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Effect of continuous oral suctioning on the development of ventilator-associated pneumonia: A pilot randomized controlled trial

Meyrick C.M. Chow [a,*], Shu-Man Kwok [b], Hing-Wah Luk [c], Jenny W.H. Law [c], Bartholomew P.K. Leung [d]

[a] School of Nursing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
[b] Intensive Care Unit, St. Paul's Hospital, 2 Eastern Hospital Road, Causeway Bay, Hong Kong
[c] Intensive Care Unit and Medical Specialties, Queen Elizabeth Hospital, 30 Gascoigne Road, Yau Ma Tei, Kowloon, Hong Kong
[d] Department of Applied Mathematics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

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ABSTRACT

Background: Both continuous and intermittent aspiration of subglottic secretions by means of specially designed endotracheal tubes containing a separate dorsal lumen that opens into the subglottic region have been shown to be useful in reducing ventilator-associated pneumonia (VAP). However, the high cost of these tubes restricts their use.
Objective: The aim of this pilot randomized controlled trial was to test the effect of a low-cost device (saliva ejector) for continuous oral suctioning (COS) on the incidence of VAP in patients receiving mechanical ventilation.
Methods: The study was conducted in the six-bed medical-surgical ICU of a hospital with over 400 beds that provides comprehensive medical services to the public. The design of this study was a parallel-group randomized controlled trial. While both the experimental and control groups used the conventional endotracheal tube, the saliva ejector was only applied to patients assigned to the experimental group. The device was put between the patient's cheek and teeth, and then connected to 100 mmHg of suction for the continuous drainage of saliva.
Results: Fourteen patients were randomized to receive COS and 13 patients were randomized to the control group. The two groups were similar in demographics, reasons for intubation, co-morbidity, and risk factors for acquiring VAP. VAP was found in 3 patients (23.1%; 71 episodes of VAP per 1000 ventilation days) receiving COS and in 10 patients (83.3%; 141 episodes of VAP per 1000 ventilation days) in the control group (relative risk, 0.28; 95% confidence interval, 0.10–0.77; $p = 0.003$). The duration of mechanical ventilation in the experimental group was 3.2 days (SD 1.3), while that in the control group was 5.9 days (SD 2.8) ($p = 0.009$); and the length of ICU stay was 4.8 days (SD 1.6) versus 9.8 days (SD 6.3) for the experimental and control groups, respectively ($p = 0.019$).
Conclusion: Continuous clearance of oral secretion by the saliva ejector may have an important role to play in reducing the rate of VAP, decreasing the duration of mechanical ventilation, and shortening the length of stay of patients in the ICU.

What is already known about the topic?

- Ventilator-associated pneumonia (VAP) is a preventable secondary consequence of intubation and mechanical ventilation. One of the promising preventive measures is aspiration of subglottic secretions.

* Corresponding author. Tel.: +852 2766 6547; fax: +852 2364 9663.
E-mail addresses: hsmchow@inet.polyu.edu.hk, meyrick@netvigator.com, hsmchow@polyu.edu.hk (Meyrick C.M. Chow).

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- Both the continuous and intermittent aspiration of subglottic secretions by means of specially designed endotracheal tubes containing a separate dorsal lumen that opens into the subglottic region proved to be useful in reducing VAP. However, the high cost of these tubes restricts their use.

What this paper adds

- Continuous clearance of oral secretion by the saliva ejector, which was designed with five holes for effective suctioning, resulted in a significant reduction in the rate of VAP, duration of mechanical ventilation, and length of ICU stay.
- The results of this pilot study can be used as a guide in the design and implementation of a full-scale, definitive randomized controlled clinical trial (RCT).

1. Introduction

Ventilator-associated pneumonia (VAP) is defined as a pneumonia event that occurs more than 48 h after patients have been intubated and have received mechanical ventilation (Koenig and Truwit, 2006). It is one of the most frequent complications among intensive care unit (ICU) patients, and has been associated with poor clinical and economic outcomes (American Thoracic Society, 2005; Powers et al., 2007; Rello et al., 2002). Two processes are considered essential in the pathogenesis of VAP: the bacterial colonization of the oropharynx and tracheobronchial tract, and the aspiration of contaminated secretions into the lower airways (Kollef, 1999; Kollef et al., 1999). The associated mucosal injury caused by the invasive insertion and manipulation of endotracheal tubes facilitates bacterial colonization of the tracheobronchial tree (Craven and Steger, 1995; Joshi et al., 1992). In addition, the presence of endotracheal tubes eliminates the cough reflex and contributes to the pooling of secretions above inflated endotracheal tube cuffs. Studies have shown that pooled secretions above inflated cuffs can predispose ventilated patients to VAP because of lower airway aspiration of these contaminated secretions (Greene et al., 1994; Oikkonen and Aromaa, 1997).

