

Oral Health, Ventilator-Associated Pneumonia, and Intracranial Pressure in Intubated Patients in a Neuroscience Intensive Care Unit

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Am J Crit Care. 2009;18: 368-376 doi: 10.4037/ajcc2009621

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ORAL HEALTH, VENTILATOR-ASSOCIATED PNEUMONIA, AND INTRACRANIAL PRESSURE IN INTUBATED PATIENTS IN A NEUROSCIENCE INTENSIVE CARE UNIT

By Virginia Prendergast, RN, MSN, NP, Ingalill Rahm Hallberg, RNT, PhD, Heidi Jahnke, RN, MSN, Cindy Kleiman, BS, RDH, and Peter Hagell, RN, PhD

Background Although oral health affects systemic health, studies of oral health during intubation among critically ill neuroscience patients are lacking. Furthermore, the effect of oral care on intracranial pressure among critically ill patients in a neuroscience intensive care unit is unknown.

Objectives To describe changes in oral health and development of ventilator-associated pneumonia during intubation among patients in a neuroscience intensive care unit and to assess the influence of oral care on intracranial pressure.

Methods Data on 45 consecutive intubated patients admitted to a neuroscience intensive care unit during 1 year were collected by using oral cultures and the Oral Assessment Guide throughout intubation and 48 hours after extubation. Occurrence of ventilator-associated pneumonia and intracranial pressures associated with oral care were recorded.

Results Oral health, assessed by the Oral Assessment Guide, deteriorated significantly during intubation and improved to almost baseline levels 48 hours after extubation. During intubation, occurrence of oral gram-negative bacteria and yeast increased. The incidence of ventilator-associated pneumonia was 24% among patients enrolled for 4 to 10 days. During or after 879 instances of oral care, overall intracranial pressure did not increase. Among 30 instances in which intracranial pressure was greater than 20 mm Hg before oral care, pressure decreased during and 30 minutes after the procedure ($P < .001$).

Conclusions Intubation may contribute to worsening of oral health among patients in neuroscience intensive care units. Execution of oral care does not seem to affect intracranial pressure adversely. Oral care should be explored further to promote good oral and systemic health in patients in neuroscience intensive care units and to determine its effect on ventilator-associated pneumonia. (*American Journal of Critical Care*. 2009;18:368-376)

Good oral health is reflected by a balanced mixture of gram-positive and gram-negative bacteria, functional integrity of the oropharynx, and synchronization of the swallowing mechanism. During hospitalization, pathogenic bacteria replace normal oropharyngeal flora within 48 hours and can colonize the respiratory tract.^{1,2} Teeth, gingiva, or both, which are implicated as a reservoir for respiratory pathogens, may contribute to the development of pneumonia.³ In intubated critically ill patients, endotracheal tubes and bite blocks used to protect the airway can act as vectors for the migration of pathogenic organisms if the organisms are aspirated.¹ The combination of poor oral health and airway devices may increase the risk of ventilator-associated pneumonia (VAP).^{4,5} The rates of morbidity and mortality associated with VAP range from 20% to 41% in various intensive care units (ICUs).⁶⁻⁸

Although the risk of VAP increases as the concentration of pathogenic oral bacteria increases,^{9,10} relationships between oral health and VAP in critically ill neuroscience patients have not been determined. Compared with other ICU patients, neuroscience patients are at greater risk for aspiration pneumonia associated with acute changes in mental status, dysphagia, and traumatic brain injury.^{5,8,11} For example, stroke patients with confirmed videofluoroscopic evidence of aspiration had a 20-fold increase in pneumonia compared with stroke patients who were nonaspirators.¹²

Among intubated, critically ill patients, airway devices can hinder close inspection of the oropharynx and impede nursing assessment of the mouth. Assessment is an integral component of nursing care, but systematic assessments of oral health among intubated patients are rare. The Oral Assessment Guide (OAG)¹³ was originally developed to evaluate oral health among oncology patients. Because of the reliability and validity of the OAG, use of the guide has been broadened to include the evaluation of oral health among the elderly and other hospitalized

patients.¹⁴⁻¹⁶ Alterations in mental status may make neuroscience ICU (NICU) patients particularly susceptible to deterioration in oral health. In addition, the use of diuretic and narcotic intravenous medications results in xerostomia.^{10,17} Additional pharmacological therapies used to induce paralysis or coma for cerebral protection suppress normal cough and gag mechanisms necessary for airway protection. Consequently, NICU patients are orally intubated for airway protection and pulmonary support.^{2,18,19} Although oral health is recognized as an important factor in the care of ICU patients,²⁰ oral health among intubated NICU patients has not been studied.

