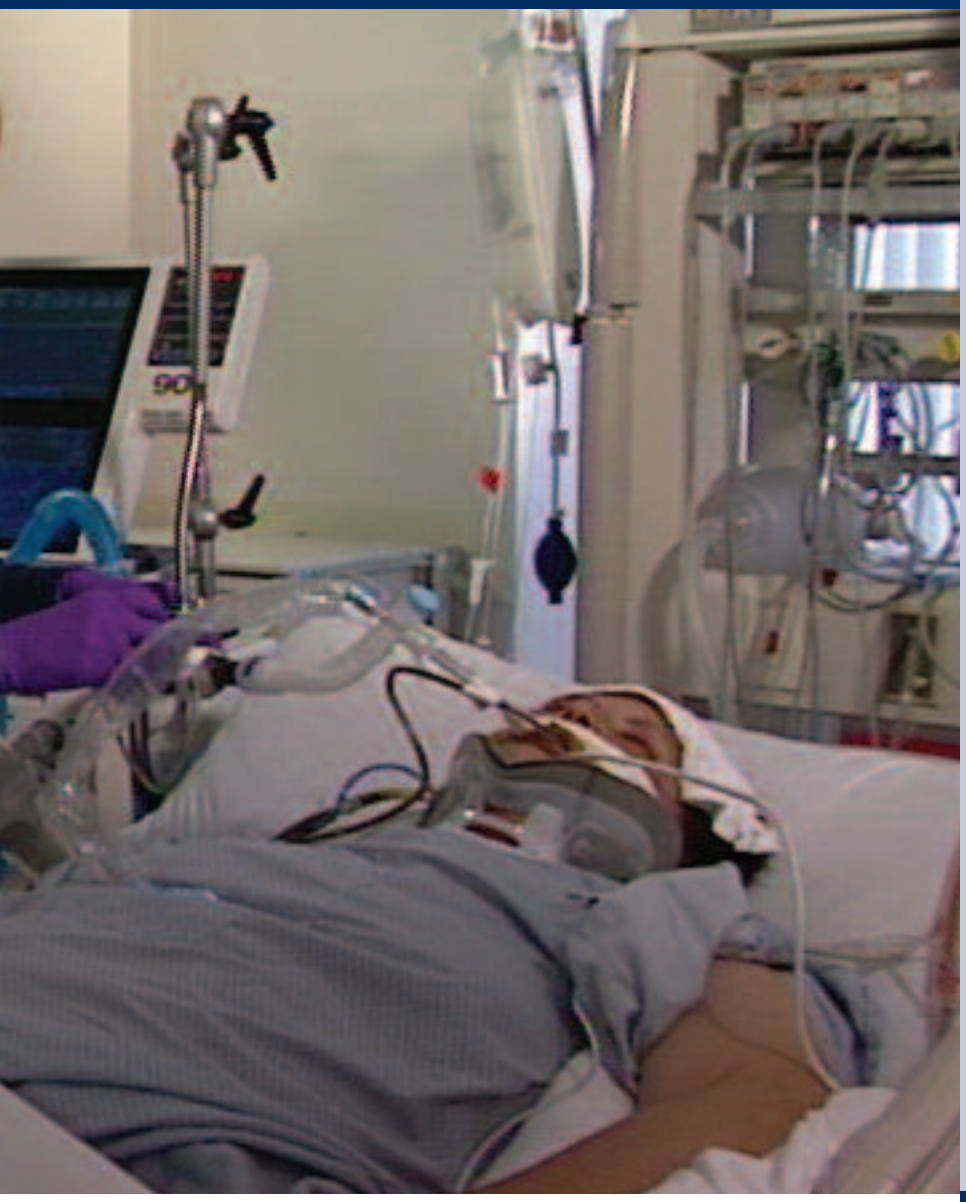

Ventilator–Associated Pneumonia

Reducing the Risk

APIC
ASSOCIATION FOR PROFESSIONALS IN INFECTION CONTROL & EPIDEMIOLOGY, INC.

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Table of Contents

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I. Introduction

Hospital acquired pneumonia is **the** leading cause of healthcare acquired infections among mechanically ventilated patients in the ICU and has attributable mortality rates of up to 50%. In all, up to one quarter of all endotracheally intubated patients will acquire pneumonia at a rate of 1 to 3% per day of intubation- prolonging their hospitalization, increasing their risk of death by two to ten-fold, and adding significant costs to their care.[1,2,3,5,6,7,8,9]

The good news is that VAP can be prevented. By incorporating the Guidelines for Preventing Healthcare Associated Pneumonia released by the Centers for Disease Control and Prevention (CDC), evidence-based guidelines by the American Association for Respiratory Care (AARC) and the American Thoracic Society (ATS), and interventions to reduce VAP, we can substantially improve facility rates of infection, improve patient care, and reduce costs to the facility.

II. Objectives

The objectives of this program are to:

- Describe the epidemiology of VAP, its microbiology and its definition
- Discuss the risk factors for VAP
- Explain prevention strategies
- Demonstrate interventions to prevent VAP

III. Epidemiology of VAP

A mechanical ventilator can be a life-saving device for seriously ill patients. Patients are intubated and placed on total or partial ventilator support when their respiratory system is incapable of initiating or maintaining ventilation; or when their self-ventilation and/or gas exchange capabilities are unable to keep up with the physiological demand caused by their diseases.[10] These diseases may be within the lung as well as in other organ systems, such as the cardiovascular system or central nervous system.[10] A ventilator dependent patient is one who requires mechanical ventilation beyond 24 hours, or has failed to respond to attempts at discontinuation.[10]

Ventilator patients are much more susceptible to the colonization and aspiration of virulent microorganisms and are therefore more susceptible to pneumonia. The reason lies in the intubation itself.