VAP is a preventable secondary consequence of intubation and mechanical ventilation. A promising preventive measure is aspiration of subglottic secretions. Two randomized controlled trials have examined the effect of the continuous aspiration of subglottic secretions by means of specially designed endotracheal tubes containing a separate dorsal lumen that opens into the subglottic region. Of the two reported studies, one found a statistically significant decrease in VAP (Valles et al., 1995), and the other demonstrated a trend favoring the aspiration of subglottic secretions (Kollef et al., 1999). Two other randomized clinical trials of the intermittent drainage of subglottic secretions were also carried out. Patients randomized to the intermittent drainage of subglottic secretions in both studies had a statistically lower incidence of VAP than those intubated with the conventional endotracheal tube (Mahul et al., 1992; Smulders et al., 2002).

Both continuous and intermittent subglottic drainage proved to be useful in reducing VAP. Accordingly, the Centre for Disease Control and Prevention and the American Association of Critical Care Nurses recommend the adoption of specially designed endotracheal tubes with a dorsal lumen for the drainage of subglottic secretions (American Association of Critical-Care Nurses, 2008; Tablan et al., 2004). However, the high cost of these tubes has restricted their use (Alp and Voss, 2006). The purpose of this study was to pilot test the effect of a low-cost device for continuous oral suctioning (COS) on the prevention of VAP, by eliminating or reducing the collection of subglottic secretions.

2. Methods

2.1. Research design and setting

The device used for COS in this study was a dental device, the Orsing Hygoformic Saliva Ejector (Adult Universal) (Fig. 1), which was originally designed for use in dental surgery for the purpose of suction. The tube of the saliva ejector is arranged spirally and equipped with five holes at the inner rim of the spiral head for suction. This design enables the user to avoid placing the suction ports in direct contact with the patients' oral mucosa, thus minimizing the chances of mucosal injury. To ensure comfort, the device can also be adjusted to fit cheeks of different shapes and sizes.

The saliva ejector is made from a non-toxic and non-polluting mixture of polyethylene and polypropylene. To ensure that the material composing the device is safe for long-term placement in the oral cavity, a migration test was undertaken in accordance with the European Commission Directive 2007/72/EC and its amendment 2007/19/EC. The result of the test revealed that the overall migration of the material making up the device was very low, indicating that the device is safe for continuous usage. In this study, the saliva ejector was changed every 24 h and whenever necessary to ensure that it was continuing to effectively drain secretions.

The design of this study was a parallel-group randomized controlled trial. While both the experimental and control groups used the conventional endotracheal tube, the saliva ejector was only applied to patients assigned to the experimental group. The device was put between the patient's cheek and teeth, and then connected to 100 mmHg of suction for the continuous drainage of

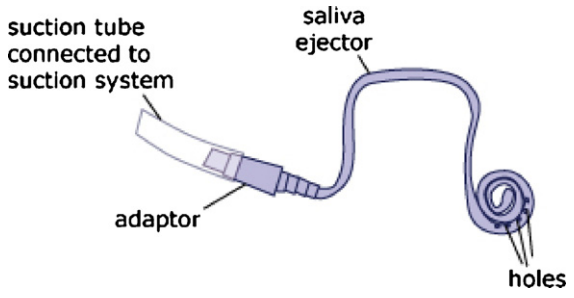

Fig. 1. Orsing Hygoformic Saliva Ejector (Adult Universal).

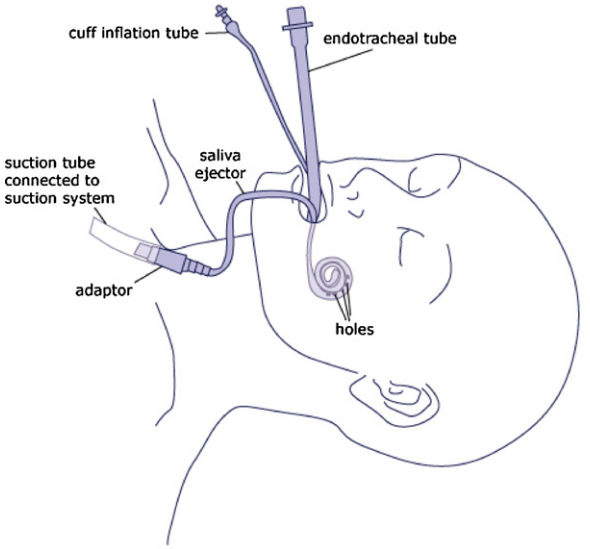

Fig. 2. Diagram of continuous oral suctioning of secretions with saliva ejector.