Critical care nurses must anticipate the effects of general nursing care, including oral care, on intracranial pressure (ICP). ICP values greater than 20 mm Hg reflect increased pressure.²¹ ICP reflects cerebral dynamics, and trends of increases in ICP are important indicators of deteriorating intracranial compliance; that is, increases in ICP may herald a worsening clinical status or outcome.²² Cutler and Davis²³ observed 253 ICU patients receiving oral care, including an unspecified subset of neurological patients, but changes in ICP and occurrence of adverse neurological responses during the provision of oral care were not determined. Nurses may be reluctant to perform oral care in NICU patients because of concerns about increasing the ICP. However, whether oral care affects ICP has not been established.

We investigated changes in oral health, as indicated by the OAG; the occurrence of oropharyngeal microbial flora; and the frequency of VAP in orally intubated NICU patients throughout the period of intubation and 48 hours thereafter. The effect of

Normal oropharyngeal flora converts to pathogenic bacteria within 48 hours.

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oral care on patients' ICP during and after completion of oral care was also assessed.

Methods

The study was approved by the appropriate institutional review board and was conducted in accordance with the Helsinki Declaration of 1975.

Informed consent was obtained from patients' next of kin.

Sample and Setting

During this 1-year study, all patients admitted to a 16-bed NICU in a 517-bed level I trauma center in the US Southwest were screened for enrollment. The hospital is a regional referral center for critically ill neuroscience patients. The most common diagnoses are acute stroke, traumatic

brain injury, and brain tumor. The NICU registered nurse to patient ratio was 1 to 1 or 1 to 2.

The names of all patients admitted to the NICU were recorded in a notebook maintained at the nurses' station. Each day, all new admissions during the previous 24 hours were screened for possible enrollment. Patients were eligible if they were 18 years or older, were intubated within 24 hours of admission to the NICU, and had a family member available to sign informed consent forms. Patients were excluded if they had fewer than 6 teeth, facial fractures or oral trauma, unstable cervical fractures, expected extubation within 48 hours, or life expectancy less than 48 hours. Because of the possibility of preexisting heavy oropharyngeal colonization,²⁴ patients already admitted to the hospital or those living in a nursing home or rehabilitation facility longer than 48 hours before admission to the NICU were also excluded. Patients were followed up throughout the period of intubation and for 48 hours after extubation.

At the time of the study, NICU policy stipulated that oral care be provided every 4 to 6 hours and as needed for comatose patients. The oral care regimen, determined at the discretion of each patient's nurse, consisted of using a child's toothbrush or foam swabs, fluoridated toothpaste, sterile water or normal saline for

rinsing the mouth, and lip lubricant. Nurses recorded when oral care was administered but not whether a toothbrush or foam swab was used. Actual times required for oral care were not recorded; estimated times were 5 to 10 minutes.

Oral care was provided by each patient's bedside nurse on the basis of the patient's ICP and on the nurse's individual practice pattern in determining if the patient could tolerate additional stimulation. ICP was monitored via an external ventricular drainage system among a subset of patients who had a secondary diagnosis of increased ICP.

Procedure

Three nurses, none of whom were involved in the bedside care of the patients, collected the data and performed the oral assessments. Admission data included patients' age, sex, and diagnosis at the time of admission. Score on the Glasgow Coma Scale, presence of an ICP monitor, medications, elevation of the head of the bed, body temperature (highest/lowest), white blood cell counts, color and quantity of sputum secretions, and length of stay in the NICU and at the hospital were recorded daily. The results of chest radiographs obtained with portable machines, as interpreted by staff radiologists, were also recorded.

The occurrence of VAP any time beyond 72 hours after admission was determined on the basis of the presence of the following 4 established criteria^{19,25,26}: abnormal white blood cell counts (leukocytosis, $>12\,000/\mu\text{L}$; or leukopenia, $<4000/\mu\text{L}$); body temperature, $<36.6^\circ\text{C}$ or $>38.5^\circ\text{C}$; purulent pulmonary secretions; and reported findings on chest radiographs. A diagnosis of probable VAP was recorded if 3 of the 4 criteria were met; when all 4 criteria were met, the diagnosis was definite VAP.