- The artificial airway bypasses the body's defense filtration mechanisms and the barrier function of the epiglottis that protect the usually sterile lower respiratory tract.[2,8]
- The artificial airway increases the production of mucous and its location in the respiratory tract, while at the same time inhibiting the body's ability to clear mucous through coughing and upper airway reflexes.[2,8]
- The artificial airway makes it easier for bacteria to have a direct route to the lungs.[2,3,8,9]
- The endotracheal tube itself can act as a reservoir for pathogens to colonize and create a biofilm within the tube. The biofilm can then be dislodged by suctioning, coughing or tube movement, and can subsequently contaminate the lower respiratory tract.[2,8]
- The endotracheal tube creates a foreign-body reaction in the body, interfering with the local immune response.[2]
- The cuff on the endotracheal tube creates a place for secretions to "pool" and stagnate where they can be easily aspirated.[2,3,8,9]

Pathogenisis

Various organisms, both pathogenic and non-pathogenic, may be found inside the body itself **(endogenously)** such as in the nasal, pharyngeal and digestive system. [6,7,8,9,11] They can also be found outside the body **(exogenously)** on sources such as contaminated equipment, and on the hands of healthcare professionals who practice poor hand hygiene, or fail to change contaminated gloves between patients.[6,7,8,9,11]

Early-onset VAP occurs in the first 1 to 4 days of ventilation, and is commonly caused by community-acquired organisms such as Streptococcus pneumoniae, Staphylococcus aureus and Haemophilus influenzae that are antibiotic sensitive. Enterobacteraceae may also be encountered. [2,3,4,6,8,9]

On the other hand, **late-onset VAP** which develops after this period is commonly caused by antibiotic-resistant gram-negative hospital-acquired organisms such as Pseudomonas aeruginosa, Acinetobacter species, Enterobacter species, and methicillin-resistant Staphylococcus aureus.[3,4,6,8,9] When VAP is caused by these virulent organisms, mortality can reach as high as 50%.[3] In at least 25% of infected patients, more than one organism was responsible for VAP.[2,8]

Colonization refers to the presence of bacteria without evidence of host response and with no adverse effects.[8] Colonization of the oropharynx with gram-negative bacilli occurs in up to 80% of intubated patients within days of ICU admission.[6] Colonization of the lungs can occur from aspiration of oropharyngeal secretions or gastric contents. It may occur from inhalation of infected aerosols, direct inoculation into the airways, the spread of infection from another site hematogenously, and the traveling of bacteria from the GI tract.[8] Most VAP is thought to originate from the aspiration of bacteria from oropharyngeal secretions and the GI tract.[3]

IV. Risk Factors

It's important to note that some ventilated patients are at higher risk for acquiring VAP.

These risk factors are tube related and include: [2,5,6,7,8,9,12,13,14]

- Duration of ventilation – the longer a patient is intubated, the greater the risk of pneumonia
- Endotracheal or tracheostomy intubation interrupts the body's defenses against aspiration and gives bacteria direct access to the lungs
- Self-extubation and subsequent re-intubation can damage or colonize the trachea
- Re-intubation creates difficulties in re-establishing airways
- Nasogastric tube placement may release bacteria from the sinuses
- Enteral feeding increases the likelihood of bacterial growth and aspiration

Additional risk factors may be related to the patient, such as: [2,5,6,7,8,9,12,13,14]

- Extremes of age
- Currently on antibiotics or previous antibiotic therapy
- Infection upon admission to the hospital
- An underlying chronic illness such as chronic obstructive pulmonary disease
- Immunosuppression from chemotherapy, radiation, steroid or anti-rejection therapies
- Previous pneumonia or remote infection
- Recent abdominal or thoracic surgery, transplants or dialysis
- Gastric distention
- Depressed consciousness with an inability to move secretions out of the lungs

Other factors that may be involved include: [2,5,6,7,8,9,12,13,14]

- Opening the ventilator circuit for any reason
- Treatment in ICU or long term care, as patients have compromised defenses which make them susceptible to pathogens
- Cross-contamination by staff during procedures, or through contaminated respiratory devices, including incentive spirometry equipment, in-line nebulizers, bag-valve mask devices, and suction catheters
- Insufficient oral hygiene so that bacteria in the mouth can be aspirated
- Exposure to infectious aerosols in the environment, Aspergillus spores in the ventilation system, and Legionella in the water supply
- Receiving nebulizer therapy through contaminated equipment
- A supine position, which makes aspiration more probable
- Non-specific antibiotic therapy or use of multiple antibiotics
- Lack of healthcare professional training in VAP prevention

V. Diagnosis

Unfortunately, an accurate diagnosis of VAP is difficult as there is no established gold standard. Healthcare professionals usually suspect VAP when ventilated patients exhibit fever, leukocytosis and purulent tracheobronchial secretions in conjunction with new or progressive pulmonary infiltrates.[1] Some facilities use the Clinical Pulmonary Infection Score or CPIS. It assigns a score of 0 to 12 using similar criteria, with VAP defined by a score of seven or more.[15] The problem – and controversy – surrounding diagnosis using either of these criteria is that they are reasonably sensitive, but are non-specific, and often inadequate.[1,6,9,15,16]

For example, fever can occur from extrapulmonary infection or inflammation, a drug reaction, or blood transfusion.[16] Fever and infiltrates can occur from atelectasis; chemical aspiration without infection; other pulmonary conditions such as pulmonary embolism or hemorrhage and acute respiratory distress syndrome (ARDS); congestive heart failure; infiltrative tumor; and drug reactions that mimic healthcare-associated pneumonia.[1,6,8,15,16] In fact, pneumonia may be overestimated by as much as 50% by using clinical indicators alone.[8]

In addition, surveillance sputum cultures from endotracheal aspirates – where patients are swabbed every week for trends or microbial information - are not recommended.[6,8,15,16,17,18] They are not useful in diagnosing pneumonia as they may yield false-positives or false-negatives, are expensive, and are little help in the selection of initial effective antimicrobial therapy.[6,8,15,16,17,18] Culturing should only be done based on clinical need and judgment.[14]

Diagnosis can be more specific when quantitative diagnostic techniques are used. These techniques have been improved with the use of invasive diagnostic testing of lower airway samples using a protected specimen brush (PSB), bronchoalveolar lavage (BAL), blind bronchoalveolar lavage (blind BAL) and protected bronchoalveolar lavage (PBAL). These methods do, however, require a specialist or pulmonologist for administration as they are significantly invasive. Alternatively, specimen capture utilizing small pulmonary catheters (or mini-BALs) have been utilized by some facilities, as the procedure may be performed by trained Respiratory Therapists and nurses. These techniques have been shown to more accurately identify pneumonia and it's causative pathogens, and may distinguish between patients who need antibiotic therapy from those who do not, and facilitate the selection of the most appropriate antibiotic for the targeted causative microorganism.[6,7,8,9,15,16,18]

In the Guidelines for Preventing Health-Care Associated Pneumonia, the CDC standardized the definition for diagnosing healthcare-associated pneumonia using clinical, microbiological, and radiological criteria, which every facility should follow.