saliva. When the patient changed position, the device had to be adjusted to the dependent side to ensure the effective clearance of secretions (Fig. 2). Before the first patient was enrolled, all ICU bedside nurses participated in at least one orientation session, in which they learned about the rationale for the study, became familiar with the saliva ejector, and had their questions answered. After demonstration of the application of the saliva ejector, each nurse was asked to perform a return demonstration of the procedure to ensure that they had mastered the required skill. An audit trail was done during the study period and it was noted that the device had been properly applied to the subjects.

The study was conducted in the six-bed medical-surgical ICU of a hospital with over 400 beds that provides comprehensive medical services to the public. The study was reviewed and approved by the Ethics Committee of the hospital and the Human Subjects Ethics Sub-committee of the university with which the research team was affiliated, and was carried out in accordance with the ethical standards set forth in the Helsinki Declaration of 1975.

2.2. Sample

Considering the popularity of pilot studies, there is little discussion in the medical literature of how to determine appropriate sample sizes for pilot studies. However, some articles have raised the issue. For example, in a discussion on pilot testing an instrument, Treece and Treece (1982) contended that for a project with 100 people as the sample, a pilot study with 10 participants should be a reasonable number. In the medical field, Julious (2005) observed that for small sample sizes there is a marked gain in precision for each increase of 1 in the sample size per group. However, the gains are less distinct after the sample size has reached 12. He then recommended 12 per group for pilot studies as being an appropriate sample size. This is equivalent to $n = 24$ for a traditional two-group study. Similar calculations were made by van Belle (2002), who also suggested a sample size of at least 12 per group to construct a confidence interval. In this pilot randomized controlled trial, we anticipated recruiting a total sample size of approximately 27 to accommodate a potential attrition rate of 10% among the participants.

2.3. Procedure

Patients entering the ICU were screened for inclusion and exclusion criteria. If a patient met the inclusion criteria and informed consent was obtained, he or she would be randomized into the experimental or control group. A randomization list was generated from a computer, and treatment allocation was concealed using sequentially numbered opaque sealed envelopes. All patients hospitalized in the ICU, aged 18 or above, and requiring mechanical ventilation through an oroendotracheal tube for 48 h or more were included in the study. Exclusion criteria were being HIV positive or contraindicated to the use of a continuous oral suctioning device (e.g., suffering from oral trauma or having undergone oral surgery), receiving immunosuppressive therapy (including COPD patients receiving $\geq$0.8 mg/kg/day of prednisone equivalent), having a blood leukocyte count of less than 1000 cells/mm^3, or having been diagnosed with solid or hematological tumors.

Identical measures for the prevention of nosocomial pneumonia were applied in both groups, e.g., no routine change of ventilator circuit, a closed tracheal suction system, a semi-recumbent body position, oral care, and hand hygiene. Enteric nutrition would also be started as soon as possible, and periodic verification of the residual gastric volume would be performed. In both groups of patients, tracheal aspirate would be collected for culture at the time of endotracheal intubation and repeated when there was any sign of pneumonia: two or more serial chest radiographs with new or progressive and persistent infiltrate or consolidation or cavitation or pneumatoceles; fever $>38\,^{\circ}$C with no other recognized cause; leukopenia ($<$4000 WBC/mm^3) or leukocytosis ($\geq$2000 WBC/mm^3); a new onset of purulent sputum or a change in the character of the sputum or increased respiratory secretions or increased suctioning requirements; rales or bronchial breath sounds; and worsening gas exchange (e.g., O_2 desaturations [e.g., $PaO_2/FiO_2 < 240$], increased oxygen requirements, or increased ventilator demand) (Horan et al., 2008).

