

Kimberly-Clark Health Care

Ventilator-Associated  
Pneumonia (VAP)  
*Best Practice Strategies  
for Caregivers*

**By D. Theron Van Hooser  
M.Ed. RRT, FAARC**

Protection. For life.



**Kimberly-Clark**

### Overview

Pneumonia accounts for nearly 15% of all hospital acquired (nosocomial) infections and 24% to 27% of all those acquired in coronary care units and medical intensive care units (ICU) respectively.<sup>1,2</sup> Ventilator-Associated Pneumonia (VAP) is a serious complication of mechanical ventilation which increases the patient's stay in the ICU and overall length of hospital stay and adds to overall costs.<sup>3,4</sup> VAP is the most common of all nosocomial infections which contribute to death.<sup>5</sup> In spite of extensive world wide efforts to understand, prevent and treat this complication,<sup>5,6</sup> a mortality rate of approximately 30% still exists.<sup>7</sup> Several organizations and institutions<sup>6,8,9</sup> have recommended strategies and approaches in an effort to address this problem. Evidence-Based Guidelines (EBGs) have been published, but there is still large variability in conformance by both physicians and nurses.<sup>10,11</sup>

There are principles and strategies which make Best Practice possible. This program will outline these strategies and discuss their impact on VAP.

### Learning Objectives

Upon completion of this educational program, the learner will be able to:

1. Describe the epidemiology of VAP including the incidence, microbiology, and mortality.
2. List several contributing risk factors leading to VAP.
3. Describe three major VAP prevention principles.
4. Describe how these principles prevent VAP.
5. Match key points to the specific major prevention principle to which it belongs.
6. Describe the ideal Best Practice VAP prevention program.
7. Describe two benefits of a successfully implemented VAP prevention education program.

### Epidemiology of VAP

As early as 1972, studies have shown that the airway of mechanically ventilated patients quickly becomes colonized with gram-negative organisms.<sup>12</sup> At that time, it was thought that pathogens came from the ventilator equipment in use. However, as the problem was studied and evidence accumulated, it became evident that the origin of the VAP was from a source other than the ventilator equipment.<sup>13</sup> The primary route of VAP pathogenesis is a combination of two processes: bacterial colonization of the aerodigestive (upper airway + upper digestive) tract and the subsequent aspiration into the lower airway.<sup>7,14</sup>

### Definition of VAP

In order for hospitals to compare data, the National Nosocomial Infection Surveillance System (NNIS) division of the Center for Disease Control and Prevention (CDC) has made benchmarks and definitions for everyone to use so that meaningful comparisons can be made. The CDC has published extensive guidelines.<sup>8</sup> These definitions are lengthy and complicated with standardized performance indicators for the monitoring of and definitions for pneumonia. Mayall defines VAP as "pneumonia in patients who have been on mechanical ventilation for greater than 48 hours."<sup>15</sup> The following discussion will use Mayall's definition.

### Microbiology

VAP is a bacterial pneumonia which develops in patients receiving mechanical ventilatory support through an artificial airway. If the infection occurs within 48 to 72 hours, it is called “early-onset”. Early-onset pneumonia is usually caused by one of the following bacteria:<sup>7</sup>

- Staphylococcus aureus (gram positive)
- Haemophilus influenzae (gram negative)
- Streptococcus pneumoniae (gram positive)

These are antibiotic sensitive strains which are common in the ICU.

Late-onset VAP is defined as pneumonia occurring after 72 hours of ventilation and is usually caused by:

- Methicillin Resistant Staphylococcus aureus (MRSA)
- Pseudomonas aeruginosa
- Acinetobacter or Enterobacter

In most patients, VAP is caused by multiple organisms.<sup>16</sup>

### Incidence

Diagnosis of VAP is difficult, therefore accurate accounting of the incidence of VAP is also difficult,<sup>17</sup> and the diagnosis varies from study to study. Clinical symptoms which can be attributable to other conditions<sup>18</sup> can and do confound the accountability. In the United States, VAP rates are reported as cases per 1000 ventilator days. The mean VAP rate for burn patients in the US is 12.3. Neurosurgical patients have the highest rate at around 20 and pediatrics the lowest at 5.9.<sup>17</sup>

The overall percentages of nosocomial infections in US hospitals rank urinary as the highest (31%), pneumonia second (27%), and blood stream third (19%).<sup>1</sup> All three classes of infection are related to devices: urinary catheters, ventilators, and indwelling catheters, respectively.<sup>1</sup> Grossman reported that with each day of mechanical ventilation and intubation, the crude VAP rate increases by 1% to 3% and the death risk increases from two-fold to 10-fold.<sup>19</sup>