These CDC criteria for signs and symptoms of pneumonia include:

- A chest x-ray showing new or progressing infiltrate, consolidation, cavitation, or pleural effusion that persists for more than 48 hrs
- New onset of purulent sputum, or change in the character of sputum
- Fever above 38.5C
- White blood cells greater than 10K/cm3
- Positive blood and/or sputum cultures **in conjunction with** other clinical signs of pneumonia[8]

Note: Your facility's infection control practitioners will use surveillance definitions based on the National Nosocomial Infection Surveillance Data System (NNIS), a division of the Centers for Disease Control and Prevention. These definitions are used to determine whether the infection should be counted in the surveillance of VAP and reported, so that hospitals can compare data and make meaningful comparisons. These definitions should not be confused with the clinical criteria discussed earlier to diagnose or treat infection.[2,5]

VI. Prevention Strategies

In order to reduce the numbers of patients acquiring VAP, **the CDC Guidelines for Preventing Healthcare-associated Pneumonia recommend that healthcare professionals be educated as to the pathogenesis of VAP, the risk factors involved in acquiring VAP, and the healthcare provider role in the prevention strategies to overcome it.**[17] A study conducted at Barnes-Jewish Hospital in St. Louis, MO determined that educating healthcare professionals who care for mechanically ventilated patients can dramatically decrease the incidence of ventilator-associated pneumonia. This includes focused education, retesting, reeducation and feedback of VAP rates to the staff. Using this strategy, Barnes-Jewish Hospital was able to decrease VAP rates by 57.6%, saving the facility between $425,606 and $4.05 million.[13]

Ventilator-associated pneumonia most often develops due to colonization of pathogenic organisms, aspiration of oropharyngeal flora, along with susceptibility to infection due to impaired defenses.[6] Therefore, the most important ways to reduce VAP are to apply prevention strategies which:

- Prevent contamination
- Reduce colonization
- Reduce or Prevent aspiration
- Boost defenses

A. Prevent Contamination

Preventing contamination is the first line of defense against VAP and can be accomplished by:

1. Adherence to the fundamentals of infection control, such as proper hand hygiene, aseptic technique and standard precautions
2. The proper use of disinfectants and sterilizers
3. Proper care and maintenance of equipment and devices

1. Infection Control

Cross contamination from other ICU patients via the hands of healthcare professionals is a major factor in contamination.[11]

Hand hygiene is the single most effective way to prevent the transmission of infectious pathogens. Decontaminate hands by washing with soap and water if hands are visibly dirty, contaminated with proteinaceous material, or are soiled with blood or body fluids. Alcohol-based hand rubs are recommended if hands are not visibly soiled. Using water and antimicrobial soap or alcohol-based hand rubs are both effective ways for healthcare personnel to decontaminate hands between patients.[17]

If hands are not visibly soiled, use an alcohol-based hand rub:

- Before having direct contact with patients
- Before performing procedures such as inserting an endotracheal tube or tracheostomy tube
- After contact with a patient's intact skin
- After contact with non-intact skin
- After contact with mucous membranes, respiratory secretions, or objects contaminated with respiratory secretions, whether or not gloves are worn
- After contact with inanimate objects in the immediate vicinity of the patient, such as a respiratory device that is used on the patient, and any part of the ventilator, such as keyboard knobs, dials, etc - whether or not gloves are worn
- While attending to patients in the ICU
- While caring for patients on isolation including those with antimicrobial resistant organisms
- After removing gloves[5,17]

Alcohol-based hand rubs must air dry on the hands to be effective, and not towel dried. For best practice in hand antisepsis, be sure to consistently follow the CDC Hand Hygiene Guideline recommendations.

Personal protective equipment is designed to protect the caregiver and to contain the spread of pathogenic microorganisms. Gowns, masks and eye protection must be worn during all patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions or excretions.[17] Masks are especially important when caring for patients with copious respiratory secretions.[7] Gloves are especially important when handling respiratory secretions, or objects contaminated with the respiratory secretions of a patient.

Healthcare professionals should change gloves and decontaminate hands during the following times:

- When moving from a contaminated body site to a clean body site on the same patient
- When moving between a contaminated body site and the respiratory tract of, or respiratory device on, the same patient
- After handling respiratory secretions or objects contaminated with secretions from one patient, and before contact with another patient, object, or environmental surface.[7,17]

Never wear the same pair of gloves when caring for more than one patient. Before providing care for another patient, be sure to remove and dispose properly of all PPE and clean hands.[17]

Some patients may require **isolation precautions** to limit the amount of pathogens that can be transferred to other patients. The type of precautions will be based on the method of transmission of the organism. For example, airborne precautions are used for infectious aerosols; droplet precautions for large droplets; and contact precautions for transmission from direct contact with the source of infection, or indirect contact with contaminated objects. Be certain to always use the PPE designated for each precaution.[7]

Other aspects of infection control to remember include the use of needles and devices whenever possible, and the safe handling and disposing of sharps.[7]

2. Disinfection and Sterilization

The hospital environment can play a significant role in the prevention of VAP. Therefore, adequate disinfection and sterilization is important to minimize the inclusion of microorganisms in the patient's environmental surroundings.

Contaminated surfaces such as floors, bedding, and equipment can all potentially harbor pathogenic organisms and greatly increase the risk of cross-transmission from the healthcare professional to the patient. Spills of infectious material should be cleaned promptly using the appropriate agents. Bedding should be changed regularly or when soiled to minimize exposure to fomites that carry pathogens.[7] Disinfectants should be used for environmental cleaning or for the outside disinfection of respirators and humidifiers (do not disinfect the internal machinery of mechanical ventilators).[5,7,17] Contaminated supplies, patient-care equipment and linen should be either discarded, disinfected or sterilized between each patient use.[7]

3. Care and Maintenance of Equipment and Devices

Care and maintenance of equipment and devices are also critical in preventing VAP. Inoculation of pathogens can occur from contaminated respiratory devices, such as spirometers, oxygen sensors, nebulizers, bag-valve mask devices, and suction catheters.[8]

The Ventilator Circuit

For many years, it was assumed that the source for VAP was most likely the ventilator circuit, which consists of ventilator tubing, an exhalation valve, and an attached humidifier. In time, however, the evidence suggested that VAP most likely evolved from other sources.[12] However, because the ventilator circuit is potentially a harbinger of pathogens, certain protocols should be practiced for safe patient care.