The following data were prospectively recorded for all study patients: demographics, the Acute Physiology and Chronic Health Evaluation (APACHE) II score, the reason for intubation, and co-morbidities. Several risk factors for VAP were recorded, such as a history of COPD, a failure to achieve a semi-recumbent position of 30°, and the use of intravenous sedation, a paralytic agent, stress ulcer prophylaxis, antibiotic therapy, and corticosteroid. In addition to the occurrence of VAP, we assessed secondary outcomes, including VAP-free time, the duration of mechanical ventilation, tracheostomy, the length of the ICU stay, the length of the hospital stay, and mortality in the ICU. All of the participants were screened daily for the

occurrence of VAP by ICU physicians who were not members of the research team. Episodes of pneumonia diagnosed within 48 h of ventilation were not considered to be associated with the ventilator. Screening for VAP was maintained until the first episode of VAP, or 48 h after weaning from the ventilator or death. In the event of unsuccessful weaning, which was taken to mean that ventilator support was needed again less than 48 h after extubation, patients were kept in the study. After extubation, all patients would be followed up for the occurrence of pneumonia after 48 h. The diagnostic criteria of VAP in this study were adapted from Horan et al. (2008). Owing to safety and feasibility, instead of obtaining bronchial secretions using a bronchoscope and a protected specimen brush, tracheal aspirate was collected as a specimen for establishing the microbiological diagnosis of pneumonia (Chawla, 2008). The criteria were as follows:

(i) Radiological

Two or more serial chest radiographs showing new or progressive and persistent infiltrate or consolidation or cavitation;

(ii) Sign and symptom I

At least one of the following:

- fever >38 °C with no other recognized cause; or
- leukopenia (<4000 WBC/mm^3) or leukocytosis (≥12,000 WBC/mm^3);

(iii) Sign and symptom II

At least one of the following:

- new onset of purulent sputum or a change in the character of the sputum or increased respiratory secretions or increased suctioning requirements;
- new onset or worsening cough or dyspnea or tachypnea;
- rales or bronchial breath sounds; or
- worsening gas exchange (e.g., O_2 desaturations [e.g., $PaO_2/FiO_2 < 240$], increased oxygen requirements, or increased ventilator demand); and

(iv) Laboratory

One of the following:

- positive culture of endotracheal aspirate or bronchoalveolar lavage fluid (BAL);
- positive growth in blood culture not related to another source of infection; or
- positive growth in culture of pleural fluid.

2.4. Data analysis

Quantitative variables were reported as the mean ± standard deviation, and were compared using the *t* test. Qualitative variables were reported as percentages, and were compared using the chi-square test or the Fisher's exact test as appropriate. The probability of remaining free of VAP was calculated using the Kaplan–Meier method, and a comparison between the two groups was performed with the log-rank test. For statistical analyses, the Statistical Package for the Social Sciences (SPSS) version 18.0 for Windows was used throughout this study.

3. Results

During the study period, 197 patients were admitted to the ICU. Forty patients met the criteria for inclusion in the study. Of the 40 eligible patients, 15 were excluded from the study because 4 of them had hematological tumors, 2 were on immunosuppressive therapy, and 7 declined to participate. A total of 27 patients were enrolled into the study. Among them, 14 were randomly assigned to the experimental group and 13 to the control group. Of these, 2 were lost to follow-up because they had received mechanical ventilation for less than 48 h (Fig. 3). There were no significant differences between the groups with respect to demographics, reasons for intubation, co-morbidity, and risk factors for VAP (Table 1).

Thirteen patients (52%) developed VAP: three (23.1%; 71 episodes of VAP per 1000 ventilation days) in the experimental group and 10 (83.3%; 141 episodes of VAP per 1000 ventilation days) in the control group (relative risk, 0.28; 95% confidence interval, 0.10–0.77; $p = 0.003$). A Kaplan–Meier analysis confirmed a significantly lower incidence of VAP in the experimental group than in the control group ($p = 0.018$) (Fig. 4). The duration of mechanical ventilation in the experimental group was 3.2 days (SD 1.3), while that in the control group was 5.9 days (SD 2.8)

Table 1
Demographics and characteristics of patients.

