INTERNATIONAL SOCIETY FOR INFECTIOUS DISEASES

GUIDE TO INFECTION CONTROL IN THE HOSPITAL

CHAPTER 33:

Mechanical Ventilation

Authors
C. Landelle, PharmD, PhD
D. Pittet, MD, MS

Chapter Editor
Gonzalo Bearman, MD, MPH, FACP, FSHEA, FIDSA

Topic Outline

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KEY ISSUES

Tracheal intubation and mechanical ventilation (MV) are the most important risk factors for hospital-acquired pneumonia in critically ill patients (3 to 21-fold increase in the risk).

KNOWN FACTS

- Ventilator-associated pneumonia (VAP) is a common and highly morbid condition in critically ill patients. Incidence varies between 5% and 67%, depending on case mix and diagnostic criteria. The overall attributable mortality of VAP is 13%. In surviving patients, it causes substantial morbidity, resource utilization, and extends hospital length of stay by at least 4 days.
- VAP is usually defined by clinical, radiographic, and microbiological criteria. These are neither sensitive nor specific relative to histopathology. These criteria are also subjective, leading to substantial inter-observer variability. Comparison of VAP rates between different centers can be difficult; change of VAP rates with time for the same center is more relevant.
- Early-onset VAP accounts for at least one-third of pneumonia cases in the critical care setting. This entity should be distinguished from late-onset episodes because of the different microbiologic spectrum, risk factors, and outcome. As pathogens causing aspiration pneumonia reflect the oropharyngeal microbial flora at time of aspiration, those causing early-onset VAP more likely reflect normal oral flora or pathogens responsible for community-acquired pneumonia (*Streptococcus pneumoniae*, *Haemophilus influenzae,* etc.*)*. Nevertheless, multidrug-resistant (MDR) pathogens may also be involved in early-onset pneumonia, especially in settings with a high prevalence of antibiotic overuse.

- Pathogens colonizing the respiratory tract and causing VAP are derived from either endogenous or exogenous sources. Those colonizing the upper respiratory tract (oropharynx, sinus cavities, the nares, and dental plaque) may be aspirated. Potential exogenous sources are a contaminated environment (sinks, faucets, etc.), contaminated equipment (MV devices, ventilator circuits, etc.), contaminated enteral feeding, contaminated aerosols, and other colonized patients in the intensive care unit (ICU). VAP can result when the inoculum is large, the microbes virulent, and the host defenses impaired. The stomach is an uncommon source of microorganisms for pneumonia in ventilated patients. Hematogenous spread from infected intravascular catheters or bacterial translocation of the gastrointestinal tract lumen occurs much less frequently.
- Emergent intubation, prolonged MV through an endotracheal tube, repeated intubation and contaminated ventilator circuits increase the risk of VAP.
- Unnecessary intubation should be avoided at all times. Non-invasive positive-pressure ventilation (NIPPV) could be used as an alternative ventilation mode in some ICU patients.
- Adequate initial antimicrobial treatment decreases the clinical impact of VAP.

SUGGESTED PRACTICE

- The American Thoracic Society with a high- or moderate-level of evidence recommended numerous preventive measures in 2005. Since then, some studies and meta-analyses have confirmed their efficacy:
  1. Effective infection control measures: education and training of healthcare workers, high compliance with alcohol-based handrubbing as the main measure for hand hygiene, and isolation to reduce cross-infection with MDR pathogens should be used routinely.

2. Surveillance of high-risk patients to determine trends and detect outbreaks of VAP within the ICU. Infection rates should be presented to intensive care physicians and nurses on a regular basis (feedback).
3. Low or reduced staffing levels have a negative impact on patient safety and healthcare-associated infections in critically ill patients and are associated with lapses in infection control practices, thus facilitating cross-transmission of pathogens. A substantial proportion of VAP could be avoided if nurse staffing could be maintained at a higher level.
4. Keeping the teeth and mouth clean, preventing the build-up of dental plaque on teeth or secretions in the mouth may help to reduce the risk of developing VAP. Effective oral hygiene care (OHC) is important for ventilated patients. OHC that includes either chlorhexidine mouthwash or gel reduces the odds of developing VAP by 30 to 40% in critically ill adults. There is no evidence that OHC including both chlorhexidine and tooth brushing is different from OHC with chlorhexidine alone.
5. Limiting the use of continuous sedation and paralytic agents that depress cough, coupled with sedation vacations and weaning protocols that facilitate removal of the endotracheal tube are strongly recommended to reduce days of mechanical ventilation and lower VAP rates.
6. Unnecessary intubation and repeated intubation should be avoided. Non-invasive positive-pressure ventilation (NIPPV) should be used whenever possible.
7. Orotracheal intubation and orogastric tubes should be preferred over nasotracheal intubation and nasogastric tubes to prevent nosocomial sinusitis and to reduce the risk of VAP.
8. The endotracheal tube cuff pressure (Pcuff) should be maintained at approximately 20-30 cm H_2O to prevent leakage of contaminated oropharyngeal secretions and gastric content around the cuff into the

lower respiratory tract. Pcuff continuous regulation using an automatic device that continuously displays the levels of Pcuff in real time has been evaluated with contradictory results.