To prevent the colonization of pathogens in the ventilator circuit, follow these protocols for best practice:

- **Avoid excessive manipulation/changes of the ventilator circuit. Change the ventilator circuit, including in-line closed suction catheters, when they are visibly soiled or malfunctioning.**

  A study in 1982 questioned the practice of changing ventilator circuits at least daily. This study showed that there are no significant differences in the frequency of positive cultures in circuits changed every 24 hours vs. every 48 hours; or increases in colonization between 24 hours vs. 48 hours. Based on this and subsequent studies, the CDC and AARC guidelines recommend that ventilator circuits should not be changed routinely for infection control purposes.[12,14]

In-line closed suction systems allow patients on ventilator support to be suctioned without being removed from support. This can decrease the complications associated with suctioning, and can cause less environmental contamination than open suction systems.[12] However, there can be high levels of contamination within the closed suction catheters. Bacteria aggregate on the surface of the catheter and tracheal tube to form a biofilm. Possible dislodgement of this biofilm into the lungs may be responsible for the development of VAP; therefore, changing in-line catheters may reduce the aspiration of bacterial aggregates.[19]

However, routinely changing in-line suctioning and the ventilator circuit increases the manipulation of the circuit, and may provide the opportunity to introduce bacteria into an originally closed system, as well as increase patient cross contamination and healthcare provider exposure to respiratory secretions.[12,17,19] The in-line closed suction catheter can be considered an extension of the ventilator circuit, and because ventilator circuits do not need to be changed regularly for infection control purposes, the same can be said about closed suction catheters.[12] The length of time an in-line suction system can be safely used has not been established.[12,19,20] It is therefore recommended by the CDC and AARC guidelines that the circuit, including in-line closed catheters, should be changed when visibly soiled or malfunctioning.[12,17]

- **Change the circuit using aseptic technique.**

  Clean hands with soap and water or alcohol-based hand rubs and don clean gloves prior to changing the ventilator circuit. Use caution: although it is not packaged sterile, the open ends of the new circuit should not be allowed to touch contaminated surfaces such as bedspreads, the floor, etc. Cross contamination to the circuit could then ensue.

- **Change the Heat Moisture Exchanger (HME) every 48 hours, or when soiled or malfunctioning**[5,17]

  Humidification prevents the thickening of airway secretions, atelectasis and destruction of airway epithelium, and is mandatory when an endotracheal or tracheostomy tube is present.[21] Humidification can be active or passive. Active humidifiers pass inspired gas through or over a heated water bath. Passive humidifiers, or heat moisture exchangers (HME), on the other hand, trap heat and humidity from the patient's exhaled gases and return some of it to the patient during the next inhalation.[12]

  Contaminated condensate within ventilator circuits may not only predispose patients to VAP, it can also spread pathogens throughout an ICU by acting as a reservoir. Therefore, scheduled removal of condensate, along with its safe disposal, should be practiced.[14] HME's maintain a dry circuit, have filtering properties, and can reduce condensate accumulation. Manufacturers of passive humidifiers typically recommend that they be changed at daily intervals; however, studies have found no significant differences in the VAP rate between humidifiers changed daily, or on a less frequent basis. Therefore, the CDC and AARC guidelines state that passive humidifiers do not need to be changed daily for reasons of infection control or technological performance.[12,17] Instead, the AARC guideline states that HME's can be used for at least 48 hours, and up to a week in some patient populations.[12] Humidifiers should be inspected during every patient-ventilator system check, and condensate removed from the circuit as necessary. If secretions have contaminated the HME insert or filter, it should be replaced.[21]

- **Use ventilator tubing that contains condensation traps.**

  This allows tubing to be drained of condensate fluid without excessive manipulation, and avoids accidental drainage of condensate into the patient's airway. Remember that condensation from the circuit should be considered infectious waste and should be collected and disposed of using strict Standard Precautions according to hospital policy.[12,17,21] Do not use a common collection container shared between patients, transport contaminated condensate from one patient to another, or empty condensate into the trash can or on to the floor as this can contaminate the environment and potentiate the spread of infectious pathogens.[14]

- **Use sterile water only to fill humidifier reservoirs**[5,17,21]

  Use clean technique when manually filling the water reservoir by cleansing hands with water and antimicrobial soap or alcohol-based hand rubs and don clean gloves.[11] In a closed automatic feed system the unused portion of the water in the water feed reservoir remains sterile and does not need to be discarded during the changing of the circuit.[21]

In-Line Nebulizers

Contamination of nebulizers due to lapses in infection control can lead to bacteria aerosolized into the lungs.[14,22] When using nebulizers, care must be taken to avoid contamination of the ventilator circuit and the patient's respiratory tract.[12]

CDC recommendations when using in-line nebulizers:[12,17]

- **Use only sterile fluid to fill the reservoir.** Tap or distilled water can potentially harbor Legionella.
- **Use single dose vials of sterile fluid and medication if possible.** Multidose vials can increase the potential for microbial contamination in the container, thereby increasing the risk of infection to your patient.
- **Empty, clean, and rinse the nebulizer with sterile water** between treatments on the same patient.
- **Change the nebulizer on a regular basis** according to facility policy.

In addition, the use of metered dose inhalers (MDI) that allow the circuit to remain closed should be utilized to deliver aerosolized medications. While both MDIs and nebulizers are effective in delivering aerosols to the lower respiratory tract, MDIs use closed systems that prevent pathogens from entering or leaving the circuit, and so prevent contamination.[22] When using MDIs, use clean technique by cleansing hands with alcohol-based hand rub or soap and water and don clean gloves. Dispose of the gloves after the treatment, and clean hands properly once again.

Manual ventilator devices

Another potential source of airway contamination is the manual ventilator devices commonly kept at the patient's bedside. And, one study showed a significantly greater likelihood of patients acquiring VAP after they were transported from the ICU for diagnostic or other interventions and required manual ventilation.[12] Manual ventilation devices should be changed on a regular basis according to facility policy.

B. Reduce Colonization

The longer a patient is acutely ill, the more likely normal flora will be replaced by potentially pathogenic microorganisms.[9] Because of the risk factors involved with VAP, colonized secretions tend to reside and grow in the oropharynx and gastrointestinal tract.[2] Therefore, interventions designed to reduce colonization are paramount in the fight against VAP.