### Traditional Signs and Symptoms of VAP<sup>15</sup>

- Chest X-ray showing new or progressive diffuse infiltrate which is not attributable to any other cause
- Onset of purulent sputum
- Fever greater than 38.5°C (101°F)
- Leukocytosis
- Positive sputum or blood cultures

### Mortality

Kollef quotes the crude mortality rate for VAP as 30%.<sup>7</sup> Craven lists the mortality to be between 27% and 43% with surgical ICU being higher than medical ICU.<sup>16</sup> It is important to note that as the number of days intubated increases, so does the mortality rate.

### VAP Risk Factors

The single largest VAP risk factor is the endotracheal tube. Because mechanical ventilator support cannot be performed without the endotracheal tube (or other artificial airway), it is a necessary evil. The endotracheal tube provides a direct passageway into the lungs, bypassing many “natural protection” mechanisms. The endotracheal tube increases the risk for VAP by:

- preventing cough (the patient's natural defense)
- preventing upper airway filtering
- preventing upper airway humidification
- inhibiting epiglottic and upper airway reflexes
- inhibiting ciliary transport by the epithelium
- acting as a direct conduit into the lungs for airborne pathogens
- potentially acting as a reservoir for pathogens by providing a place for biofilm to form
- having a cuff which provides a place for secretions to “pool” in the hypoglottic area
- initiating a foreign body reaction, interfering with the local immune response

Host or patient risk factors include:<sup>17</sup>

- age of 65 or more
- underlying chronic illness (e.g. Chronic Obstructive Pulmonary Disease (COPD), emphysema, asthma)
- immunosuppression
- depressed consciousness
- thoracic or abdominal surgery
- previous antibiotic therapy
- previous pneumonia or remote infection

Other device treatment and personnel related risk factors include:<sup>4,7,12,17</sup>

- nasogastric tube placement
- bolus enteral feeding
- gastric over-distension
- stress ulcer treatment
- supine patient position
- nasal intubation route
- instillation of normal saline
- understaffing
- nonconformance to handwashing protocol
- indiscriminate use of antibiotics
- lack of training in VAP prevention

## Three Major VAP Prevention Principles

Ventilator associated pneumonia can be reduced with the implementation of a Best Practices program with these three factors or principles:

- Staff education
- Colonization reduction
- Aspiration avoidance

### Staff Education

To change the VAP rate in any given ICU, a change in human behavior is needed. Like all behavioral changes, education and reinforcement is required. Education is therefore the first step in a VAP best practice program, followed by reduction of oropharyngeal colonization and reduction of aspiration. Education of the staff about VAP is absolutely necessary for a successful program. The implementation of all three strategies are required to maximally lower the VAP rate over the long term.<sup>20</sup>

### Colonization Reduction

Colonized secretions reside in both the gastrointestinal tract and oropharynx.<sup>21</sup> Basic nursing care principles are the first line of defense.<sup>17</sup> Incorporating the following key points and practices can reduce colonization.

#### • *Handwashing*

The practice of handwashing and the wearing of gowns and gloves are basic and quite possibly the most important actions taken for reducing colonization. Methicillin Resistant Staphylococcus aureus (MRSA) is commonly spread by caregivers' hands.<sup>12</sup> Gloves and gowns have been shown to be effective in preventing the nosocomial spread of antibiotic resistant bacteria including Vancomycin-resistant enterococci (VRE) as well as MRSA.<sup>7</sup>

#### • *Oral Hygiene*

The importance of patient oral and nasal hygiene is often overlooked, although it is one of the most basic of nursing interventions. Sole found that less than half of the 27 surveyed sites (48%) had written policies for oral care of intubated patients, and even fewer (37%) had oral suction policies.<sup>22</sup> The use of closed suction systems (CSS) may contribute to the inattention paid to oral care in that oral suctioning is an integral part of traditional open suction procedures. Yet, it is widely recognized that the mouth is a virtual garden of normal bacterial flora and pathogenic organisms. Both Kollef<sup>7</sup> and Kunis<sup>12</sup> have advocated chlorhexidine oral rinse to reduce the oral bacterial load; however, its regular use may lead to chlorhexidine resistant organisms. Several studies have shown that oral decontamination is an effective method for reducing VAP.<sup>23-25</sup>