Oral health was evaluated every 72 hours by using the OAG,¹³ an assessment based on 8 items: voice, swallow, lips, tongue, saliva, mucous membranes, gingiva, and teeth. Teeth were assessed by swabbing a solution of vegetable dye on tooth surfaces and then inspecting the surfaces for biofilm or debris by using a hand-held dental mirror. Each item of the OAG is rated on a 3-point scale: 1, normal finding; 2, a mild change; and 3, marked compromise. Because patients were intubated, the voice item was omitted. Consequently, total OAG scores could range from 7 (excellent oral health) to 21. The total OAG score was used as the primary measure of oral health, but item-level data were also examined for exploratory purposes.

Before data collection, the 3 data collectors were trained in oral assessment by a registered dental hygienist. Overall, OAG interrater percentage of agreement between the 3 data collectors and the hygienist exceeded 85% for assessments performed on 10 patients before data collection began. OAG scores from all 4 raters yielded a

Neuroscience ICU patients are susceptible to deterioration in oral health due to mental status changes.

Oral health deteriorated during intubation but improved almost to baseline by 48 hours after extubation.

coefficient of concordance (Kendall's W)²⁷ of .76. Among the 3 nurse raters, Kendall's W was also .76.

Oral samples for culturing, obtained every 72 hours in conjunction with the OAG, were acquired by rubbing a sterile swab along the lower gingival margin. Each swab was used to inoculate 3 petri plates; each plate contained a different growth medium: blood agar, chocolate agar, or McConkey agar.² All 3 plates were incubated in 7% to 10% carbon dioxide at 35°C. After 48 hours, samples of growth on the plates were examined by using Gram stains, and growth on each plate was described as none, light, moderate, or heavy. For the purpose of this study, microorganisms were reported as present or absent. Organisms were classified as gram-positive bacteria, gram-negative bacteria, or yeast.

The frequency of oral care during each 24-hour period was recorded directly from the nurses' notes, reflecting the time that oral care was administered. The nursing staff was informed that data from the chart were being collected but were unaware that information about the frequency of oral care was also recorded.

A baseline OAG score and an oral sample for culture were obtained from each patient at the time of enrollment in the study. Every 72 hours thereafter, an OAG assessment was performed and an oral sample for microbial cultures was collected until the patient was extubated or underwent a tracheostomy. Approximately 48 hours after extubation/tracheostomy, assessment with the OAG was repeated and another oral sample for culture was obtained.

For patients with intracranial monitors, ICP values were obtained from external ventricular drainage systems that were closed every 30 minutes to obtain the ICP value. The value was recorded by the bedside nurse. These recorded ICP values were obtained from the computerized record of vital signs for 3 time periods, 30 minutes before, during, and 30 minutes after, for each documented performance of oral care.

Data Analysis

Data were analyzed by using SPSS, version 14.0 (SPSS Inc, Chicago, Illinois). The level of significance was set at $\alpha = .05$ (2-tailed). Variables were checked regarding assumptions underlying parametric and nonparametric statistics and were described and analyzed nonparametrically if assumptions for parametric statistics were not met.²⁷ Because few patients were intubated longer than 10 days, observations beyond this time were not included in the analyses. The VAP criteria (ie, temperature, white blood cell counts, pulmonary secretions, findings on chest radiographs) were collapsed into 2 groups for subse-