1. Oral Hygiene

Pathogenic microflora of the mouth and oropharynx have a major role in several diseases, including pneumonia, chronic lung diseases, bacteremias, and endocarditis.[23] Oral microbial flora are concentrated on dental plaque,

which provides a habitat for the colonization of microorganisms.[24,25] The accumulation of dental plaque and oral microbial flora, together with the decrease in local oral immunity, increases bacterial colonization of the oropharynx by S. aureus and other potentially pathogenic organisms.[24,25]

Unfortunately, patients treated in an ICU often have compromised oral health due to their medical conditions or treatments, equipment use, or the inability to care for themselves.[24] Studies show that within 48 hours after admission, the oropharyngeal flora changes from gram-positive to gram-negative organisms, including those that cause VAP.[24] Oral care during hospitalization can prevent the accumulation of plaque, stimulate oral immunity, and thereby reduce the amount of organisms that can migrate to and colonize the lungs.[24]

While evidence-based protocols are lacking, studies have shown that routine oral hygiene consisting of frequent tooth brushing, suctioning of oral secretions and swabbing of the mouth with antiseptic agents, such as chlorhexidine, have been found to reduce VAP by nearly 58%.[2,8,24,26]

When brushing teeth, use a soft pediatric toothbrush to remove debris and microorganisms, as foam swabs are not effective against the removal of dental plaque.[23,24] Removable partials and dentures should be taken out and thoroughly cleaned.[23]

Low-intensity suctioning during mouth care can be helpful, as well as protect against aspiration.[23] If loose teeth, infected gingivae or large deposits of tartar are observed, a dentist should be consulted.[23]

Chlorhexidine has broad-spectrum action against both gram-positive and gram-negative bacteria, is not associated with microbial resistance or serious side effects, and allergic reactions are rare.[24] The use of oral chlorhexidine (0.12% solution) should be administered by spray every 12 hours.[24] The CDC recommends the use of oral chlorhexidine gluconate (0.12%) during the pre-operative and post-operative period on adult patients who undergo cardiac surgery who are at high risk for VAP.[14,17]

2. Nasal Hygiene

As with oral hygiene, nasal hygiene is an important aspect of patient care that is often overlooked or neglected. Secretions can accumulate and crust in nares of patients who have nasogastric or nasoenteric tubes. Protocols developed by the facility for routine cleansing of the nose and suctioning of nasopharyngeal secretions can reduce bacterial colonization.[8]

3. Common Suction Protocol

The endotracheal tube prevents glottic closure. This creates a reduction in the ability to cough. In addition, the presence of the endotracheal tube results in an increase in the production of mucus in the lower airway. Colonization of the oropharyngeal flora in accumulated secretions above the cuff can occur in up to 80% of intubated patients.[2,8] If the oropharyngeal secretions are then aspirated into the lower airway, colonization and/or infection can occur. Suctioning, therefore, is a critical strategy that removes these secretions from the patient's airway.

Studies show that when standardized and common protocols for endotracheal suctioning are practiced throughout the facility, lower infection rates and their associated costs, and fewer deaths can be achieved.[13] The CDC Guidelines recommend tracheal suctioning as a routine prior to extubation.[2] However, suctioning should only be performed when necessary, and as defined by your facility's policy, as unnecessary suctioning may introduce organisms into the lower respiratory tract.

In general, the need to suction endotracheal secretions can be determined by the following:[27]

- Noisy breathing or coarse breath sounds by auscultation
- Visible secretions in the airway
- Decreased tidal volume during pressure-controlled ventilation, or increased peak inspiratory pressures during volume-controlled mechanical ventilation
- Suspected aspiration of upper airway or gastric secretions
- The lack of integrity and patency of the artificial airway
- The patient exhibits clinical signs and symptoms for suctioning (i.e. coughing)

There are two types of suction-catheter systems: the open single-use catheter system (OSS), and the closed multi-use catheter system (CSS). There are several advantages to the closed suction system. First, the closed system is associated with lower costs.[19] Secondly, the use of in-line or closed suction systems are associated with less cross-contamination.[2,19] This is because the use of CSS reduces the opportunity for outside pathogens to contaminate the circuit, and acts as a barrier to separate the healthcare professional and the patient from the contaminated catheter.[19] It also protects contamination in the environment from entering into the circuit. Third, CSS facilitates continuous mechanical ventilation and oxygenation during the suctioning event.[27] The American Association of Respiratory Care guideline recommends the use of CSS as part of an infection control program.[2,12]

Patients should be assessed for endotracheal suctioning as a routine part of the patient/ventilator system check.[27] When performing any type of suctioning, be sure to maintain aseptic technique to reduce contamination.[7,8]

- Perform hand hygiene upon entering the room. Since cross-contamination and direct inoculation are ways to colonize the patient with pathogenic bacteria, effective hand hygiene must be performed.
- Prepare a clean work area. The bedside table should be decontaminated using an alcohol wipe or environmental cleaning solution and allowed to air dry.

Use the following protocols for best practice while suctioning:

In-Line or Closed Suctioning[5,27,28]

When performing in-line or closed suctioning, you will be using clean technique.

1. First, don clean gloves.
2. Attach the suction tubing to the end of the in-line catheter.
3. Make sure the suction pressure is set at 80 to 120 mm/hg, which is a low setting yet strong enough to effectively clear the secretions.
4. Open the irrigation port and attach a sterile saline ampule to the port.
5. Using the numbers on the catheter, advance the catheter to the desired depth.
6. Conduct the suctioning by withdrawing the catheter using continuous suction. Withdraw the catheter its fully extended length, being careful not to pull too far, or the protective sleeve will balloon and oxygen and pressure will be lost. If it is not pulled out far enough, airway obstruction may occur. The duration of each suctioning pass should be approximately 10-15 seconds.

7. After each pass, completely rinse the closed suction system with sterile saline following manufacturer's recommendations for the amount of saline to use. This will remove the mucus from the suction catheter and minimize colonization. Do this by slowly introducing the saline and using intermittent suction, therefore preventing the saline from going back into the patient's airway.
8. When suctioning is complete, retract the catheter into the plastic sheath.
9. Dispose of your gloves and cleanse your hands.

Single-Use or Open Suctioning[5,27,28]

When performing single-use or open suctioning, you will use sterile technique.

1. Select a catheter based on the inner diameter of the tracheostomy or endotracheal tube, and the amount and character of secretions. Attach to the catheter tubing.
2. Don the proper PPE. Since there may be exposure to bodily fluids, a mask, eye protection, gown and sterile gloves are recommended. Sterile gloves should be donned using sterile technique, paying attention not to contaminate the outside of the glove.
3. Continue sterile technique by designating one hand to hold the sterile catheter and one to hold the tubing or handle other non-sterile functions.
4. Using the non-sterile hand, pre-oxygenate the patient with 100% oxygen and/or hyperventilate the lungs with a ventilator manual "sigh" or resuscitation bag as needed. Pre-oxygenation may be accomplished by using the 100% O2 button on the ventilator; however, keep in mind that several breaths may be needed to completely purge the circuit and deliver 100% oxyqen.
5. Make sure the suction pressure is set at 80 to 120 mm/hg.
6. Use sterile technique each time the suction catheter is passed through the artificial airway into the trachea and back out.
7. Insert the catheter quickly, yet gently, until the desired depth is reached.
8. Continuously suction and withdraw. Repeat the procedure until all secretions are removed.
9. Give the patient several lung inflations between suction passes using a ventilator "sigh" or resuscitation bag.
10. Do not lay the catheter down in between suction passes as this increases the risk of contamination.
11. Do not rinse the catheter between passes, but do change the catheter if it becomes clogged.
12. When you are through, hold the catheter in the sterile hand, and remove the glove over the catheter, so that the catheter is contained in the glove. Then, dispose of the single-use catheter properly.
13. Rinse the suction canister tubing thoroughly using tap water, then place on top of the suction device.
14. Dispose of PPE properly and cleanse your hands.