9. The main cause of VAP is due to the aspiration of secretions containing bacterial pathogens into the lower respiratory tract. Aspiration of subglottic secretions requires the use of specially designed endotracheal tubes containing a separate dorsal lumen that opens into the subglottic region. The use of endotracheal tubes with subglottic secretion drainage has shown to be effective for the prevention of VAP, but the cost-effectiveness of the strategy deserves further investigation.
10. Contaminated condensate should be carefully emptied from ventilator circuits and condensate should be prevented from entering either the endotracheal tube or inline medication nebulizers.
11. Enteral nutrition is preferred over parenteral nutrition to reduce the risk of complications related to central intravenous catheters and to prevent reflux villous atrophy of the intestinal mucosa that may increase the risk of bacterial translocation.
12. A restricted transfusion trigger policy for transfusion of red blood cell and other allogeneic blood products is recommended; leukocyte-depleted red blood cell transfusions can help to reduce VAP in selected patient populations.
13. Selective oropharyngeal decontamination (SOD) and selective digestive decontamination (SDD) have been studied for many years. These involve the use of topical oral antibiotics for SOD, and topical oral and intestinal antibiotics, often with a systemic antibiotic added during the first few days of the regimen for SDD, with the goal being the elimination of potential pathogens from the oropharynx and/or gastrointestinal tract. With the eradication of endogenous bacterial sources, infection may be avoided. SOD and SDD are effective in reducing the incidence of VAP in the ICU. SDD with systemic antimicrobial therapy reduced mortality. Importantly, the main

concern associated with the use of SOD or SDD remains the development and spread of antimicrobial resistance. Overall, the currently available evidence does not support the use of SOD or SDD as a preventive strategy on a large scale, particularly in settings with endemic cross-transmission of MDR microorganisms.

- The following measures are recommended in the absence of a strong level of evidence: avoid unnecessary aspirations; saline instillation before tracheal suctioning; cleaning, disinfection, and sterilization of reusable components and appropriate maintenance of equipment; use of sterile water for rinsing reusable equipment; not implementing ventilator circuit changes unless specifically indicated; change of filters in the breathing circuit every 7 days; use of gloves when handling respiratory secretions; and use of heat and moisture exchangers.
- The following measures are suggested without definitive scientific evidence of their benefit: silver-coated endotracheal tube; use of probiotics; closed-suction systems; use of selective oropharyngeal decontamination (SOD) or selective digestive decontamination (SDD) in settings with endemic cross-transmission of MDR microorganisms; kinetic bed therapy; positive end-expiratory pressure (PEEP); physiotherapy; semi-recumbent position (>30°); stress bleeding prophylaxis; intensive insulin therapy; prone position for acute respiratory distress syndrome (ARDS); and mucus shaver. Of note, semi-recumbent position is a low cost intervention but compliance is often below optimal.
- The following measures have not demonstrated their efficacy: early tracheotomy; and iseganan (antimicrobial).
- Since the early 2000s, several multimodal strategies to prevent VAP have been applied in before-after studies. Most have been associated with VAP reduction. “Bundle” strategies are now applied in the ICU, but it remains difficult to assess the significance and effect of each individual measure on VAP prevention. A great deal of attention must be given to factors that might improve adherence with preventive measures.

SUGGESTED PRACTICE IN UNDER-RESOURCED SETTINGS:

- In under-resourced settings, standard infection control measures should be implemented: education and training of healthcare workers, high compliance with alcohol-based handrubbing, isolation to reduce cross-infection with MDR pathogens, and surveillance of high-risk patients to determine trends and detect outbreaks of VAP within the ICU.
- A multimodal strategy with at least 3 to 5 effective infection control measures to prevent VAP should be implemented. Priority measures are: avoidance of unnecessary intubation and repeated intubation; use of NIPPV; use of sedation vacations and weaning protocols; use of orotracheal intubation; control of endotracheal tube cuff pressure; oral hygiene care; use of enteral nutrition; and avoidance of elective changes of ventilator circuits, humidifiers, and endotracheal tubes.
- Measures without a strong level of evidence or without definitive scientific evidence of their benefit should be avoided.

SUMMARY

VAP is the most frequent ICU-acquired infection in mechanically ventilated patients and is associated with considerable morbidity and costs, significant antibiotic use, and high mortality rates. Microaspiration of oropharyngeal secretions contaminated by endogenous flora around the endotracheal tube cuff is the major route for microbial invasion. A large number of preventive measures and strategies have been proposed with variable degrees of effectiveness. Consequently, physicians should first consider preventive measures with a demonstrated impact on patient outcomes, such as optimal infection control practices (particularly, hand hygiene), NIPPV, sedation, and weaning protocols, oral hygiene care, and endotracheal tube with drainage of subglottic secretions. Clearly, there is no single preventive mechanism that will completely avert this

complication, and patients at risk of VAP must be approached with a package or bundle of preventive measures. The use of a “ventilator bundle” appears attractive in many ways, although the choice of practices incorporated in this bundle needs critical evaluation. Successful VAP prevention relies on multimodal, multidisciplinary strategies.

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