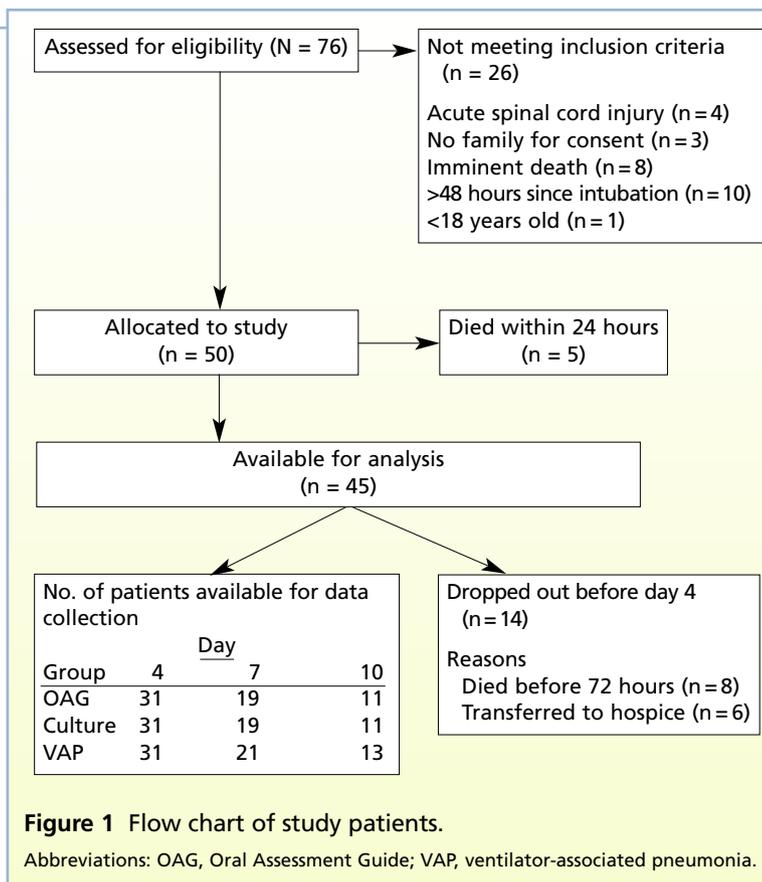


Figure 1 Flow chart of study patients.

Abbreviations: OAG, Oral Assessment Guide; VAP, ventilator-associated pneumonia.

quent analyses; the groups were no VAP (0-2 criteria met) and possible/probable VAP (3-4 criteria met). Presence or absence of microorganisms and classification (gram-positive bacteria, gram-negative bacteria, or yeast) were reported for each time point.

Results

Of the 76 intubated patients screened on admission, 50 were eligible for the study (Figure 1). Of these, 45 (21 men, 24 women) were enrolled (Table 1). According to admission scores on the Glasgow Coma Scale, injuries were moderate (51%) or severe (49%). Of the 45 patients enrolled, OAG scores and oral culture data were available for analysis for 31, 19, and 11 patients on days 4, 7, and 10, respectively (Figure 1). Because of extubation or death, 14 patients dropped out of the study before day 4. Two patients undergoing surgery were unavailable for collection of OAG scores and oral samples for culture on days 7 and 10. Data for determining VAP diagnosis were available for 31, 21, and 13 patients on days 4, 7, and 10, respectively. The mean number of days of intubation was 7. The head of the bed was elevated more than 30° in all patients at all time points. Throughout the study, patients received histamine₂ receptor antagonist

Oral care had no adverse effects on intracranial pressure.

Table 1
Characteristics of the sample (n = 45)

Characteristic ^a	Value
Age, y	
Mean (SD)	49.16 (16.2)
Range	18-85
Sex	
Male	21 (47)
Female	24 (53)
Diagnosis	
Stroke	29 (64)
Trauma	9 (20)
Brain tumor	4 (9)
Other	3 (7)
Score on Glasgow Coma Scale ^b	
Median (1st-3rd quartile)	9 (7-10)
Range	3-11
Median score 9-12 (moderate)	23 (51.1)
Median score 3-8 (severe)	22 (48.9)
Intracranial pressure monitor inserted	34 (76)
Days in neuroscience intensive care unit	
Mean (SD)	12.8 (7.5)
Range	1-31
Days in hospital	
Mean (SD)	15.1 (9.0)
Range	1-37

^a Values are expressed as number (%) of participants, unless otherwise indicated.
^b Possible score range, 3-15 (15 = no impairment of consciousness).

Table 2
Changes in total scores on the Oral Assessment Guide during intubation

	Day				P ^a
	Enrollment (n = 45)	4 (n = 31)	7 (n = 19)	10 (n = 11)	
Total score 7-21 (7 = good)					
Median	12 (11-14)	14 (13-15)	15 (12-17)	16 (14-17)	
(1st-3rd quartile)					
Range	9-16	11-17 ^b	11-20 ^b	12-20 ^b	
Items score range, 1-3, (1 = good), median (1st-3rd quartile)					
Swallow	3 (2-3)	3 (2-3)	3 (2-3)	3 (2-3)	.30
Lips	2 (1-2)	2 (2-2)	2 (2-2)	3 (2-3) ^b	.003
Tongue	2 (1-2)	2 (2-2) ^b	2 (2-3) ^b	2 (2-3)	.005
Saliva	1 (1-2)	2 (1-2)	2 (2-2) ^b	2 (1-2)	.03
Mucous membranes	1 (1-2)	2 (1-2) ^b	1 (2-2) ^b	2 (1-2)	.04
Gingiva	1 (1-1)	2 (1-2) ^b	1 (1-2)	2 (2-3) ^b	.003
Teeth	2 (2-2)	2 (2-3)	2 (2-3)	2 (2-3)	.02

^a Friedman test.

^b Significant difference from enrollment (Wilcoxon signed rank test followed by Bonferroni adjustment).

medications and 1 to 3 xerostomic medications daily. Oral care was documented for each patient a mean of 3.3 times a day.