Note: Healthcare professionals who perform endotracheal suctioning should be aware of the complications associated with the procedure, and take the necessary precautions to ensure patient safety. The complications associated with endotracheal suctioning include: hypoxia, tissue trauma to the bronchial or tracheal mucosa, cardiac and respiratory arrest, interruption of mechanical ventilation, and cardiac dysrhythmias.[27]

Oral Suctioning

When performing suctioning of oral secretions, keep in mind that this is a clean procedure, not sterile. Therefore, the best protocol is to:

1. Use an oral suction catheter and clean gloves.
2. Do not use single-use catheters during tracheal suctioning for this function, as it is vital that the catheter once used for oral suctioning not be re-introduced into the airway.
3. Rinse the suction catheter with sterile saline when finished.
4. Store the catheter in an approved container when not in use.
5. Suction oral secretions whenever there is a pooling of secretions.[5,27]

4. Closed Suction Rinse Protocol

After suctioning, sterile saline should be used to thoroughly and completely rinse the closed suction system. This minimizes colonization of the system by removing the mucus from the suction catheter. For the most effective method, be sure to follow the instructions provided by the manufacturer of the closed suction system.[2,8]

Note: This should not be confused with Saline Lavage, which refers to the instillation of saline in either the endotracheal tube or the tracheostomy tube, often to remove thick secretions. This is a controversial practice that may actually dislodge bacteria from the tube and into the lung, while at the same time causing oxygen desaturation. Therefore, it is not recommended.[2]

5. Condensation Traps

Bacterial colonization can also occur when warm expired air condenses in ventilator tubing; and as the condensate accumulates, so does the chance for microbial growth. To prevent accumulation, the tubing should be drained and discarded periodically.[12,17]

Condensation traps can be instrumental in preventing external contamination. They allow for less manipulation of tubes, and further reduce the chance of contamination from outside pathogens by permitting drainage without having to open the circuit; therefore, closed drainage systems should be used whenever possible.[2]

To safely drain condensation from a closed drainage system, follow these guidelines: [12,13,17,21]

1. First decontaminate your hands using water and antimicrobial soap or an alcohol-based hand rub.
2. Don clean gloves. Masks and eye protection will not be necessary as infectious material is contained within the closed circuit.
3. Collect the fluid in the collection device without opening the ventilator circuit.
4. Consider the drainage infectious waste, and dispose of the waste according to facility policy.
5. When you are done, remove and dispose of your gloves properly, and decontaminate your hands.

If you are draining condensation from a circuit that must be opened, use aseptic technique: [12,13,17,21]

1. First, decontaminate your hands using water and antimicrobial soap or an alcohol-based hand rub.
2. Put on clean gloves, a mask, and eye protection.
3. Now drain the fluid into the collection container. Take care not to allow the condensate to drain toward the patient.
4. Carefully open the ventilator circuit and drain the fluid into the wide mouthed container, being careful not to touch the circuit tip to the container. Avoid any spillage. Reconnect the tubing carefully to avoid contamination.
5. Consider the drainage infectious waste, and dispose of the waste according to hospital policy. Do not empty the fluid into the trash can or floor!
6. Carefully reconnect the ventilator tubing so as to avoid contamination of the inside of the connectors.
7. Finally, remove and properly dispose of your PPE, and be sure to cleanse your hands afterwards.

6. Stress Ulcer Prophylaxis

Patients on ventilator support are susceptible to stress ulcers. To reduce peptic acidity and bacterial colonization in the gastrointestinal tract, patients on ventilator support may be prescribed prophylaxis.[2,8] Unfortunately, antacids or histamine type-2 antagonists can actually increase gastric pH, resulting in an environment more conducive to microbial growth, and so their use has not been established as best practice.[2,8,14] The medication also increases the gastric volume, putting pressure on the esophageal sphincter. Gastric bacteria can then pass through the sphincter into the esophagus and upper airway through reflux or regurgitation, and lead to micro-aspiration.[2] Sucralfate does not seem to affect gastric pH, and may be an effective alternative prophylactic agent; however, a multi-discliplinary team should assess the need for prophylaxis, and the appropriate medication.[6,8,14,29]

C. Reduce or Prevent Aspiration

Aspiration of bacteria in the oropharyngeal, sub-glottic and GI tract is a primary factor in acquiring VAP. Therefore, aspiration must be actively prevented.[2,3,8,9]

1. Elevate Head of Bed 30-45˚

To prevent aspiration, elevate the head of the bed 30 to 45 degrees unless contraindicated. This is a simple, effective, low cost intervention based on the theory that gravity will prevent aspiration of tracheal secretions and has been demonstrated to decrease the incidence of VAP.[2,3,8,13,17,30] This practice is recommended for the duration of mechanical ventilation as long as it is not clinically contraindicated (i.e. hypotension, or procedures requiring the head of the bed to be less than 30 degrees).[2,3,8,30]

2. Subglottic Suction

Patients with endotracheal tubes are unable to cough and remove secretions naturally. In ventilator dependent patients, oropharyngeal secretions become colonized with pathogenic organisms.[8] The suctioning of trapped sub-glottic secretions is a critical preventive strategy that not only decreases colonization, it prevents the micro-aspiration of oropharyngeal secretions that accumulate above the endotracheal cuff.[2,3,6,9,29]

Suctioning of subglottic secretions should occur when the cuff is deflated, before repositioning tubes, and prior to extubation.[17] A single-use catheter inserted alongside the endotracheal tube may be used to remove accumulated subglottic secretions. Early trials show a reduction in VAP in the patients with continuous subglottic aspiration and a delay in onset of VAP.[8] The CDC advocates the use of an endotracheal tube with a dorsal lumen above the endotracheal cuff to allow continuous or frequent intermittent suctioning of tracheal secretions in the subglottic area.[17]

