

**SPECIAL PAPER****The Importance of Oral Hygiene in Prevention of Ventilator-Associated Pneumonia (VAP): A Literature Review****Hadi Darvishi Khezri, MSc**

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**Correspondence:** Amir Emami Zeydi, Department of Nursing, Amol Faculty of Nursing and Midwifery, Fayaz Bakhsh Alley, Taleb Amoli St, Amol, Iran. Email: emamizeydi@yahoo.com**Abstract**

Ventilator-associated pneumonia (VAP) is the most common nosocomial infection reported among mechanically ventilated patients. VAP is an emerging concept and remains a significant clinical problem for critically ill patients. Although VAP is often preventable, its effects on morbidity, mortality, length of hospital stay, and cost are enormous. VAP is not a new diagnosis, but education and research on the prevention of this serious problem are still continuing. Oropharyngeal colonization is the main risk factor for the development of VAP. Oral health can be compromised by critical illness and mechanical ventilation. It can also be influenced by nursing attentions. Therefore, education and focus on suitable oral care strategies are necessary. Moreover, nursing research to define the best process for all patients in ICU is needed. Whether nursing actions decrease VAP rates remains an empirical question that requires more research since no valid and reliable survey could be found in the literature for oral care practices on orally intubated critically ill patients. An oral care survey for orally intubated patients is hence essential to determine the best existing practices. Many studies have thus attempted to determine the effects of this intervention on the incidence of VAP. The present study aimed to review the literature focusing on oral hygiene in prevention of VAP.

**Key-words:** Evidence-Based Practice, Oral Hygiene, Pneumonia, Ventilator-Associated.

## Introduction

Pathogenic oral microflora plays an important role in several systemic diseases including cardiovascular diseases, endocarditis, respiratory problems, bacteremia, and ventilator-associated pneumonia (VAP) (Seymour & Whitworth 2002, Munro & Grap 2004). Within this group of diseases, nosocomial pneumonia has been increasingly studied and the relationship between VAP and microorganisms from the oral cavity has been progressively recognized (Taraghi et al., 2011). VAP is a form of nosocomial pneumonia that happens in patients receiving mechanical ventilation for longer than 48 hours (Augustyn, 2007). According to the most recent National Healthcare Safety Network report, in 1749 hospitals in the US, the mean incidence of VAP was 2 cases per 1000 ventilator days in 2009 (Dudeck et al., 2011). VAP was also responsible for half of antibiotic prescriptions in mechanically ventilated patients (Ashraf & Ostrosky-Zeichner 2012). The risk of developing VAP increases with the need for mechanical ventilation. VAP not only prolongs the length of hospital stay but also strikingly raises hospital costs. Moreover, its estimated mortality rate has been between 20% and 70% (Warren et al. 2003, Cason et al. 2007, Beraldo & Andrade 2008, Jamaati et al., 2010, Perrie et al., 2011, Coppadoro et al., 2012).

Occurrence of nosocomial infections is openly related to the adequacy of staff. Considering the importance of nursing care in VAP prevention and the great lack of nurses and the resultant increase in the number of less experienced nurses in the intensive care unit (ICU), education on VAP prevention is vital (Zack et al., 2002, Labeau et al., 2007, Ross & Crumpler 2007, Labeau et al., 2008). Nurses need to understand the pathophysiology of VAP, risk factors for this type of pneumonia, and policies that may prevent the disease. The purpose of this literature review was to highlight oral care interventions in prevention of VAP by nurses.

## Epidemiology

However, the real incidence of VAP is difficult to assess but its incidence that reported in the literature ranges from 10 to 20% (Safdar et al., 2005, Coppadoro et al., 2012). Historically, surgical ICUs have had higher rates of VAP compared to medical ICUs (Craven, 2000).

## Pathophysiology and etiology

According to the onset, VAP can be divided into 2 types of early and late. Early onset VAP occurs 48 to 96 hours after intubation and is associated with antibiotic-susceptible organisms. Late-onset VAP occurs more than 96 hours after intubation and is associated with antibiotic resistant organisms such as *Pseudomonas aeruginosa*, *methicillin-resistant Staphylococcus aureus* (MRSA), *Acinetobacter* species, and *Enterobacter* species. The latter type of VAP is accompanied by powerful pathogens and consequently has higher mortality (Augustyn, 2007).

