PATIENTS WHO DEVELOP VAP, a common hospital-acquired infection (HAI), experience higher morbidity and mortality than hospitalized patients who don’t develop pneumonia. VAP increases the length of hospital stay and number of ventilator days, accounting for an additional $14,000 to $57,000 in costs per hospitalization.4,5

In 2005, the Institute for Healthcare Improvement (IHI) initiated the ventilator bundle: a cluster of interventions that, when consistently administered together, improve patient outcomes. The four key elements of the ventilator bundle are elevation of the head of the bed to 30 to 45 degrees, daily sedation vacations and assessment of readiness to extubate, peptic ulcer disease (PUD) prophylaxis, and deep vein thrombosis prophylaxis.6

Despite the benefit of PUD prophylaxis, medications that increase the pH of gastric secretions can subsequently become a causative factor for the development of VAP by allowing bacterial overgrowth in the stomach. If aspirated, these gastric secretions increase the risk of VAP.7-9

To reduce the incidence of VAP, oral application of CHG 0.12% solution was added to the IHI bundle in 2010 because evidence indicated that this practice inhibits formation of dental plaque, which can harbor pathogenic bacteria.6 Aspiration of oral secretions is the primary route for bacteria carried to the lungs.10 An effective oral care protocol that reduces plaque, decontaminates the oral cavity, and employs frequent suctioning to minimize the aspiration risk can potentially reduce the incidence of VAP.

Background

A substantial body of literature shows the effectiveness of various oral care protocols to reduce VAP in patients with endotracheal tubes undergoing mechanical ventilation in the ICU. Protocols have included cleaning the mouth with povidone-iodine and rinsing with weakly acidic water;11 using an oral care commercial product;12 timed tooth brushing with toothpaste;13 applying oral antibiotics or CHG as a solution, gel, paste, or oral rinse;14-16 and adding tooth brushing with and without toothpaste to the CHG protocol.17-19

In a sample of 1,252 patients, cleaning the oral mucosa with povidone-iodine, brushing the teeth, and rinsing with weakly acidic water significantly reduced the incidence of VAP but didn’t reduce hospital or ventilator days.10 In a separate sample of 759 patients, a commercial combination product kit/protocol (Sage Products, Inc., Cary, Ill.), which involved cleaning with hydrogen peroxide, brushing with a suction toothbrush, and applying cetylpyridinium chloride, a topical disinfectant, to the oral mucosa, reduced the incidence of VAP from 12 per 1,000 ventilator days to 8 per 1,000 ventilator days ($P = 0.06$).11

In a randomized controlled trial of 345 patients, researchers found
that brushing the teeth with toothpaste for 1 minute every 8 hours reduced the incidence of VAP to zero,\textsuperscript{13} which reinforced the importance of mechanical and abrasive removal of plaque as part of an oral care protocol.\textsuperscript{10–21}

The oral application of antibiotics hasn't consistently been effective in reducing VAP rates; however, the effectiveness of the antiseptic CHG in reducing VAP rates has been well documented.\textsuperscript{13} In two separate meta-analyses of 11 clinical trials (N = 3,242) and 7 clinical trials (N = 1,650), oral application of CHG (0.12% solution, 0.20% gel, or 2% paste) significantly reduced VAP rates.\textsuperscript{14–15} Used as an oral rinse, CHG 2% solution was far superior for reducing VAP rates compared with 0.9% sodium chloride solution rinse in a randomized controlled trial of 207 patients; the VAP rate in the CHG group was 7 per 1,000 ventilator days compared with 21 per 1,000 ventilator days in the control group.\textsuperscript{16}

Other researchers have examined the effect of adding tooth brushing to an oral care protocol using CHG 0.12% solution with conflicting findings. In a randomized controlled clinical trial of 547 patients assigned to one of four groups, Munro and colleagues found that CHG significantly reduced VAP rates, but adding tooth brushing with toothpaste to the CHG application had no additional effect on the incidence of VAP.\textsuperscript{17} In a second randomized trial of 147 patients who were assigned to either CHG only or tooth brushing with CHG, researchers found that adding electric tooth brushing along with standard use of CHG didn't reduce VAP rates.\textsuperscript{18} However, using a protocol of tooth brushing with toothpaste and CHG application in a sample of 871 patients, Sona and colleagues found a 46% decrease in VAP rates (from 5.2 to 2.4 per 1,000 ventilator days) when compared with the preintervention group of 777 patients (P = 0.04).\textsuperscript{19}

The literature clearly demonstrates that the oral application of CHG is effective in reducing VAP rates.\textsuperscript{18,19,21} Although it seems reasonable that tooth brushing with toothpaste would further reduce VAP rates by mechanically and abrasively removing plaque, the results of previous studies have been inconsistent.\textsuperscript{12,16–18} Additionally, most published studies have been conducted in ICUs with patients who had endotracheal tubes. We found minimal published research about the effectiveness of an oral care protocol in reducing VAP rates in mechanically ventilated patients with tracheostomies on a step-down unit similar to ours, a PCU.