3. Cuff Pressure Maintenance

When positive pressure ventilation is used, it is critical that the correct pressure within cuffed endotracheal tubes be maintained to facilitate ventilation of the lungs.[2,8] Under-inflated cuffs form creases that allow contaminated secretions to migrate past the cuff and aspirate into the lungs.[2] The ideal cuff pressure should be high enough to prevent migration of the secretions, and yet low enough to prevent tissue damage of the contacted mucosal tissues. This has normally been set between 20 to 25mm/Hg, and cuff pressure should be measured and recorded on a regular basis.[2] However, be aware that even with correct inflation, microaspiration of bacteria from the oropharynx and GI tract can still occur.[8] Since pooling occurs above and around the cuff, take care when repositioning the cuff that oral care and subglottic suctioning be performed before repositioning tubes, and avoid any unnecessary manipulation of the tube.[2,8]

4. Enteral Feeding/Preventing Gastric Distention or Reflux

Aspiration is a common complication in patients receiving enteral nutrition through gastric and nasogastric feeding tubes.[8] Enteral feeding can alter the acidity of gastric content, increasing the likelihood of reflux.[8,14] Also, the placement of nasogastric and nasoenteric tubes violates the gastroesophogeal sphincter which increases the potential for reflux.[8,30] Reflux propels stomach contents into the esophagus, allowing bacteria to migrate or translocate up the tube into the upper airway. Nasogastric and nasoenteric tubes are therefore not recommended for enteral feeding in ventilator dependent patients.[2,8,31,32]

While aspiration is a concern with all feeding tubes, patients requiring long-term feeding should be considered for gastrostomy or jejunal tubes.[2,8] Both types of tubes are associated with lower instances of aspiration, and an overall reduction in cases of pneumonia. [2,6,8,14,31] In particular, jejunal or post-pyloric placement is associated with less gastroesophageal regurgitation, less risk of aspiration, shorter feeding time, and increased nutrient delivery.[2,31]

In order to reduce the risk of acquiring VAP through gastric reflux or over-distension, practice the following protocols:

- **If not already elevated, raise the head of all ventilator dependent patients from a supine position to 30 - 45 degrees**.

  The patient should be placed in a semirecumbent position during and 1 hour after intermittent enteral feeding, if possible.[2,3,8,31]

- **Always verify tube placement prior to feeding and routinely verify tube placement**

  Tubes displaced due to migration or episodes of vomiting or coughing can migrate to the esophagus, leading to aspiration.[17,31]

- **Consider continuous rather than intermittent feeding**.

  In studies, continuous and intermittent feeding were both better tolerated in patients than bolus feedings. Some experts suggest that patients should receive continuous feedings to avoid stomach distension, and preserve peptic acidity levels in the stomach, and thereby gastric colonization.[2,8,31]

- **Measure gastric residuals prior to enteral feeding.**

  When gastric emptying is impaired, high residual volumes can occur. Gastric residual volumes should be monitored before enteral feedings are administered.[13] Enteral feeding guidelines suggest that gastric residuals should be measured every two hours when feedings begin, and every 4 to 6 hours once feedings begin. Feeding should be withheld from the patient if on two successive assessments residual volumes are too high or bowel sounds are absent.[6]

D. Boost Defenses

By boosting defenses, both healthcare professionals and patients can become less susceptible to the pathogenic organisms in the community, and the healthcare facility.

1. Vaccination

Vaccination of both staff and patients is recommended. Patients who are at risk of VAP should receive the influenza vaccine, and be vaccinated against pneumococcal disease. These include patients over the age of 65, who have chronic pulmonary disease, chronic cardiovascular disease, and are immunocompromised.[17] The most optimal time to vaccinate patients is prior to discharge from the hospital or when they return to visit their primary care physician after their illness. Staff who receive their annual influenza vaccination are not only protected against respiratory disease, they also reduce the risk of endangering the patients on ventilator support.[2,17]

2. Oral vs. Nasal Tube Placement

The placement of nasotracheal and nasogastric tubes cause nasal irritation and may increase the risk of sinusitis.[8,13,31] Sinusitis occurs in up to 30% of patients within a week of intubation. Bacteria causing sinusitis can colonize the upper airway, and the use of a nasal endotracheal tube or feeding tube obstructs the clearance of secretions from the sinuses. The subsequent aspiration of infected secretions in turn increases the risk of VAP.[8,14] One study has found that 73% of nasally intubated patients acquired sinusitis vs. 34% of orally intubated patients. The study concluded that orally intubated patients are less likely to develop sinusitis, and that VAP rates are reduced when the tubes are discontinued as soon as possible so there is less potential for bacterial infection.[8] The CDC also advocates the use of orotracheal rather than nasotracheal intubation on patients unless contraindicated by the patient's condition.[17]

3. Ventilator Weaning or Discontinuation

As we discussed earlier, the longer a patient is ventilated, the greater the likelihood of pneumonia, and the greater the cost of care. It makes sense, then, that whenever the conditions that place the patient on the ventilator begin to resolve, the patient should be discontinued from ventilation as soon as medically indicated.[2,8,10] Strategies to shorten the duration of ventilation include limiting the administration of sedation, the use of weaning protocols or early attempts at spontaneous breathing.[14]

The Evidence-Based Guidelines for Weaning and Discontinuing Ventilatory Support by the American College of Chest Physicians, the American Association for Respiratory Care, and the American College of Critical Care Medicine, as well as the Surviving Sepsis Campaign Guidelines for Management of Severe Sepsis and Septic Shock recommend that a weaning protocol be in place for mechanically ventilated patients.[10,29] However, the weaning process must not be too aggressive, as premature discontinuation – either in a plan of care or through

accidental extubation - can create difficulties in establishing airways, compromise gas exchange, and increase the risk of aspiration.[2,8,10] Re-intubation of patients who are extubated too early increases their risk of VAP.[17] Strategies to prevent accidental extubation should be practiced as routine, such as adequately securing endotracheal tubes to the patient, and/or restraining the patient per hospital policy, if necessary.[8,13]

Additionally, the CDC recommends **non-invasive ventilation** to reduce the need for and duration of endotracheal intubation when feasible and not medically contraindicated via positive-pressure ventilation delivered continuously by face or nose mask. This should be used in patients who are in respiratory failure, are not needing immediate intubation, or as part of the process of ventilator weaning.[13,14,17] Studies show that non-invasive ventilation reduces the risk of VAP, the length of stay, and patient mortality.[9]

The Surviving Sepsis Campaign guidelines call for the daily evaluation of spontaneous breathing to determine when patients may discontinue mechanical ventilation, based on studies which show that daily spontaneous breathing trials reduce the duration of mechanical ventilation.[29] This practice, then, as an aggressive team approach is encouraged.[8]

VII. Conclusion

In conclusion, statistics prove that VAP is a far too frequent, potentially deadly hospital-associated infection. But as we've learned, these numbers can be reduced. Studies show that significant advances against VAP can be made through a combination of factors:

- Staff education[13]
- The use of evidence-based guidelines
- The selection of the most appropriate products

All healthcare professionals involved in the care of patients dependent on ventilators must learn the causes behind VAP and employ strategies that prevent contamination, reduce colonization, prevent aspiration, and boost the defenses of our patients.