Oral Health Assessments

During intubation, total OAG scores increased from 12 at baseline (n = 45) to 16 at day 10 (n = 11). This deterioration in oral health was significant for all time points after the day of enrollment (Table 2). This same pattern of deterioration was noted within each of the main diagnostic subgroups, that is, stroke and trauma (data not shown).

In a subset of 24 patients, OAG scores were available on enrollment, the final day of intubation, and 48 hours after extubation. On the basis of their scores, oral health deteriorated during intubation and returned almost to baseline levels 48 hours after extubation (Figure 2). Scores differed significantly across the 3 time points ($P = .004$, Friedman test), between enrollment and the last day of intubation ($P < .001$), and between the last day of intubation and 48 hours after extubation ($P = .03$, Wilcoxon signed rank test with Bonferroni corrections for multiple comparisons). Scores did not differ between enrollment day and 48 hours after extubation ($P = .68$).

Oropharyngeal Flora

On enrollment day, gram-negative bacteria were present in 22% of the 45 patients. By day 10, gram-negative bacteria were present in 50% of the remaining 11 patients (Figure 3). Of these samples, *Enterobacter* species (43%) and *Klebsiella pneumoniae* (36%) predominated. The main gram-positive bacteria identified was *Staphylococcus aureus*. Yeast, present in 4% of the patients on the day of enrollment, was present in 29% of the 11 patients on day 10.

Ventilator-Associated Pneumonia

During days 4 through 10, probable/definite VAP developed in 11 patients (24%). Among the 31 patients enrolled on day 4, a total of 8 (26%) had VAP. Among the 21 patients enrolled on day 7, a total of 7 (33%) had VAP. Finally, among the 13 patients evaluated on day 10, a total of 6 (46%) had VAP.

Intracranial Pressure

In the 34 patients (76%) with intracranial monitoring devices, ICP data were recorded 30 minutes before, during, and 30 minutes after 879 provisions of oral care. No overall differences in ICP values across these 3 time points were detected (Figure 4; $P = .24$, Friedman test). In the 849 observations in which ICP was less than 20 mm Hg 30 minutes before oral care, ICP remained at less than 20 mm Hg in all but 17 instances (2%) during oral care and in all but 16 instances (2%) 30 minutes after oral care (data not shown).

In the 30 instances in which ICP was greater than 20 mm Hg before oral care, values decreased ($P < .001$, Friedman test) over time (Figure 5A). ICP decreased to less than 20 mm Hg in 20 instances (67%) during oral care and in 23 instances (77%) 30 minutes after oral care.

Among the 13 patients whose ICP was higher than 20 mm Hg (range, 21-50 mm Hg) before oral care, 3 patients had values that remained higher than 20 mm Hg during and after oral care (Figure 5B).

Discussion

Oral Health

Oral health in NICU patients appears to deteriorate during intubation and to improve after extubation. For example, the presence of oral pathogenic bacteria and yeast increased during intubation. Furthermore, total OAG scores deteriorated during intubation and improved almost to baseline levels 48 hours after extubation. Together, these findings support the hypothesis that oral health deteriorates during prolonged intubation. Because the longer that patients are intubated, the more oral health appears to deteriorate, oral care interventions that best promote oral hygiene must be determined.

Previous experience has indicated that the OAG has adequate validity, reliability, and sensitivity.^{13,17,28} Although the OAG has not been reported as an assessment tool specifically for NICU patients, it has been used with adult ICU patients to determine the quality of oral care provided by bedside nurses.¹⁶ The OAG has also been used in children and adults with conditions as diverse as cancer, HIV infection, and dementia, and in geriatric and rehabilitation units. In all instances, OAG scores reflected deteriorations in oral health status corresponding to worsening medical condition.^{15,28,29} Although the acceptable range for the total OAG score for NICU patients is unclear, the overall total score did worsen in our patients, corresponding to the duration of intubation.

Furthermore, scores on several items (lips, tongue, saliva, mucous membranes, and gingiva) reflected worsening conditions as the duration of intubation increased. Worsening item scores have also been reported in leukemia patients undergoing chemotherapy.^{13,17} These findings suggest that scores on both individual items and the overall scale can indicate changes in oral health and provide tentative support for the usefulness of the OAG as an oral assessment tool among NICU patients.