	Experimental group ($N = 13$) Mean (SD)	Control group ($N = 12$) Mean (SD)	*p* value
Age (year)	70.3 (14.3)	79.4 (12.5)	0.104
APACHE II score	21.5 (7.3)	23.0 (6.4)	0.601
	Experimental group *N* (%)	Control group *N* (%)	*p* value
Gender			
Male	7 (53.8%)	7 (53.8%)	0.821
Female	6 (46.2%)	5 (41.7%)	
Reason for intubation			
Acute respiratory failure	7 (53.8%)	7 (53.8%)	0.821
Shock	2 (15.4%)	0 (0%)	0.157
Cardiac failure	2 (15.4%)	2 (16.7%)	0.930
Neurological disease	2 (15.4%)	1 (8.3%)	0.588
Miscellaneous	0 (0%)	2 (16.7%)	0.125
Co-morbidity			
COPD	3 (23.1%)	5 (41.7%)	0.319
Cardiovascular disease	7 (53.8%)	4 (33.3%)	0.302
Chronic renal disease	5 (38.5%)	2 (16.7%)	0.225
Diabetes mellitus	6 (46.2%)	5 (41.7%)	0.821
Risk factors			
Coma	9 (69.2%)	9 (75.0%)	0.748
Sedation	5 (38.5%)	6 (50.0%)	0.561
Paralytic agent	1 (7.7%)	2 (16.7%)	0.490
Stress ulcer prophylaxis	12 (92.3%)	10 (83.3%)	0.490
Enteric feeding	9 (69.2%)	5 (41.7%)	0.165
Head of bed less than 30°	1 (7.7%)	0 (0%)	0.327
Antibiotics	12 (92.3%)	12 (100%)	0.327
Corticosteroid	0 (0%)	1 (8.3%)	0.288
Urgent intubation	8 (61.5%)	7 (58.3%)	0.870
Multiple intubation	4 (30.8%)	4 (33.3%)	0.891
Reintubation	0 (0%)	1 (8.3%)	0.288
Nebulization	8 (61.5%)	9 (75%)	0.471

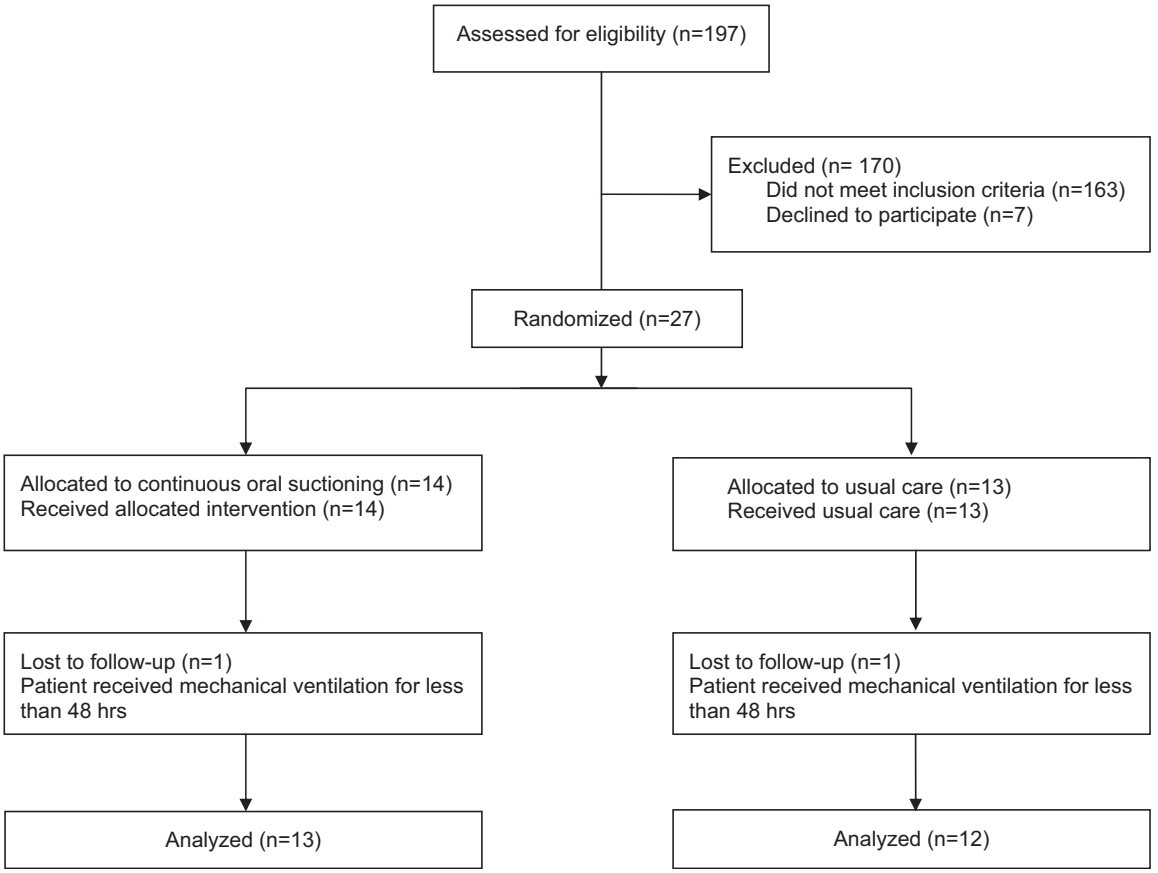

Fig. 3. Flow of participants through trial.