#### • *Common Suction Protocol*

Standardized, common endotracheal suction protocols, in which everyone suctions the same way, are of central importance in the reduction of colonization. The use of a CSS should be part of a VAP reduction program.<sup>7,13</sup> It has been shown that a focused education program using a common protocol actually lowered the infection rate and substantially reduced the associated costs and morbidity.<sup>26</sup>

### • *Closed Suction System*

The CSS provides a barrier to separate the contaminated (colonized) catheter from the caregiver and other patients. One study has shown a significant reduction in the VAP rate with closed suctioning.<sup>27</sup> The recently revised clinical practice guideline published by the American Association for Respiratory Care (AARC)<sup>13</sup> recommends the use of the CSS as part of a VAP prevention strategy. In addition to reducing the risk of microbial contamination as compared to the open suctioning technique, closed suctioning permits continuous ventilation reducing respiratory stress and vulnerability.

Change out timing of CSS at 24 hours is presently being debated with at least two studies.<sup>28,29</sup> Another study has shown increased colonization when extending the use of the CSS longer than the recommendations stated on the label.<sup>30</sup> The length of time a CSS can be safely used beyond that which is indicated in the Directions for Use has not been determined.<sup>13</sup>

### • *Saline Lavage*

Research does not support the use of saline lavage. Saline instillation in either the endotracheal tube or the tracheostomy tube is controversial<sup>31</sup> and may even be detrimental to the patient.<sup>32</sup> One study concludes that bacteria may be dislodged from the catheter and endotracheal tube into the lung<sup>33</sup> during the procedure while simultaneously causing oxygen desaturation.<sup>31</sup> However, some textbooks still recommend the use of saline sparingly for thick secretions.<sup>34</sup>

### • *Closed Suction System Rinse Protocol*

Saline instillation into the patient's artificial airway as discussed above is controversial and not supported by the literature, but this is not to say that saline rinsing the CSS after the suction episode should not be done. Thorough and complete rinsing of the CSS with sterile saline after the suction is of utmost importance when attempting to minimize colonization. Interestingly, Sole found that there is a difference in practice between nurses and respiratory therapists when rinsing the CSS.<sup>22</sup> The optimal method of cleansing the system is to follow the Directions for Use provided by the manufacturer.

### • *Maintain Closed Circuit*

Obviously reducing the opportunity for contamination to occur from outside pathogens will reduce the colonization within the circuit; therefore, maintaining a closed circuit is emphasized by the AARC<sup>13</sup> and others.<sup>35</sup>

### • *Use Closed Condensation Traps*

Condensation traps permit drainage without requiring the circuit to be opened, thus preventing external contamination. When using active humidification, the use of condensation traps in the ventilator circuit which do not require opening to be emptied is recommended by Zack.<sup>26</sup> This also reduces manipulation of the tubing thus reducing contaminated colonization dump into the airways. Opening the circuit for other procedures should be avoided.<sup>13</sup>

### • *Stress Ulcer Prophylaxis*

All patients receiving mechanical ventilator support are susceptible to gastrointestinal hemorrhage (stress ulcer).<sup>7</sup> Prophylactic agents such as antacids and histamine type-2 antagonists are often used to protectively reduce peptic acidity. In this changed pH environment, the stomach may become colonized with pathogenic bacteria. As gastric volume is increased, micro-aspiration may also occur at any time. Both factors will increase the opportunity for VAP to occur. Alternatively, sulcralfate has been advocated<sup>20</sup> because it does not decrease the acidity or increase gastric volume and can prevent bleeding.

- *Selective Decontamination of the Digestive Tract (SDD)*

If microorganisms survive the peptic environment, regurgitation or reflux can place bacteria into the esophagus and upper airway. A procedure more widely used in Europe,<sup>12</sup> administration of topical antibiotics (Tobramycin, Polymixin B and others) via a paste or solution into the mouth and stomach with the goal of reducing the colonization and subsequent VAP, is controversial. However, neither of two meta-analyses of the research literature showed significant difference in mortality when the data was corrected for the systemic administration of antibiotics.<sup>36</sup> Furthermore, the use of SDD has been associated with emergence of antibiotic-resistant strains of bacteria -- a worldwide problem which is on the increase.<sup>36</sup>

### Aspiration Reduction or Prevention

The pathogenesis of VAP involves micro-aspiration of oropharyngeal and/or gastric secretions.<sup>21</sup> Any intervention which reduces the opportunity for aspiration will reduce the opportunity for VAP. Many of these interventions are simple and cost efficient. Key points for reducing or preventing aspiration include, but are not limited to, the following:

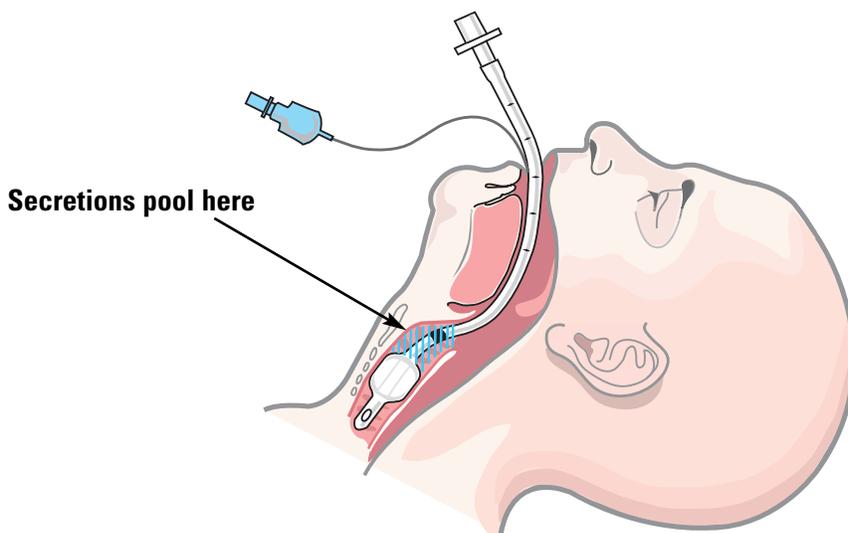
- *Regular Oral Suction and Hygiene*

As mentioned in the oral hygiene section above, oral care which includes suctioning is widely recognized as a major preventive strategy, yet actual practices vary widely and do not always reflect current research.<sup>22,37</sup> The CDC guideline, "Guidelines for Preventing Health-Care Associated Pneumonia, 2003", recommends oral suction as a routine prior to extubation.<sup>9</sup> In addition, Zack included oral hygiene in the educational program which reduced VAP by 57.6% in a hospital which has 5 intensive care units.<sup>26</sup>

- *Subglottic Suction*

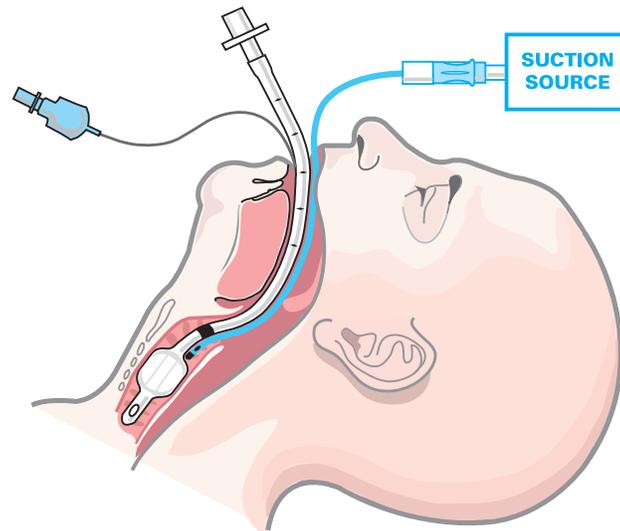
The endotracheal tube prevents glottic closure. As a result, the patient is unable to cough and remove secretions in a natural way. However, accumulation or pooling of oropharyngeal secretions above the endotracheal tube cuff occurs and then these fluids can be aspirated. See Figure 1.

**Figure 1**



Removal of these secretions by suction can reduce the risk of aspiration and may be the most cost effective and safe intervention.<sup>38</sup> Four studies have shown subglottic suction to be safe and effective,<sup>14,38-40</sup> while only one study showed no difference in colonization.<sup>41</sup> Figure 2 shows one method of performing subglottic suction with a separate suction catheter placed into the sub-glottic area.

**Figure 2**



- ***Minimize Endotracheal Tube Manipulation and Maintain Cuff Pressure***

Cuffed endotracheal tubes are essential in adults when positive pressure ventilation is used. The correct pressure within the cuff is critical to prevent aspiration around the cuff yet maintain ventilation and adequate capillary perfusion of the contacted mucosa.<sup>42</sup> The ideal cuff pressure has not been established; however, most authors agree that the cuff should be maintained at or below 20 mm/Hg as one study has shown that VAP is increased by 2.5 times if the cuff pressure is allowed to go below 20 mm/Hg.<sup>22</sup> Presumably, pathogenic laden secretions are able to migrate between the cuff and tracheal wall through minute channels which may be created when the pressure drops and the cuff is manipulated. Therefore, cuff pressure should be measured and recorded on a regular basis.<sup>17,22,42</sup> Also, when the tube is repositioned, oral care and subglottic suction should be performed to reduce disruption and aspiration of colonized bacteria.<sup>17</sup> Unnecessary manipulation of the tube should be avoided.