**Methods**

**Setting and sample.** The 12-month prospective study was conducted in a 24-bed PCU at a quaternary care hospital in Kansas City, Mo. (See Glossary of research terms.) The inclusion criteria consisted of all patients age 18 or older with a tracheostomy who were mechanically ventilated for at least 48 hours. Patients with tracheostomies who came to the PCU from a long-term acute care facility or home on mechanical ventilation weren't excluded. Exclusion criteria included pneumonia diagnosed after less than 48 hours on mechanical ventilation, and previous (current admission) VAP. The relevant P value is one-tailed because it's hypothesized that the proportion of VAPs will be lower in the sample that received the intervention than in the population from the NHSN 2009 benchmark.

**Procedures.** Before the nurses (N = 17) were educated about the oral care protocol, they were anonymously surveyed using a survey by Grap et al. to assess frequency and methods of oral care for mechanically ventilated patients with tracheostomies.\textsuperscript{20} Before this study was conducted, the nurses didn't use a consistent oral care protocol, and the hospital didn't have a policy for oral care. The frequency of oral care ranged from 0 to 5 times a day; they used a wide variety of supplies, but 41% of the nurses indicated they didn't brush patients' teeth with toothpaste, and 41% indicated they didn't apply CHG.

CHG 0.12% solution was selected for oral decontamination because this antimicrobial agent has activity against Gram-positive and Gram-negative microorganisms. Tooth brushing using an adult toothbrush with toothpaste provides mechanical abrasion to remove dental plaque and reduces concentrations of harmful microorganisms on the tongue.

**Research question**

The purpose of this study was to examine the effect of an oral care protocol involving tooth brushing with toothpaste and application of CHG 0.12% solution in reducing VAP rates in mechanically ventilated patients with tracheostomies on the PCU.

Because our study population involved mechanically ventilated patients with tracheostomies, the risk factors for VAP with endotracheal tubes must be distinguished from the risk factors for tracheostomy tubes. Major risk factors associated with endotracheal tubes are impairment of ciliary transport by the epithelium and the cough function.\textsuperscript{22} In comparison, patients with tracheostomies on mechanical ventilation have fewer risk factors because the tracheostomy tube allows for better access for oral care and more effective pulmonary suctioning and usually requires less sedation.\textsuperscript{23}
In staff meetings, the nurses were taught the oral care protocol with verbal instructions and demonstration (see Following the protocol). Nurses were instructed to provide the oral care protocol every 12 hours. Because applying CHG required a healthcare provider’s prescription, the preset time of administration was documented in the computerized medication administration record (MAR). To track nurses’ adherence to the oral care protocol, both the tooth brushing with toothpaste and application of CHG were recorded on a documentation sheet that was placed in each patient’s room above the bedside computer where medications are scanned. For the study, calculation of adherence for CHG application and tooth brushing wasn’t taken from the MAR. Instead, the study documentation sheet provided a comprehensive tool for collecting the data and a brief description of the oral care protocol for each shift. The documentation tool helped to make data collection and entry efficient because it was the sole responsibility of the primary investigator (PI). Copies with full details of the oral care protocol were located in a unit cabinet in an open file box accessible to all staff.

Most of the patients enrolled in the oral care protocol who were on mechanical ventilators with tracheostomies couldn’t perform their own oral care. Any patients who were able to brush their own teeth (two in this study) were allowed to do so after they’d been instructed on the oral care protocol; for the rest of the patients, nurses provided oral care. The oral care protocol was provided to the patients starting the day they were transferred to the PCU and ending when they were removed from the ventilator, transferred from the PCU, or discharged to another facility.

The PI collected all data. Medical records were reviewed to collect the descriptive and outcome data. For the purposes of this study, criteria from the CDC were used to establish the diagnosis of VAP: new or progressive pulmonary infiltrates accompanied by fever, leukocytosis, purulent tracheal secretions, and worsening gas exchange that began more than 48 hours after mechanical ventilation was initiated. If there was any question regarding a possible diagnosis of VAP, the infectious-disease physician on the research team was consulted to determine whether or not these criteria were fulfilled. The same criteria were also used by a single infection control nurse who identified the VAP cases in the year before this study was initiated.