Ventilator-Associated Pneumonia

Throughout the study, oral health steadily deteriorated while the presence of pathogenic oropharyngeal

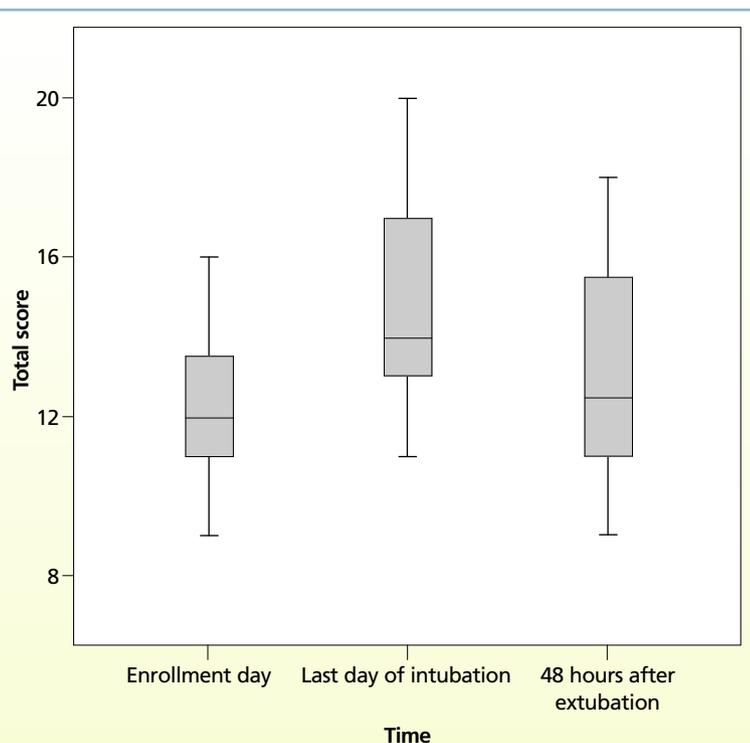


Figure 2 Changes in total scores on Oral Assessment Guide among patients with available scores on day of enrollment, last day of intubation, and 48 hours after extubation (n = 24).

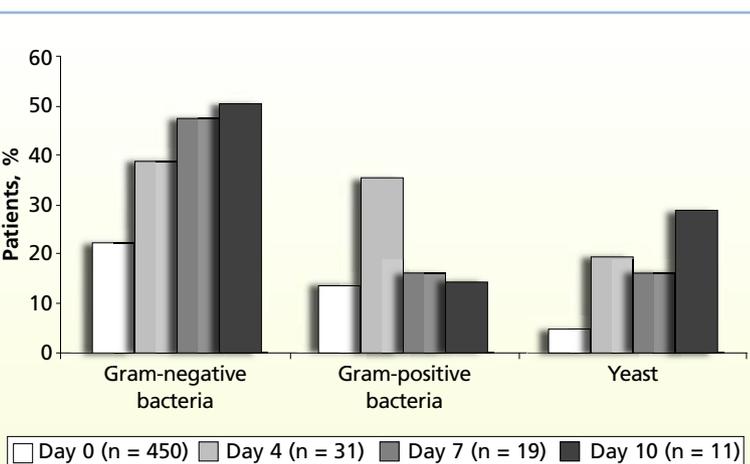


Figure 3 Percentage of patients who had heavy growth of oropharyngeal gram-negative bacteria (*Enterobacter* species, *Klebsiella pneumoniae*, *Haemophilus influenzae*, *Pseudomonas aeruginosa*, *Serratia marcescens*), gram-positive bacteria (*Staphylococcus aureus*, *Streptococcus pneumoniae*), and/or yeast (*Candida albicans*) on cultures of oral samples from day of enrollment through day 10 of intubation.

bacteria progressively increased. A definitive diagnosis of VAP is difficult to establish, and although procedures such as bronchoalveolar lavage can improve the diagnostic accuracy, use of lavage is not considered mandatory.¹⁹ Therefore, and because of its invasive nature, we did not use bronchoalveolar lavage.