- ***Reverse Trendelenberg's (Head Up) Position***

Supine body position is a risk factor for VAP. Elevation of the head of the bed to 30 degrees is strongly supported as a preventive strategy that lowers the risk of aspiration.<sup>43</sup> Semi-recumbent (elevation of head above 30 degrees) position is low cost, and effective.<sup>44</sup> Routine (standing) orders to keep all mechanically ventilated patients in the semi-recumbent position can be cost effective but will require an education program for both nurses and physicians to ensure compliance.<sup>45</sup>

### • *Post-pyloric Feeding*

When gastric feeding tubes are placed, the gastroesophageal (cardiac) sphincter is violated which can cause or contribute to reflux. The feeding tube is yet another PVC tube transcending the oropharynx, which can provide a route for microbial access and colonization. Alternatively, delivering the feeding solution via percutaneous enteral gastric tube into the small bowel (post pyloric) has several advantages: reduction in gastroesophageal regurgitation, increased nutrient delivery, shorter feeding time, and a lower VAP rate.<sup>46</sup> In addition, continuous rather than bolus feeding is better tolerated by the patient to keep the stomach from becoming over distended and preserve peptic acidity at levels lethal to most bacteria.<sup>17</sup> The optimal approach for providing nutrition to mechanically ventilated patients is yet undefined; however, small bowel feeding is associated with an overall reduction of pneumonia.<sup>20</sup>

### • *Early Extubation*

Because the occurrence of VAP increases with the length of mechanical ventilation,<sup>4</sup> it is important to wean the patient off the system as soon as clinically feasible.<sup>7,17</sup> Furthermore, premature or accidental extubation prevention strategies are important as reintubation will increase the risk of aspiration.

## Best Practice Summary

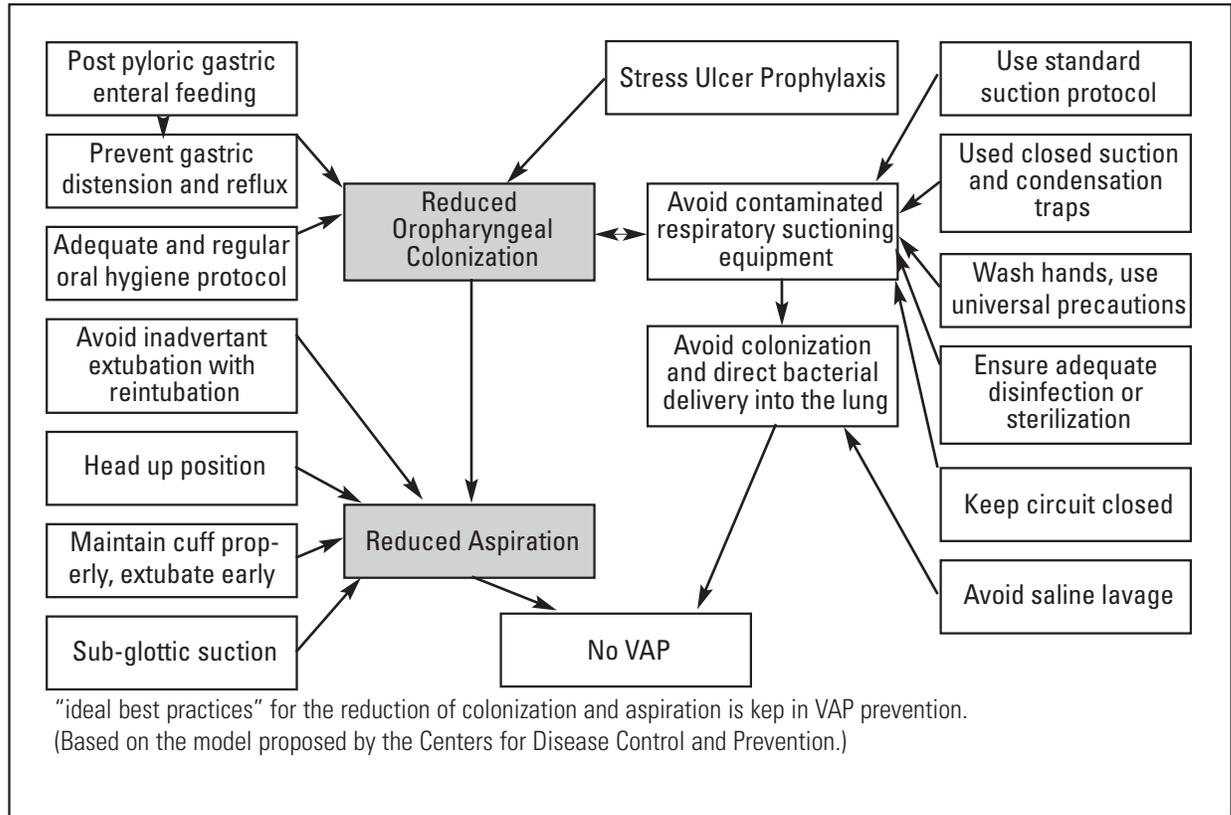
The Best Practice for prevention of VAP has three interrelated active components: educate, reduce colonization and prevent aspiration.