($p = 0.009$); and the length of ICU stay was 4.8 days (SD 1.6) versus 9.8 days (SD 6.3) for the experimental and control groups, respectively ($p = 0.019$) (Table 2). No significant differences were identified between the two groups in terms of tracheostomy, length of hospital stay, or mortality.

The microorganisms that caused VAP in this study are shown in Table 2. In this trial, 13 patients acquired VAP. From the microbiological analysis, it was evident that 8 of these episodes were monomicrobial, whereas the others were polymicrobial episodes. The 5 polymicrobial VAP cases occurred exclusively in the control group.

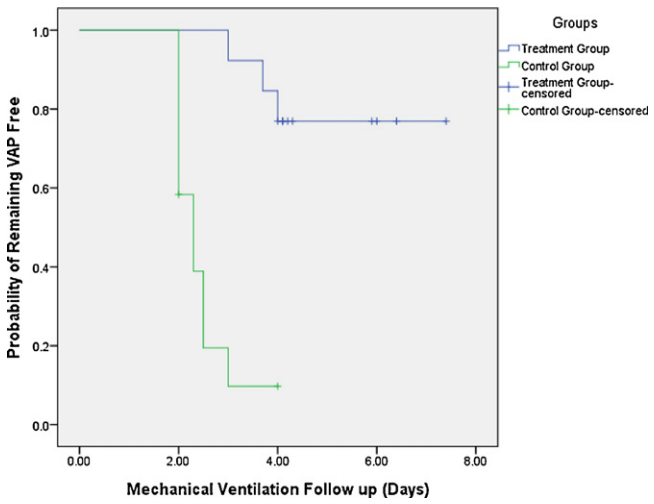

Fig. 4. Probability of remaining ventilator-associated pneumonia (VAP) free.

Table 2
Clinical outcome and microorganisms causing ventilator-associated pneumonia (VAP).

Clinical outcome	Experimental group ($N = 13$) N (%) or mean (SD)	Control group ($N = 12$) N (%) or mean (SD)	p value
Acquired VAP	3 (23.1%)	10 (83.3%)	0.003
Duration of mechanical ventilation (day)	3.2 (SD 1.3)	5.9 (SD 2.8)	0.009
Length of ICU stay (day)	4.8 (SD 1.6)	9.8 (SD 6.3)	0.019
Length of hospital stay (day)	9.8 (SD 3.7)	21.8 (SD 25.0)	0.126
Tracheostomy	0 (0%)	2 (16.7%)	0.125
Mortality	1 (7.7%)	4 (33.3%)	0.109
Microorganisms causing VAP	**Experimental group ($N = 13$) N (%)**	**Control group ($N = 12$) N (%)**	**p value**
VAP			
Monomicrobial VAP	3 (100%)	5 (50%)	0.118
Polymicrobial VAP	0 (0%)	5 (50%)	
Gram positive bacilli			
S. aures	1 (33.3%)	5 (50%)	0.612
S. pneumonia	1 (33.3%)	1 (10%)	0.326
Gram negative bacilli			
Pseudomonas aeruginosa	0 (0%)	2 (20%)	0.400
Stenotrophomonas maltophilia	0 (0%)	1 (10%)	0.569
Escherichia coli	0 (0%)	2 (20%)	0.400
Klebsilella supp.	1 (33.3%)	2 (20%)	0.631
Candida albicans	0 (0%)	2 (20%)	0.400

4. Discussion

In the ICU, nosocomial pneumonia is the most common infection, and there is a 6–20-fold increase in the rate of nosocomial pneumonia for patients who are mechanically ventilated (Celis et al., 1988; Chastre and Fagon, 2002; Torres et al., 1990). The incidence of VAP varies from 7% to 70% in different studies (Alp and Voss, 2006; Safdar et al., 2005). In this pilot study, although the nurses adhered to the measures for preventing VAP, such as hand hygiene, avoiding routine changes of ventilator circuits, and maintaining the patients' semi-recumbent position, VAP still occurred in 13 out of 25 (52%) patients. The relatively high incidence of VAP in our pilot study might have been due to an overall increase in the need to make multiple attempts at intubation in the experimental and control groups. It has not been possible to determine if this was a significant risk factor in this pilot study. A larger sample and a thorough statistical analysis are needed for us to fully understand the independent effect that each of the risk factors has on the development of VAP.