The pathophysiology of VAP involves 2 main routes: colonization of the respiratory and digestive tracts and microaspiration of discharges of the upper and lower portions of the airway (Taraghi et al., 2011). Bacterial migration of the lungs can be caused by spread of organisms from many different sources including the oropharynx, sinus cavities, nares, dental plaque, gastrointestinal tract, patient to patient contact, and the ventilator circuit (Kunis & Puntillo 2003). Inhalation of colonized bacteria from any of these sources can cause an active host response and, finally, VAP (Taraghi et al., 2011).

## Risk Factors

The risk factors for VAP can be divided into 3 classifications, i.e. host-related, device-related, and personnel-related risk factors (Table 1) (Langer et al., 1989, Cook et al., 1998, Drakulovic et al., 1999, Akça et al., 2000, Arozullah et al., 2001, Pawar et al. 2003, Apostolopoulou et al., 2003, Kobashi & Matsushima 2003, Bullock et al., 2004, Alp et al., 2004, Grap et al., 2012, Tsai et al., 2012).

The presence of an endotracheal tube (ETT) inhibits normal coughing, normal swallowing, and the protection of the trachea contact by epiglottis closure. As respiratory pathogens continue to flourish within their protective plaque structures, they make their way into the subglottic pool and are placed around the ETT cuff for migration.

This process enables them to descent into the lungs and start infection. ETTs cause an abnormal interruption between the upper airway and the trachea. They thus bypass the structures in the extrathoracic airway and give the bacteria a direct path into the intrathoracic airway. Because the upper airway is bypassed, a decrease

**Table 1. Risk factors for ventilator-associated pneumonia**

<p>Host-related</p> <ol style="list-style-type: none"> <li>1. Supine body positioning</li> <li>2. Severe underlying condition</li> <li>3. Chronic obstructive lung disease</li> <li>4. Adult respiratory distress syndrome</li> <li>5. Compromised immune system</li> <li>6. Immobilization due to trauma or illness</li> <li>7. Surgical procedure involving the head, neck, thorax, or upper abdomen</li> <li>8. Level of consciousness (coma)</li> <li>9. Emergency intubation</li> <li>10. Number of intubations</li> <li>11. Advanced age</li> <li>12. Malnutrition</li> <li>13. Transfusion of packed red blood cells (RBCs)</li> <li>14. Medications including prior antibiotics, histamine-2 (H<sub>2</sub>) receptor antagonists, proton pump inhibitors (PPIs), paralytic agents, and continuous sedation and immunosuppression</li> <li>15. Hypoalbuminemia</li> <li>16. Uremia</li> <li>17. Duodenogastroesophageal reflux (bile acid in oral secretions)</li> <li>18. Need for emergent surgery</li> <li>19. High Acute Physiology and Chronic Health Evaluation score (usually &gt; 18) on admission</li> </ol>
<p><i>Device-related</i></p> <ol style="list-style-type: none"> <li>1. Endotracheal tube</li> <li>2. Longer duration of intubation</li> <li>3. Ventilator circuit</li> <li>4. Nasogastric or orogastric tubes</li> </ol>
<p><i>Personnel-related</i></p> <ol style="list-style-type: none"> <li>1. Improper hand washing</li> <li>2. Failure to change gloves between contacts with patients</li> <li>3. Not wearing personal protective equipment when antibiotic resistant bacteria have been identified</li> </ol>

occurring in the body's ability to filter and moisten air. In addition, the mucociliary clearance can be impaired because of mucosal damage during intubation (De Rosa & Craven 2003). Mucus in the airways can become stagnant and serve as a medium for bacterial growth. Therefore, maintenance of aseptic technique when performing endotracheal suctioning is essential to prevent contamination of the airways (Augustyn, 2007).

Saline lavage of ETT before suctioning dislodges bacteria from the ETT into the lower airways and thus surges the risk for VAP (Moore, 2003). Saline lavage has long been considered as a means to liquefy secretions and prevent plugs of mucus in ETTs. Maintaining adequate hydration, ensuring suitable humidification of the ventilator circuit, and using nebulizer or mucolytic agents can help reduce the viscosity of secretions and remove the need for saline lavage (Akgul & Akyolcu 2002). Although some investigators have compared the effects of heat and moisture exchangers (HME filter) and heated humidifiers on the incidence of VAP, a final conclusion was not obtained about the form of humidity which collaborated with a higher incidence of VAP (Augustyn, 2007).