### 1. VAP Prevention Staff Educational Platform

Benefits from a well designed and carefully instituted VAP prevention program can be demonstrated in both improved outcomes and reduced costs.<sup>7</sup> A self study module developed by Kollef's group at Barnes-Jewish hospital in St. Louis reduced the VAP rate from 12.6 to 5.7 per 1,000 ventilator days.<sup>47</sup> This was a 57.6% decrease ( $p < .001$ ). The total estimated cost savings for this institution was up to \$4.05 million.<sup>26</sup> Although the optimal approach to VAP prevention has not yet been clearly defined and there are still controversial strategies (e.g. SDD), mandatory education of caregivers who care for mechanically ventilated patients can decrease the VAP rate while providing substantial cost savings.

The major components of the VAP educational program should address the factors surrounding the reduction of colonization and aspiration. Figure 3 on page 10 shows the relationship.

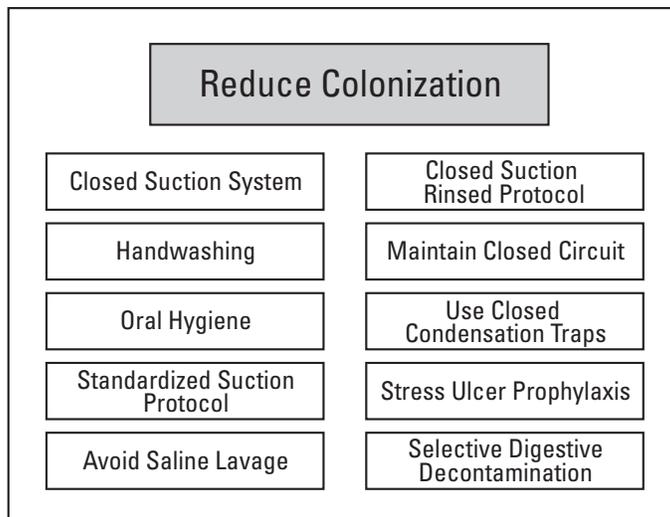
Figure 3



## 2. Reduce Colonization

Avoidance of unnecessary antibiotics, avoidance of nasal intubation, and proper oral hygiene can all contribute to reduction of colonization. Handwashing is of utmost importance in an effective VAP prevention program. Figure 4 shows the 10 factors for reducing colonization of the oropharyngeal area.

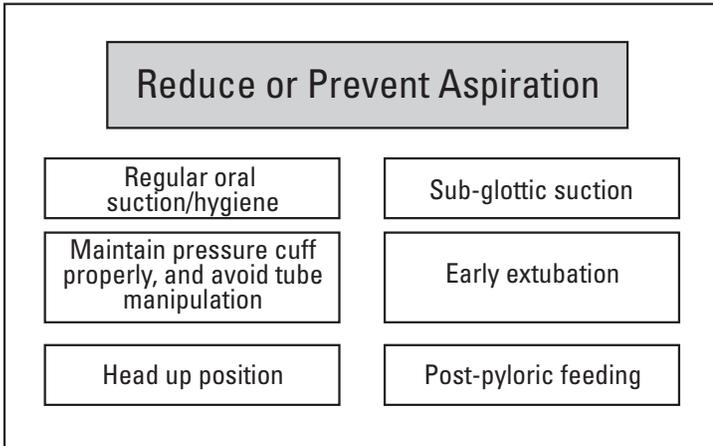
Figure 4



### 3. Prevent aspiration

Aspiration can occur at any time. Endotracheal tube movement should be avoided and proper cuff inflation should always be maintained.

Figure 5



### Conclusion

VAP is a serious complication of mechanical ventilation. It is the most common of all hospital acquired infections that contribute to patient death. VAP carries a mortality rate of approximately 30%.