Oropharyngeal colonization plays an important role in the pathogenesis of VAP. Johanson et al. (1969) reported an association between oropharyngeal colonization and the risk of developing VAP. A subsequent study confirmed that oropharyngeal colonization is a risk factor for VAP (Bonten et al., 2001). In intubated patients, bacteria-laden nasal and oral secretions were collected above the endotracheal tube cuff and below the glottis. VAP developed when this subglottic secretion traveled down to the lower respiratory tract if leakage occurred around the cuff. Studies on the use of an endotracheal tube with a dorsal lumen above the cuff for removing subglottic secretions found that the incidence of VAP could be decreased by 50% (Kollef et al., 1999; Mahul et al., 1992; Valles et al., 1995). Similarly, in this study the incidence of VAP in the experimental group (23.3%) was 60% less than the control group (83.3%). This preliminary result supports further research on the continuous clearance of oral secretions by the saliva ejector, which was designed with five holes for effective suctioning. This might have contributed to a substantial decrease in the collection of subglottic secretions and, hence, in a reduction in the rate of VAP.

A saliva ejector costs US$0.06. In terms of resource impact, the proposed intervention in this study might be a good alternative to continuous subglottic suction in preventing VAP in the ICU. A formal costing study is warranted to explore the question of whether improvements in cost might be realized if patient outcomes are improved and the length of stay is reduced. The findings could be particularly useful in developing countries with limited resources, where the prevalence of nosocomial infections is generally higher (Alp et al., 2011).

Mechanical ventilation and additional days in the ICU require more resources and cause an increase in healthcare expenses. A longer duration of mechanical ventilation also exposes patients to a greater risk of morbidity and mortality (Jimenez et al., 1998; Cook et al., 1998). For instance, Ely et al. (1999) found a relationship between ventilation duration and mortality. They noted that patients who were ventilated for 1–7 days had a mortality rate of 33%, and that a subsequent increase in ventilator days increased the mortality rate. In this pilot study, significant decreases in the duration of mechanical ventilation and length of ICU stay were found in the experimental group. The duration of the patients' mechanical ventilation and the length of their ICU stay decreased from 5.9 (SD 2.8) to 3.2 (SD 1.3) days, and from 9.8 (SD 6.3) to 4.8 (SD 1.6) days, respectively. COS appears to have been effective in preventing VAP, hence resulting in a significant reduction in the duration of mechanical ventilation and length of ICU stay. Although only those participants who had received mechanical ventilation for more than 48 h were included in the analysis, and the groups did not differ

in demographics, reasons for intubation, co-morbidity, and risk factors for VAP (Table 1), we could not exclude the possibility that VAP was reduced because of earlier extubation in the experimental group. In addition, before being discharged from the ICU, the patients were extubated and all of them were followed up for the occurrence of pneumonia after 48 h. Therefore, it was likely that the reduction in the length of the ICU stay was attributable to COS. The differences in the length of the hospital stay, tracheostomy, and mortality between the experimental and control groups do not appear to be statistically significant. Taking into consideration the small sample size in this pilot study, these results should be interpreted with caution. Hoem (2008) contended that indicators of statistical significance should be used flexibly rather than mechanically. For example, much higher *p*-values may be expected to indicate statistical significance in very small data sets, while for large studies *p*-values much smaller than 0.05 may be needed to indicate important features in the data.

4.1. Limitations

The findings of this research should be considered in light of its limitations. First, recruiting participants who are receiving mechanical ventilatory support for clinical study poses particular challenges (Chlan et al., 2009). Our results are limited by the small size of our sample. Further studies with larger samples are warranted to evaluate whether COS can decrease the incidence of VAP. Second, our findings represent the practices of only one hospital. We do not know if these practices are followed at other sites. A multisite study would be necessary to determine whether these findings also occur at other sites.

4.2. Implications for future research

Although there was a positive trend toward the use of the intervention, it would be unwise to advocate the use of COS in practice. Instead, the results of this pilot study can be used as a guide in the design and implementation of a full-scale, definitive randomized controlled clinical trial (RCT).