### Diagnosis

The establishment of an appropriate diagnosis of VAP is one of the most crucial and challenging issues in the care of critically ill patients. Diagnosing VAP has remained difficult and controversial. The diagnosis can be made on the base of radiographic and clinical findings, results of microbiological tests of sputum, or aggressive testing such as bronchoscopy (Porzecanski & Bowton 2006). The chance of VAP rises if a patient has clinical signs such as fever, leukocytosis, and purulent sputum as well as abnormal findings on chest radiographs (Grossman & Fein 2000). A randomized trial of diagnostic plans for patients with suspected VAP, on 740 patients from 28 hospitals, showed that the use of quantitative culture of bronchoalveolar lavage fluid (BAL) would be related to an increased use of targeted therapy and improved clinical outcomes (Heyland et al., 2006).

### Prevention

Many strategies have been incorporated into "VAP bundles". A VAP bundle is a set of treatments implemented simultaneously to reduce VAP incidence. Recent studies have proposed that the use of bundle treatments can result in considerable

decreases in rates of VAP (Coppadoro et al. 2012, Westwell 2008, Morris et al., 2011, Brierley et al. 2012). Four elements VAP prevention bundle includes head-of-bed elevation, oral chlorhexidine, sedation holds, and weaning (Morris et al., 2011). Hutchins et al. mentioned that the use of an oral care protocol along with a ventilator bundle led to an 89.7% reduction in the VAP rate in mechanically ventilated patients from 2004 to 2007 (Hutchins et al., 2009).

Although VAP has complex risk factors, many nursing interventions can reduce the incidence of VAP (Table 2) (Coppadoro et al., 2012, Morris et al., 2011, Bingham et al., 2010, Nseir et al., 2011, Rello et al., 2012). Plans to eliminate VAP, such as using non-invasive ventilation and oral care, using sucralfate rather than H<sub>2</sub> antagonists for stress ulcer prophylaxis, and actions to prevent aspiration, e.g. semi-recumbent positioning or elevation of the head of the bed and constant subglottic suctioning, and kinetic bed therapy have all been revealed to decrease the risk of VAP (Heyland et al., 2002, Safdar et al., 2004). Early tracheostomy has been supported as one of the potential preventive measures for VAP. Although tracheostomy decreases the duration of ventilation and ICU stay (Griffiths et al. 2007), a recent randomized controlled trial failed to prove a reduction in VAP incidence when early tracheostomy (6-8 days after intubation) was performed (Terragni et al., 2010).

Several studies have evaluated the efficacy of VAP prevention using silver-coated ETTs. In a study, the use of a silver-coated ETT was related to lower rates of VAP and late-onset VAP (Kollef et al., 2008). Hence, the use of anti-bacterial coated ETT seems appropriate to treat patients expected to be ventilated for more than 48 hours. It is thus a cost-effective method which would probably result in VAP prevention (Shorr et al., 2009).

Care of the internal lumen of the ETT might be a new method to prevent VAP (Berra et al. 2012). The mucus shaver is a device able to keep the ETT free of secretions by mechanical elimination of the deposits. Although the elimination of biofilm with this device may be useful, no data is yet available to show a diminishing VAP incidence.

Modified cuffs have been suggested to improve tracheal sealing and decrease secretion drainage. No absolute clinical data is accessible about the use of materials other than polyvinyl chloride (PVC), such

as polyurethane, silicone, or latex, to prevent VAP (Zanella et al., 2011). However, a retrospective study on more than 3000 patients indicated a relationship

between the use of a polyurethane cuff and a reduction in VAP incidence (Miller et al., 2011).