There are three basic strategies demonstrated to effectively reduce the prevalence of VAP. These include: 1) staff education; 2) implementation of specific recommendations for the reduction of microbial colonization; and 3) the prevention of microbial aspiration. Implementing these recommendations will save lives. They will also save hospital time and expense when compared to the alternative – caring for the VAP patient. Incorporating these strategies into the care of ventilated patients also demonstrates facility efforts to address patient safety initiatives.

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## Ventilator Associated Pneumonia (VAP) Best Practice Strategies for Caregivers

### Post Test

1. Ventilator Associated Pneumonia (VAP) comes from:

- a.) Contaminated ventilators
- b.) Community pneumonia
- c.) Other patients
- d.) Colonization the subsequent aspiration
- e.) Bad vaccination

2. The mortality rate of VAP is:

- a.) Undetermined
- b.) Less than 10%
- c.) Approximately 30%
- d.) Approximately 75%
- e.) Approximately 90%

3. Match the following bacteria to the appropriate VAP.

A. early-onset

B. late-onset

\_\_\_\_\_

\_\_\_\_\_

Staphylococcus aureus  
Pseudomonas Aeruginosa

4. Risk factors for VAP related to the host include all but which of the following:

- a.) Age 65 or more
- b.) Immunosuppression
- c.) COPD
- d.) previous antibiotic therapy
- e.) non-invasive ventilation

5. Which of the following is not a risk factor for VAP?

- a.) Use of condensation drain in circuit
- b.) Bolus enteral feeding
- c.) Supine position
- d.) Nasogastric tube placement
- e.) Saline lavage

6. Which of the following are the two prevention strategies presented in this program?

- a.) Prevent colonization and aggressive antibiotic use
- b.) Prevent aspiration and use non-invasive ventilation
- c.) Hand washing and glove usage
- d.) Prophylactic ulcer treatment
- e.) Prevent or reduce colonization and prevent or reduce aspiration

7. Prevention or reduction of colonization of the oropharyngeal area and then prevention or reduction of aspiration of pooled secretions from the sub-glottic area are two strategies which reduce VAP rate by preventing the pathogens from entering the lungs.

- a.) True
- b.) False

8. Indicate "A" in the space provided if the key point prevents or reduces colonization and "B" if it prevents or reduces aspiration.

- \_\_\_\_\_ Hand washing
- \_\_\_\_\_ Oral hygiene
- \_\_\_\_\_ Post Pyloric enteral feeding
- \_\_\_\_\_ Reverse trendelenburg's position
- \_\_\_\_\_ Stress ulcer prophylaxis
- \_\_\_\_\_ Sub-glottic suction
- \_\_\_\_\_ Use of closed suction system

9. Best Practice is defined in this program as "Any key point which will prevent or reduce both oropharyngeal colonization and \_\_\_\_\_."

- a.) use of antibiotics
- b.) aspiration
- c.) hypoventilation
- d.) hypoxia
- e.) mortality

10. A well designed educational program aimed at the prevention of VAP will have which of the following effects:

- a.) make JCAHO inspection easier
- b.) provide more time for nursing procedures
- c.) improved outcomes and reduced costs
- d.) better patient care and fewer ICU admissions
- e.) more justification for staffing pattern revision

**Ventilator Associated Pneumonia (VAP)  
Best Practice Strategies for Caregivers**

**This program has been approved for 1.0 hour Continuing Respiratory Care Education (CRCE) credit by the American Association for Respiratory Care, 9425 N. MacArthur Blvd. Suite 100 Irving TX 75063**

Name: \_\_\_\_\_ SSN: (optional) \_\_\_\_\_

Title: \_\_\_\_\_ AARC #: (required) \_\_\_\_\_

Home address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_

Home Phone: \_\_\_\_\_ Work Phone: \_\_\_\_\_

Facility Name: \_\_\_\_\_

The evaluation process is important to determine the extent to which this program has met your learning needs and to measure its overall effectiveness. Please circle your rating as to how well the program objectives were met.