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IX. Post Test

1. Intubation makes ventilator patients more susceptible to the colonization and aspiration of virulent organisms because:
   - **A** Mucous production is decreased, causing the body to lose vital bacteria-trapping mechanisms
   - **B** The tube acts as a reservoir for pathogens to grow
   - **C** The cuff traps secretions where they stagnate and are aspirated
   - **D** B & C only
   - **E** All of the above

2. Risk Factors for acquiring VAP include:
   - **A** Re-intubation, an elevated position, and frequent admission to the hospital
   - **B** Self-extubation, enteral tube feeding, and immunosuppression
   - **C** Middle age, recent throat surgery, and the use of rotational antibiotic therapy
   - **D** Nasogastric tube placement, incentive spirometry, and frequent oral hygiene

3. **T / F** The diagnosis of VAP can be difficult, as other conditions can exhibit common clinical symptoms.

4. Alcohol-based hand rubs may be used:
   - **A** After contact with the ventilator when gloves aren't worn
   - **B** After contact with mucous membranes when gloves are worn
   - **C** Before direct contact with patients
   - **D** A & C only
   - **E** All of the above

5. **T / F** For the purposes of infection control, ventilator circuits should be changed daily.

6. The following can be said about using nebulizers:
   - **A** Use sterile water only to fill the reservoir
   - **B** Nebulizers should be changed after each use
   - **C** Two treatments can be made with the nebulizer before cleaning, disinfecting and rinsing
   - **D** Multidose vials of medication are recommended for use

7. The following are recommended ways to reduce colonization:
   - **A** Rinsing closed suction systems with tap water after use
   - **B** Oral hygiene
   - **C** Selective Decontamination of the Digestive Tract
   - **D** All of the above

8. **T / F** To reduce aspiration, subglottic suctioning should be performed before repositioning tubes, prior to extubation, and whenever the cuff is deflated.

9. To reduce the risk of VAP from enteral feeding:
   - **A** Elevate patients 30-45° from a supine position and use bolus feeding
   - **B** Verify tube placement before feeding, and use nasogastric tube placement
   - **C** Consider jejunal tube placement, and measure gastric residuals prior to feeding
   - **D** All of the above.

10 **T / F** Alternatives to translaryngeal intubation include tracheostomies and positive ventilation through a nose or face mask.

X. Evaluation Form

Please print clearly and fill in all data to ensure accurate record-keeping.

Name:_____ Title: _____

Facility Name:_____

RN/LPN License (State and #*): _____SSN*:_____

Home Address:_____

City:_____ State:_____ Zip:_____

Home Phone #:_____ Work Phone #:_____

(*) RN/LPN License number or Social Security Number is required to obtain CE Credit.

Please check appropriate box: ☐ **RN/LPN** ☐ **Other**

Iowa Nurses Only: *Please complete and leave evaluation form with conference coordinator at the conclusion of the conference in exchange for a Certificate of Completion, or you may submit the evaluation form to the Iowa Board of Nursing.*

California and Florida registered nurses *must provide your RN license number.*

EVALUATION

Date:_____ Faclilitator:_____

The evaluation process is important to determine the extent to which this program has met your learning needs and to measure its overall effectiveness. Circle the number that best reflects the extent of your agreement with each statement.

OBJECTIVES

Indicate to what degree the objectives for this program were met.	**Poor**				**Excellent**
1. Identify patient care activities during which infection causing microorganisms may be transmitted	1	2	3	4	5
2. Identify the different types of aseptic technique	1	2	3	4	5
3. Define when to use clean and sterile aseptic technique	1	2	3	4	5
4. Demonstrate best practices for aseptic technique in the acute care setting	1	2	3	4	5
5. Differentiate between antiseptics and disinfectants and explain their proper applications	1	2	3	4	5

OVERALL EVALUATION

6. Content	1	2	3	4	5
7. Audiovisual materials	1	2	3	4	5
8. Handout materials	1	2	3	4	5
9. Overall quality of the program	1	2	3	4	5

PROGRAM INTEGRITY

Indicate your agreement with the following statement	**Disagree**				**Agree**
10. The content in this course was presented without bias of any commercial product or drug.	1	2	3	4	5

11. How long did it take you to complete this program?_____

12. What other topics would be of benefit to you?_____

13. Additional comments._____

XI. Post Test Answers

1. **D. B & C only.** A is incorrect as intubation increases bacteria-trapping mucous production, while at the same time the body is unable to effectively clear the mucous.
2. **B. Self-extubation, enteral tube feeding, and immunosuppression.** The other sentences included several wrong answers, including an elevated position, frequent admission to the hospital, middle age, recent throat surgery, the use of rotational antibiotic therapy, incentive spirometry, and frequent oral hygiene.
3. **True.** VAP should be diagnosed using clinical, microbiological and radiological criteria.
4. **E. All of the above.** Whether gloves are worn or not, hands should be cleaned after contact with secretions, inanimate objects and patients, and alcohol-based hand rubs are appropriate for this function.
5. **False.** Studies do not support this. The ventilator circuit, including in-line catheters, should be changed when they are visibly soiled or malfunctioning.
6. **A. Use sterile water only to fill the reservoir.** The other answers are incorrect as nebulizers should be changed regularly, but not after each use; nebulizers should be cleaned, disinfected and rinse between each treatment; and multidose vials can increase the potential for contamination.
7. **B. Oral hygiene.** Sterile water should be used to rinse closed suction systems, and SDD is not a recommended practice.
8. **True.** This will not only decrease colonization, it will prevent the micro-aspiration of oropharyngeal secretions.
9. **C. Consider jejunal tube placement, and measure gastric residuals prior to feeding.** The other sentences included incorrect answers such as use bolus feeding (intermittent feeding is better, but not as good as continuous feeding), and use nasogastric tube placement (which increases the risk of VAP).
10. **True.** These may be considered as part of a ventilator-weaning strategy.

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