4.2.1. Sample size calculation

One reason to conduct a pilot study is to provide information for use in calculating the sample size of a subsequent main study (Arain et al., 2010). This seems especially sensible in situations where no data are available from previous studies to inform this process. Preliminary data collected from the current study were used to estimate the sample size requirements for the definitive RCT on COS. The expected event rates in the control group and treatment group were 83.3% and 23.1%, respectively. In a power analysis, the sample size for each group was estimated at 10 to reach a power of 0.8 with a 0.05 significance level, using G-power. Based on this calculation, the pilot study has already met sample size requirements for hypothesis testing. However, variance estimates obtained from pilot studies can be subject to substantial sampling errors. Treatment effects may be under- or overestimated because of the imprecision inherent in data from small samples (Sim and Lewis, 2012; Leon et al., 2011). Therefore if not used cautiously, the results of pilot studies can potentially mislead sample size or power calculations (Kraemer et al., 2006). Alternatively, it is common in practice to determine a required sample size by an estimate based on data from previous similar trials. In determining sample size requirements for the definitive RCT, VAP data from a previous study on the continuous aspiration of subglottic secretions conducted by Valles et al. (1995) were used for the estimation. The sample and data collection methodology were nearly identical to those in this study. Previous data showed that the VAP rates in the control group and treatment group were 32.5% and 18.4%, respectively. Based on the conditional assumption of a type 1 error of 0.05 and a power of 80%, the sample size required would be 149 per group. We anticipate recruiting a total sample size of approximately 331 to accommodate a potential attrition rate of 10% among the participants.

4.2.2. Adjudication of VAP

Careful adjudication of VAP can reduce random errors, and consistent decision-making requires strict criteria. In this open-label pilot study, the diagnostic criteria of VAP were standardized and agreed upon by all of the ICU physicians, who were not members of the research team. After training, they screened all of the participants in both the experimental and control groups daily for the occurrence of VAP. Disagreement between adjudicators would be resolved through discussion and consensus decision-making. Because these adjudications were made by physicians who were aware of the patients' treatment assignments, they were reviewed by the research team to ensure consistency and completeness. To further enhance the diagnostic accuracy of VAP, endotracheal aspirate was collected for culture not only at the time of intubation, but also repeated for any participant with a clinical suspicion of VAP. The diagnostic value of endotracheal aspirate was confirmed in a recent randomized trial conducted by the Canadian Critical Care Trials Group (2006) that involved 740 patients in 28 ICUs in Canada and the United States. They compared a diagnosis of VAP based on endotracheal aspirate culture with a diagnosis based on bronchoalveolar lavage culture and found no difference in clinical outcomes.

Owing to budgetary constraints, we were unable to use adjudication committees to conduct a blinded assessment of outcomes in this pilot study. The time-consuming nature of adjudication and the associated manpower costs in using this more stringent adjudication process would have diverted research funds from study infrastructure, data acquisition, or analysis. However, for a definitive RCT, a blinded assessment to ensure the rigorous adjudication of clinical outcomes is definitely an important issue to consider.

4.2.3. Training, safety, and regulatory issues

Before commencing the study, the research team gave all nursing staff in the ICU training on how to apply the saliva ejector and provide continuous oral suctioning.

Return demonstrations by nurses were assessed to ensure proper application and use of the device. Given the novelty of the intervention, the training provided an opportunity to develop consistent practices to confirm the competencies and skills required for the investigation to be conducted with accuracy and precision. This is critical, especially if multiple sites and investigators are engaged in the study.

The intervention itself was well received by nurses and patients, and the pilot study evolved quite well. All of the patients completed the intervention, and no adverse event was associated with COS. The saliva ejector was tolerated well, and no safety concerns were identified. Although the saliva ejector has been approved for use in dental surgery for suctioning, its application for the prevention of VAP is considered off-label. Currently, COS is an investigational intervention.

5. Conclusion

The incidence of VAP is high in mechanically ventilated patients. VAP brings an increase in morbidity and mortality, lengthens hospital stays, and raises healthcare costs. Preventing VAP is always preferable to treating it. COS may have an important role to play in reducing the rate of VAP, decreasing the duration of mechanical ventilation, and shortening the length of stay of patients in the ICU. The results of this pilot study warrant a full-scale RCT to ensure that the effects are real and that the intervention will have long-term benefits. Much work is needed to establish its efficacy as a non-invasive intervention in the prevention of VAP.

Conflict of interest

None declared.

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Ethical approval

Ethical approval was given by the Ethics Committee of the St. Paul's Hospital and the Human Subjects Ethics Subcommittee of The Hong Kong Polytechnic University (reference number: HSEARS20081021004-01).

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