or pediatric settings. Since the study was conducted at one institution, generalizations to other patient populations warrant additional exploration. Despite these study limitations, the findings have significant implications for oral care protocols. While antiseptic-rinses may have a role in oral care protocols, mechanical aspects of tooth brushing cannot be ignored.

Changes in oral and respiratory flora during the time of endotracheal intubation are important to define for best practices for oral hygiene among critically ill, intubated patients. Nosocomial bacterial species have been found to be genetically indistinguishable from tracheal aspirates underscoring the fact the teeth, tongue, and gingival margins may be reservoirs of bacteria responsible for nosocomial pneumonia [31]. It follows that a comprehensive oral care protocol directed towards promotion of oral health is an effective means to reduce the burden of nosocomial organisms. Improved oral hygiene may result in decreased risk of VAP thereby improving patient outcomes and decreasing hospital health care costs. Future studies need to expand the target populations of patients receiving such a protocol for patients in a variety of ICUs. And when applicable, focus should

also include pre-operative oral hygiene protocols for patients that are expected to require intubation during the post-operative time period.

Conclusions

Use of a tongue scraper, electric toothbrush, and oral gel resulted in less oral and respiratory colonization by known nosocomial pathogens. Larger studies are necessary to further investigate comprehensive oral care.

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