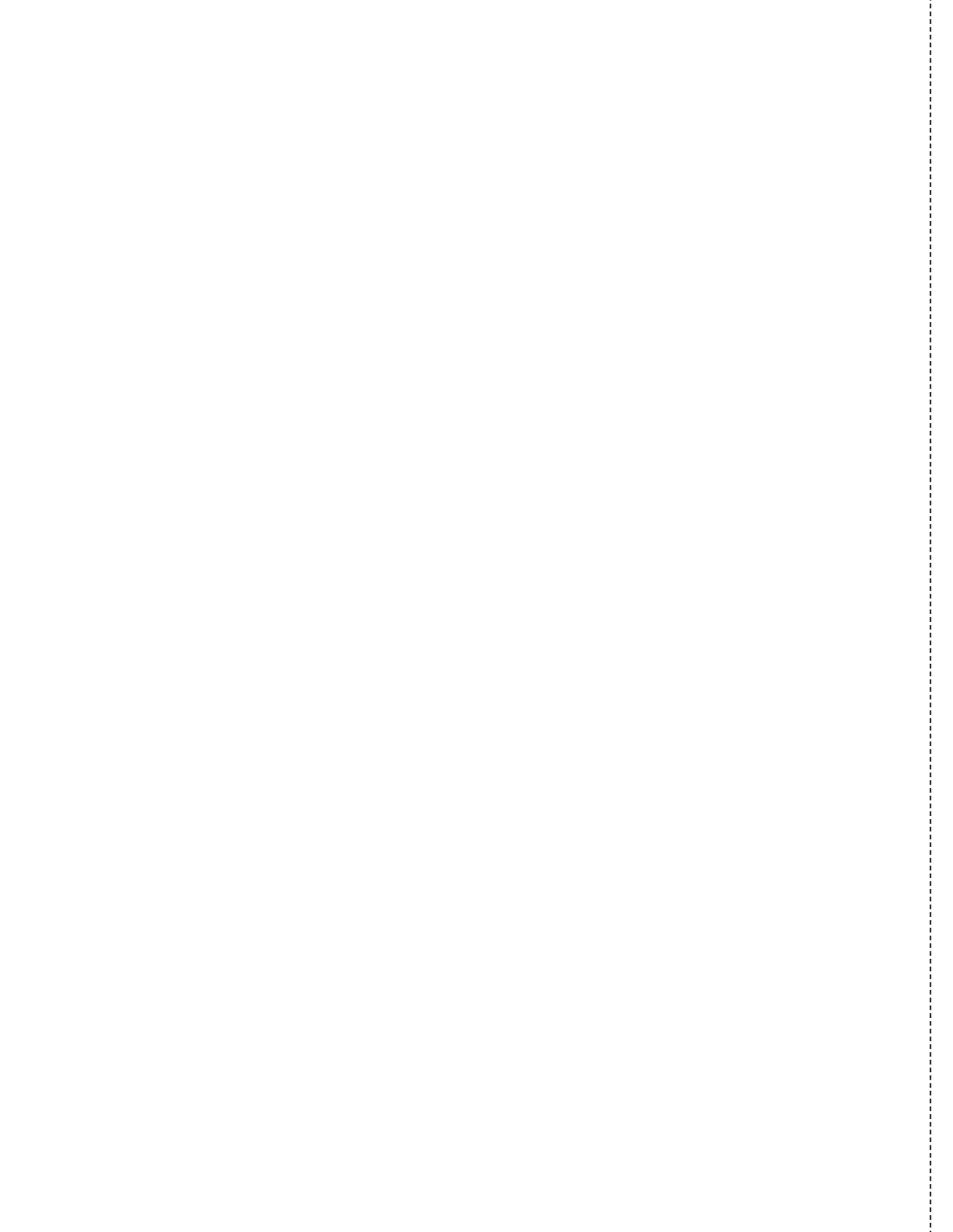
<b>Program Objectives</b>	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Unsure</b>	<b>Agree</b>	<b>Strongly Agree</b>
1. Describe the epidemiology of VAP including the incidence, microbiology, and mortality.	1	2	3	4	5
2. List several contributing risk factors leading to VAP.	1	2	3	4	5
3. Describe three major VAP prevention principles.	1	2	3	4	5
4. Describe how these principles prevent VAP.	1	2	3	4	5
5. Match key points to the specific major prevention principle to which it belongs.	1	2	3	4	5
6. Describe the ideal Best Practice VAP prevention program.	1	2	3	4	5
7. Describe two benefits of a successfully implemented VAP prevention education program.	1	2	3	4	5

<b>Overall Evaluation</b>	<b>Poor</b>	<b>Fair</b>	<b>Average</b>	<b>Good</b>	<b>Excellent</b>
8. Overall quality of the program.	1	2	3	4	5
9. Content	1	2	3	4	5

10. How long did you take to complete this program?  
\_\_\_\_\_

11. What other topics would be of benefit to you?  
\_\_\_\_\_

12. Additional comments.  
\_\_\_\_\_







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