**Table 2. Strategies to prevent ventilator-associated pneumonia**

<p><i>Prevent colonization</i></p> <ol style="list-style-type: none"> <li>1. Follow protocol for hand washing</li> <li>2. Use oral decontamination</li> <li>3. Use stress ulcer prophylaxis</li> <li>4. Avoid saline lavage with suctioning</li> <li>5. Turn patients at least every 2 hours</li> <li>6. Change ventilator circuit no more than every 48 hours</li> <li>7. Anti-microbial agent(s)-coated <b>endotracheal tubes</b>, e.g. silver-coated endotracheal tubes</li> </ol>
<p><i>Prevent aspiration</i></p> <ol style="list-style-type: none"> <li>1. Position the head of the bed &gt; 30°</li> <li>2. Minimize the use of narcotic and sedative agents</li> <li>3. Thoroughly suction the oropharynx</li> <li>4. Use endotracheal tubes that have continuous subglottic suction ports</li> <li>5. Monitor gastric residual volumes for overdistention</li> <li>6. Maintain adequate endotracheal tube cuff pressures (20-30 cm H<sub>2</sub> O)</li> <li>7. High-volume/low-pressure endotracheal tube cuffs made of polyvinylchloride (PVC)</li> </ol>

### Noninvasive Ventilation

Since VAP is connected with intubation, avoidance of intubation is the most effective non-pharmacological preventive measure. Girou et al. found that rates of nosocomial pneumonia and all nosocomial infections were much less in patients supported with noninvasive ventilation than those intubated and ventilated mechanically (8% vs. 22% and 18% vs. 60%;  $p=0.04$  and  $p<0.001$ , respectively). In addition, the proportion of patients receiving antibiotics for nosocomial infection (8% vs. 26%;  $p=0.01$ ), length of ICU stay (9 vs. 15 days;  $p=0.02$ ), and crude mortality (4% vs. 26%;  $p=0.002$ ) were all far lower among patients receiving noninvasive ventilation (Girou et al. 2000). Randomized trials have found similar results

(Bersten et al. 1991, Heyland et al. 2002). They have shown that patients with exacerbations of chronic obstructive pulmonary disease (COPD) supported by noninvasive ventilation had a 62% descent in mortality compared to patients who were intubated and mechanically ventilated. Moreover, the need for endotracheal intubation was diminished in the first group (Massimo & Giorgio 2000, Lightowler et al. 2003).

### Oral Care:

Accumulation of bacteria in the throat is one of the most important risk factors for VAP and the relation between VAP and oral microflora is thoroughly known (Fourrier et al., 1998). Oropharyngeal colonization is a strong independent predictive factor

for colonization of trachea and bronchi (Taraghi et al., 2011, Berry et al., 2011, Zurmehly 2013). In 76% of VAP cases, the bacteria colonizing the mouth and lung are identical (Tablan et al., 2004, Berry et al., 2011). Scannapieco et al., showed that the potential pathogens that cause VAP, including *Streptococcus aureus* and *Pseudomonas aeruginosa*, were found in the oral cavity of ICU patients (Munro et al. 2006). George et al. reported that 42% of pathogens isolated from respiratory secretions of 26 patients with VAP had previously existed in their oropharynx (George et al. 1998). Many studies have evaluated the efficacy of oral decontamination for the prevention of nosocomial pneumonia. Policies for prevention of VAP via oral hygiene include subglottic suctioning and removing dental plaques and associated microbes with mechanical interventions (e.g. tooth brushing and rinsing of the oral cavity) and pharmacological interventions (e.g. use of antimicrobial agents) (Abele-Horn et al., 1997). Therefore, it seems that an effective way to prevent VAP is reducing the amount of oral microorganisms.

Nurses are the first line of protection in preventing bacterial colonization of the oropharynx and the gastrointestinal tract. Scrupulous hand washing for 10 seconds should be performed before and after all contacts with patients. In addition, gloves should be worn when contact with oral or endotracheal secretions is probable (Tablan et al., 2004). Hixson et al., suggested that even though oral hygiene is considered as typical nursing care, it is often disregarded in critically ill patients (Hixson et al. 1998). A reliable and comprehensive oral hygiene program is a VAP prevention strategy commonly recommended by Centers for Disease Control (CDC), (Hixson et al., 1998) the Association for Professionals in Infection Control and Epidemiology (APIC), (APIC 2004) the Institute for Healthcare Improvement (IHI), (IHI 2012) and the American Association of Critical Care Nurses (AACN) (Wiegand & Carlson 2005). It has been found that integration of routine oral care into standard practice may diminish VAP by as much as 60% (Scannapieco et al., 2001).