**Data analysis**

All data were entered into Statistical Package for the Social Sciences. Because VAP rates in the PCU hadn’t
been assessed before this study, the VAP rate in the NHSN Report for 2009 was used because it was considered the best data available for comparison. The Chi-squared test was the statistical test used in analysis to conduct the PCU VAP rate.

Results

Demographics are shown in Looking at patients’ characteristics. The 75 subjects (sample) were on mechanical ventilators, had tracheostomies, and had been admitted or transferred to the PCU between November 1, 2009 and October 31, 2010. Ninety-six percent of patients in the sample were transferred from the ICU on mechanical ventilators to the PCU. The length of stay on the PCU was 1 to 31 days with a mean of 11.1 days. Nursing staff adherence with tooth brushing ranged from 9% to 100% with a mean of 80%; adherence with CHG application ranged from 22% to 100% with a mean of 80% (N = 64, missing = 11).

At the conclusion of the 12-month study in the PCU, two cases of VAP occurred over 1,789 ventilator days, resulting in a VAP rate of 1.1 per 1,000 ventilator days. Following the study, the nurses followed the same oral care protocol, and in 2011, there were 218 ventilator days and zero infections. The benchmark for the VAP rate of adult step-down unit (postcritical care) noted in the NHSN report for 2009 indicates a mean of 1.5 cases per 1,000 ventilator days.1

The intervention’s effectiveness was tested by comparing the proportion of VAPs per total ventilator days for PCU patients in the sample to the proportion of VAPs per total ventilator days for PCU patients in the national population (using 2009 data). The statistical significance of this comparison was obtained by computing the Z-test for the significance of the difference of a proportion from a hypothesized population value. The sample proportion was 0.00112 (2/1,789), and the proportion derived from the national population data was 0.00262 (27/10,307). Because the expected value of the sample frequency was below 5, the continuity correction was applied. The critical alpha (type I error) level for the threshold of significance was set at 0.05. The continuity-corrected Z was 1.03, for which the one-tailed P value was 0.1523. Consequently, the sample proportion of VAP isn’t statistically significant when compared with the population proportion.2

Discussion and limitations

Although the effectiveness of oral care protocols in reducing VAP rates in ICU patients with endotracheal tubes has been studied extensively, patients with tracheostomy tubes haven’t been studied adequately. To our knowledge, this is a unique published study about the effect of an oral care protocol in reducing VAP in mechanically ventilated patients with tracheostomies in the PCU.

In retrospect, we determined that the low documented CHG application adherence (low end 22%) and tooth brushing with toothpaste (low end 9%) were due to multiple factors that can be corrected in future studies assessing this intervention; for instance, the protocol could be specifically documented in the computerized medical record. The comprehensive oral care documentation sheet that included a brief listing of the interventions to be done at 1200 (noon) and 2400 (midnight) was an additional documentation task for the nurses. The nurses did document application of the CHG in the MAR per the scanning technique prior to administration. CHG, like all ordered medications, is scanned before being given to each patient. Tooth brushing with toothpaste was documented in the computer documentation section of the activities of daily living, but it didn’t specify what type of oral care was completed.

In addition, some nurses working in the PCU hadn’t taken part in the original education about the protocol of oral care for the study. Some nurses assigned to these patients

Following the protocol

Use this protocol to provide oral care to ventilated patients with a tracheostomy:

- Gather these supplies: Yankauer suction device, oral sponge swabs, toothbrush, tube of toothpaste, and CHG solution 0.12%.
- Perform a nursing assessment of patient’s tongue, oral mucosa, teeth, and lips. Don’t brush any sores. Instruct the patient before providing oral care.
- Brush teeth and tongue and oral mucosa for 1 to 2 minutes with gentle strokes using toothpaste and a small amount of water to moisten the toothbrush; use a few gentle strokes to brush the tongue of edentulous patients.
- Suction the mouth as needed during and after tooth brushing to remove excess water and secretions.
- Apply CHG solution 0.12% to the oral cavity and tongue with oral sponge swabs 30 to 60 minutes after tooth brushing or mouth cleaning. Suction any excess as needed.
- For patients with dentures: remove the dentures and clean them with denture-cleaning tablets, then swab the oral cavity and tongue with CHG solution 0.12%. Suction the mouth as needed to remove excess solution and secretions.
came from the ICU or an agency, and because they weren’t consistently informed or adherent, they contributed to some missed documentation. Also, some documentation sheets were lost for patients discharged, transferred, and emergently transferred to the ICU.