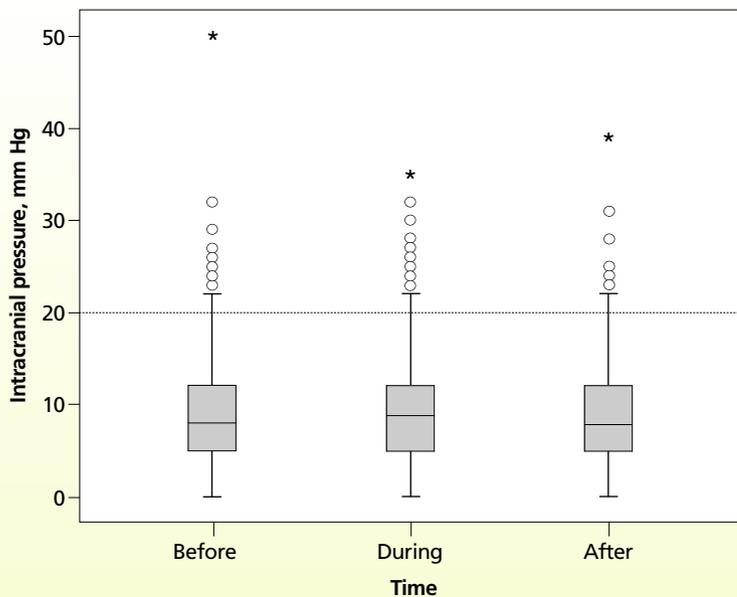


Figure 4 Recordings of intracranial pressure obtained 30 minutes before, during, and 30 minutes after oral care (n = 879).

In the 11 patients available for an oral culture on day 10, a total of 50% had gram-negative bacteria. The gram-negative bacteria identified were the most common bacteria implicated in the development of pneumonia.³⁰ Similar oropharyngeal colonization was documented by Garrouste-Orgeas et al²⁵ in 86 patients, 20% of whom had neurological diagnoses. In that study, the oropharyngeal bacteria were congruent with the pulmonary bacteria in 47% of the documented pneumonias.

Compared with the national average of 9% to 27%,^{1,31} our VAP rate of 25% was high on day 4 and reached 46% in the 13 patients still enrolled on day 10. Although our sample size was small, these results are suggestive of a population of high-risk patients. In a prospective, randomized, double-blind, placebo-controlled study of 226 patients, Bergmans et al⁴ found that oropharyngeal colonization was a key component in the development of VAP among ICU patients. The variation in the reported rates of VAP may partially reflect the heterogeneity of patients in different types of ICUs.^{7,8}

Several key interventions have been recommended to reduce the occurrence of VAP, such as using endotracheal tubes with continuous aspiration of subglottic secretions, elevating the head of the bed 30° to 45°, following sedation protocols to minimize deep sedation, administering histamine₂ blockers, using unspecified oral care protocols (general oral care recommended), and maintaining strict infection control.^{19,32,33} With the exception of subglottic suctioning, these interventions were instituted in all patients in our study. At the time of the study, however, the American Association of Critical-Care Nurses had not yet issued the practice alert³⁴ on oral care in the critically ill outlining suggestions for oral care practice in ICUs. Consequently, we cannot determine whether noncompliance with these new guidelines may have contributed to the relatively high rate of VAP in our study. Notwithstanding, studies are needed to understand the relationship between oral care practices and the development of VAP.

We did not collect sputum samples. Therefore, no clear association can be determined between oropharyngeal and pulmonary aspirates in patients in whom VAP developed. Patients admitted to a facility longer than 48 hours before arrival in the NICU were excluded from the study in order to have comparable data for monitoring oral health. Consequently, our data cannot be used to make conclusions about changes in oropharyngeal flora among patients who have been in a hospital, nursing home, or rehabilitation facility before NICU admission.