### **Subglottic Suction**

Among the VAP prevention strategies, reduction of aspiration with continuous aspiration of subglottic secretions (CASS) can be effective (Dodek 2004). A recent meta-analysis on approximately 2500 patients emphasized the importance of subglottic secretion drainage systems in preventing VAP, restricting ICU

stay, and decreasing days of ventilation (Muscedere et al. 2011). Another meta-analysis by Dezfulian et al., (2005) demonstrated that CASS is effective in preventing early onset VAP. A controlled trial by Kollef et al. revealed that CASS prevented early onset VAP but not late onset VAP (Wunderink, 1999). Since studies evaluating CASS have not produced consistent results, its role in the prevention of VAP remains controversial. However, its use has been recommended in the updated Canadian Critical Care Trials group (Muscedere et al., 2008) and the guidelines of the British Society for Antimicrobial Chemotherapy (Masterton et al., 2008). Continuous aspiration has been shown to cause mucosal damage in animal models (Berra et al., 2004). Consequently, intermittent aspiration systems are mostly preferred. A multicenter study showed a reduction in VAP rate in the group treated with intermittent secretion drainage (Lacherade et al., 2010).

### **Tooth Brushing**

Dental plaque may serve as a base for pathogens in ICU patients since it may be colonized by possible respiratory pathogens such as *MRSA* and *Pseudomonas aeruginosa* (Gipe et al., 1995, Grap et al., 2003). Fundamentally, dental plaque and associated microorganisms can be removed by local decontamination with the topical use of tooth brushing (Chan et al., 2007). While some studies have shown the effectiveness of tooth brushing in reducing VAP, some others could not establish such an effect (Munro et al., 2009, Zamora, 2011, Lorente et al., 2012, Alhazzani et al., 2013). Removing dental plaque organisms during tooth brushing might provide a larger pool of organisms for translocation from the mouth to subglottic secretions or the lung (Lorente et al., 2012). A review of the association between oral care and bloodstream infections in patients receiving mechanical ventilation, especially in patients with poor dental health, proposed the need for further investigation (Jones & Munro 2008).

In a clinical study, Yao et al. showed that after 7 days of twice daily tooth brushing with purified water, cumulative VAP rates were significantly lower in the experimental group compared to the control group (17% vs. 71%;  $p < 0.05$ ). They hence suggested twice daily tooth brushing with purified water to decrease VAP and improve oral hygiene (Yao et al. 2011). A literature search on 8 studies indicated that tooth brushing was recommended as a high standard of oral care for mechanically ventilated patients since it decreased VAP when used with chlorhexidine

(Roberts & Moule 2011). It seems that tooth brushing needs to be accompanied by an antimicrobial mouthwash. On the other hand, in a recent randomized controlled trial, Lorente et al., reported that adding manual tooth brushing to chlorhexidine oral care was not beneficial in prevention of VAP (Lorente et al., 2012). Ames has recently mentioned that powered toothbrushes with a rotation oscillation action decreased plaque and gingivitis more effectively than manual toothbrushes (Ames, 2011). Pediatric toothbrushes may be easier to use in intubated patients and would improve quality of oral care (Fitch et al., 1999).

### Chlorhexidine Mouthwash

Among the variety of synthetic mouthwashes in the market, chlorhexidine (CHX) is the most effective anti-microbial mouthwash and has been approved by the American Food and Drug Administration (FDA) (Paknejad et al., 2006) and the American Dental Association (ADA) (Salehi et al., 2005). CHX is considered as the gold standard amongst mouthwashes and is now widely used as the standard of care for intubated patients (Coppadoro et al., 2012). CHX has a wide range of activity against gram-positive microorganisms including multiresistant pathogens such as *MRSA* and *vancomycin-resistant enterococci (VRE)* (Katz et al., 2001, Koeman et al., 2006). Many studies have been performed on antibacterial effects of CHX mouthwash. Veksler and Arweiler demonstrated that CHX significantly reduced the number of oral bacteria (Veksler et al., 1998, Arweiler et al., 2001). Scannapieco et al. evaluated the effects of CHX on oral pathogenic bacteria in 115 mechanically ventilated trauma patients and showed that CHX reduced *Staphylococcus aureus* and negative agents such as *Pseudomonas aeruginosa* and *Acinetobacter* in dental plaques (as a source of bacteria) by 0.12% (Scannapieco et al., 2009).