The results of our study suggest that an oral care protocol of tooth brushing with toothpaste, followed by the application of CHG 0.12% solution 30 to 60 minutes later, may reduce the incidence of VAP in mechanically ventilated patients with tracheostomies on the PCU. Over a 12-month period with the oral care protocol in the PCU, the VAP rate was 1.1 per 1,000 ventilator days. This is lower than the 2009 rates recently issued by the NHSN, which reported a national pooled mean of 1.5 per 1,000 ventilator days in adult step-down units (postcritical care). A limitation of our study is that the VAP rate in the NHSN report included patients with either endotracheal or tracheostomy devices, whereas our VAP rate included patients using only tracheostomy tube devices. The findings from our study are consistent with those of Sona and colleagues, who used a similar protocol for their ICU patients with endotracheal tubes.

Giard and colleagues compared the risk factors of early-onset VAP (E-VAP) and late-onset VAP (L-VAP) in 11 ICUs in France. Their findings revealed the following independent risk factors for L-VAP (versus E-VAP): older age, high Simplified Acute Physiology Score II, any infection on admission, the presence of another HAI before VAP, and central venous catheter use before VAP. (The Simplified Acute Physiology Score is a severity score and mortality estimation tool made up of 12 physiologic variables and 3 disease-related variables. The scores range from 0 to 163 points, with 163 being the “worst” measurement.) Both patients diagnosed with VAP in the PCU were older adults with pneumonia diagnosed more than 7 days after mechanical ventilation was initiated. Our patient population more closely matches patients with risk factors for L-VAP rather than E-VAP.

The economic impact of our study results is important. The cost of supplies used for this oral care protocol was about $15 per patient. Because hospitals are now being penalized for hospital-acquired conditions, an effective oral care protocol not only reduces morbidity but also achieves substantial financial benefits.

Even though the nursing staff’s mean adherence with the oral care protocol was 80%, adherence by individual nurses ranged widely, from 9% to 100%. We couldn’t assess adherence for 15% of the patients whose adherence sheets were lost. Although the nursing staff’s adherence to the oral care protocol wasn’t 100%, this study involved the implementation of a protocol in a unit without an established protocol and it reinforced the importance of oral care. Practices of nurses employed in hospitals with oral care protocols are more congruent with the VAP prevention guidelines than those of nurses employed in hospitals without protocols.

The data are now being consistently monitored for the incidence of VAP on our PCU. As explained above, there was no statistical significance between the sample group and the

### Looking at patients’ characteristics*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N (%)</th>
<th>[Mean (SD*); range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>75</td>
<td>[63.2 (15.5); 18-91]</td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>40 (53%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>35 (47%)</td>
<td></td>
</tr>
<tr>
<td>Days with tracheostomy</td>
<td>16 (11.9); 2-58</td>
<td></td>
</tr>
<tr>
<td>Days on ventilator</td>
<td>24 (13.9); 4-62</td>
<td></td>
</tr>
<tr>
<td>Primary diagnosis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>43 (57%)</td>
<td></td>
</tr>
<tr>
<td>Trauma/closed head injury</td>
<td>5 (7%)</td>
<td></td>
</tr>
<tr>
<td>Stroke</td>
<td>5 (7%)</td>
<td></td>
</tr>
<tr>
<td>Infection/sepsis</td>
<td>4 (5%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>18 (24%)</td>
<td></td>
</tr>
<tr>
<td>Secondary diagnosis:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>20 (27%)</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>17 (23%)</td>
<td></td>
</tr>
<tr>
<td>Infection/sepsis</td>
<td>5 (7%)</td>
<td></td>
</tr>
<tr>
<td>Renal failure</td>
<td>4 (5%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>29 (38%)</td>
<td></td>
</tr>
</tbody>
</table>

*N = 75; SD = standard deviation.
benchmark. This indicates the need for nurses to further test the use of an oral protocol in larger populations.

Because most published studies have addressed the effect of oral care on the VAP rate in patients with endotracheal tubes in the ICU, this study addressed a limited amount of literature by studying patients with tracheostomies in the PCU. Two literature searches were done, neither of which yielded additional studies as specific as this one. Although we didn’t identify a statistically significant reduction in the incidence of VAP, we demonstrated the feasibility of implementing an oral care protocol in a busy clinical setting and identified several areas for improvement in future studies.

More research is needed to determine the most effective oral care protocol to reduce VAP in this population. Future studies should compare other oral care protocols with the protocol in this study in a prospective randomized clinical trial to determine the most effective protocol for this population. Empowering nurses with evidence to provide the best oral care for mechanically ventilated patients is critical to promoting positive patient outcomes.

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