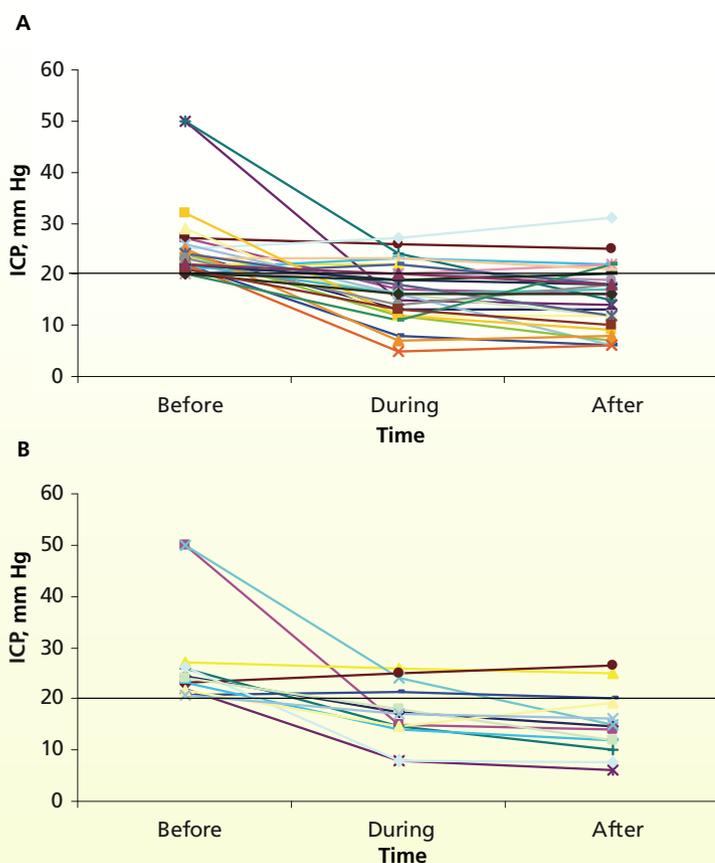


Figure 5 A, All instances of intracranial pressure (ICP) >20 mm Hg before oral care activity and subsequent recordings (n = 30). ICP decreased <20 mm Hg in 20 of 23 instances during and after oral care ($P < .001$; Friedman test). B, Individual observations with ICP >20 mm Hg before oral care (n = 13). Values are means of recordings at the respective times for each patient.

Despite these limitations, oral health deteriorated significantly during intubation, with increases in the concentration of oropharyngeal pathogenic gram-negative bacteria and a high rate of VAP. Because of the lack of evidence-based standards for oral care for intubated NICU patients and the recent recommendation to establish oral care protocols, experimental intervention studies with larger samples of patients are needed.

Intracranial Pressure

Neuroscience patients have multiple risk factors for aspiration. However, before our study, research on NICU patients with an ICP monitor to determine their response to oral care had not been done. In our study, high ICP values decreased or remained stable during oral care, and normal ICP values rarely increased to more than 20 mm Hg. Although the number of patients with increased ICP was small, we detected no trend that indicated a worsening of ICP during and immediately after oral care. To our knowledge, these findings are unique and should be validated in larger samples of patients.

ICP trends in response to other nursing care activities have been mixed.³⁵⁻³⁷ In the first study of ICP changes in response to nursing activities, Mitchell and Mauss³⁶ found no significant increase in ICP and/or cerebrospinal fluid drainage from externalized drains in 8 of the 9 patients studied during a 24-hour period. In a study³⁸ of 20 patients with a traumatic brain injury, ICP increased 1 to 4 mm Hg during bathing. Conversely, in a study³⁹ of 5 severely brain-injured patients, ICP increased more than 20 mm Hg during 2 instances of bathing. Although elevations in ICP during oral care were reported in 19 patients with a severe closed head injury, the ICP returned to baseline values approximately 1 minute after the care procedure.⁴⁰ Thus, mixed results have been reported, and more research is needed.

Nurses must monitor the responses of patients with high ICP to care activities and modify activities as needed. During our study, the nurses may not have provided oral care in some instances in which ICP was higher than 20 mm Hg because they were concerned about the potential deleterious effects of such stimulation. Therefore, data on such ICP responses to oral care, if any, were not available. The ICP recordings made during the delivery of oral care also could have been influenced by technical factors (dampened waveform, obstructed catheter, error in calibration) or therapeutic interventions (head positioning, administration of osmotic diuretics, pain medications). Finally, oral care techniques, length of time spent

delivering the oral care, and veracity of documentation were not controlled. Consequently, we cannot formulate recommendations on the provision of oral care in relation to ICP.

Nevertheless, our findings indicate the importance of evaluating oral care protocols in NICU patients in relation to changes in ICP and of conducting systematic studies on the relationship between oral care and ICP. Because of documented worsening oral health, increasing occurrence of pathogenic oropharyngeal bacteria, and a high VAP rate in NICU patients, ICU nursing staff must be able to provide safe oral care to these high-risk patients.

Conclusions

Our small sample size and the recruitment of patients from a single facility may limit the generalization of our findings to other settings because of differences in patient management, demographic characteristics, and oral care routines. However, overall oral hygiene as a modifiable factor for VAP⁴¹ should be explored with interventional studies to elucidate best oral care practices for intubated patients. Furthermore, investigations of ICP during oral care are needed to optimize provision of this essential nursing activity.

ACKNOWLEDGMENTS

This research was conducted at Barrow Neurological Institute, St Joseph's Hospital and Medical Center. Special thanks to Kristin Deshmukh, Pam Goslar, Steve Salas, and Omar Gonzalez for assisting with data collection and suggestions on the microbial analysis. We gratefully acknowledge the participation of the patients and nursing staff in this study.

FINANCIAL DISCLOSURES

This study was supported by a grant from the Barrow Neurological Foundation.

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