In 2005, the guidelines of the American Thoracic Society noted the benefits of oral chlorhexidine washes in decreasing rates of VAP in patients who had undergone coronary artery bypass graft surgery (ATS 2005). Various studies have been performed to assess the effects of CHX on dental biofilm and gingival infection. Although their results were promising regarding the reduction in plaque accumulation and colonization by various bacterial types (Scannapieco et al., 2009, Fourrier et al., 2000, Vianna et al., 2004, Segers et al., 2006), the effects of CHX on VAP remain controversial (DeRiso et al.,

1996, Fourrier et al. 2000, Munro et al. 2007). In a meta-analysis, Pineda et al. demonstrated that the use of oral decontamination with CHX neither caused significant reduction in the incidence of VAP, nor altered the mortality rate (Pineda et al., 2006). Koeman et al., (2006) and Ozçaka et al., (2012) suggested that topical oral decontamination with CHX reduced the incidence of VAP. In a systematic review and meta-analysis, Labeau et al. showed that the use of CHX resulted in a significant risk reduction of VAP relative risk (RR): 0.67; 95% confidence interval (CI): 0.50-0.88;  $p=0.004$  (Labeau et al., 2011). Another systematic review and meta-analysis by Zamora reported similar findings (Zamora, 2011). It seems that moderating oropharyngeal colonization by CHX, at least theoretically, reduced the probability of VAP. However, its influence on mortality reduction has not yet been clarified (Chlebicki & Safdar 2007). In a systematic review on 8 randomized controlled trials, Snyders et al. indicated a 36% higher chance of VAP in the control group compared to the CHX group (RR: 0.64, 95% CI: 0.44-0.91). They also introduced the use of 2% chlorhexidine as the most effective method to reduce the incidence of VAP. However, there was no evidence of the efficacy of CHX on mortality (Snyders et al., 2011). Among the various concentrations of CHX (0.12%, 0.2%, and 2%), favorable outcomes were more pronounced with CHX 2%. (Ashraf & Ostrosky-Zeichner 2012, Andrews & Steen 2013). We recommend physicians and nurses to promote routine use of oral CHX (0.12%-2%) for oral hygiene in ventilated patients.

### Herbal Mouthwashes in ICU

Adverse effects and resistance to synthetic mouthwashes have been reported as a problem in ICU patients (Munro et al., 2006, Allaker & Douglas 2008). Some studies have thus been performed to find antibacterial materials with plant origin. Taraghi et al., (2011) showed that an herbal mouthwash of persica<sup>®</sup> (miswak extract), reduced the number of bacterial colonies and were effective on *S. aureus* and *Streptococcus pneumonia* in ICU patients under mechanical ventilation. They determined and compared the immediate antibacterial effects of persica<sup>®</sup> mouthwash 10%, CHX gluconate 0.2%, and normal saline in mechanically ventilated ICU patients. Their results showed that all 3 mouthwashes reduced the colony count numbers after the intervention. Both CHX gluconate 0.2% and persica<sup>®</sup> 10% were similarly effective on *Staphylococcus*

*aureus* and *Streptococcus pneumonia* (Taraghi et al., 2011). Furthermore, the World Health Organization (WHO) recommends and encourages the use of chewing persica sticks (miswak) as an effective oral hygiene procedure (Amoian et al., 2010). Gholipour Baradari et al., reported that the herbal mouthwash Matrica® (Camicell™) reduced the number of bacterial colonies and was effective on *Streptococcus aureus* and *Streptococcus pneumonia* in ICU patients under mechanical ventilation. They hence concluded that the mouthwash could be used as an alternative to chemical mouthwashes. Their results showed that CHX and Matrica® reduced the number of bacterial colonies and were effective on *Streptococcus aureus* and *Streptococcus pneumoniae*. However, CHX had greater antibacterial effects than Matrica® (Baradari et al., 2012).

### Further Research

A number of policies have been suggested for VAP prevention. Nevertheless, only a few have been confirmed to be effective and many others must be further evaluated in large clinical trials before definite recommendations can be made. Antimicrobial coated ETT, alternative cuff forms and materials, and ETT secretion removal are among the strategies which need to be particularly assessed. Additional studies would be of great value in the continuing contest to decrease the rates of VAP.

We recommend all ICUs to use an oral hygiene protocol based on the best available evidence-based practice. They are also suggested to employ interventions to prevent VAP from the beginning of intubation and until extubation. Furthermore, we recommend future studies with the aim of comparing herbal mouthwashes, e.g. persica and Matrica®, to prevent the occurrence of VAP.

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