SUPPLEMENT ARTICLE: SHEA/IDSA PRACTICE RECOMMENDATION

Strategies to Prevent Ventilator-Associated Pneumonia in Acute Care Hospitals

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PURPOSE

Previously published guidelines are available that provide comprehensive recommendations for detecting and preventing healthcare-associated infections. The intent of this document is to highlight practical recommendations in a concise format designed to assist acute care hospitals in implementing and prioritizing their ventilator-associated pneumonia (VAP) prevention efforts. Refer to the Society for Healthcare Epidemiology of America/Infectious Diseases Society of America "Compendium of Strategies to Prevent Healthcare-Associated Infections" Executive Summary and Introduction and accompanying editorial for additional discussion.

SECTION 1: RATIONALE AND STATEMENTS OF CONCERN

1. Occurrence of VAP in acute care facilities.
   a. VAP is one of the most common infections acquired by adults and children in intensive care units (ICUs).[1,2]
      i. In early studies, it was reported that 10%-20% of patients undergoing ventilation developed VAP.[3,4] More-recent publications report rates of VAP that range from 1 to 4 cases per 1,000 ventilator-days, but rates may exceed 10 cases per 1,000 ventilator-days in some neonatal and surgical patient populations.[5-9] The results of recent quality improvement initiatives, however, suggest that many cases of VAP might be prevented by careful attention to the process of care.

2. Outcomes associated with VAP
   a. VAP is a cause of significant patient morbidity and mortality, increased utilization of healthcare resources, and excess cost.[10-13]
      i. The mortality attributable to VAP may exceed 10%.[14-22]
      ii. Patients with VAP require prolonged periods of mechanical ventilation,[23] extended hospitalizations,[4,11,16] excess use of antimicrobial medications, and increased direct medical costs.[11,13,14]

3. Pathogenesis of and risk factors for VAP
   a. VAP arises when there is bacterial invasion of the pulmonary parenchyma in a patient receiving mechanical ventilation.
      i. Inoculation of the formerly sterile lower respiratory tract typically arises from aspiration of secretions, colonization of the aerodigestive tract, or use of contaminated equipment or medications.[24]

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ii. Risk factors for VAP include prolonged intubation,[25] enteral feeding,[26] witnessed aspiration,[27] paralytic agents,[27] underlying illness,[7,11,27,28] and extremes of age.[28]

SECTION 2: STRATEGIES TO DETECT VAP

1. Surveillance definition

a. The definition of VAP is perhaps the most subjective of the common device-related healthcare-associated infections.[29-32] Most hospital epidemiologists and infection prevention and control professionals use the VAP definition put forth by the National Healthcare Safety Network, which uses 3 groups of criteria: clinical, radiographic, and microbiological.[33]

i. Despite the use of a common definition, significant interobserver variability has been noted.[34-36]

ii. Factors such as the surveillance strategy, diagnostic techniques, and microbiology and laboratory procedures likely account for some of the differences in VAP rates between different institutions.[29]

2. Methods for surveillance of VAP

a. Active surveillance is required to accurately identify patients with VAP.[22,37] Case finding by review of administrative data alone, such as discharge diagnosis codes, is inaccurate and lacks both sensitivity and specificity.[38,39]

i. Case finding of VAP is complex as a result of clinical criteria that vary with age and other host factors.

ii. The need for review of 2 or more chest radiographs for patients with underlying pulmonary or cardiac disease also contributes to the difficulties in identifying patients with VAP.

iii. Gram staining and semiquantitative culture of endotracheal secretions or quantitative culture of specimens obtained through bronchoalveolar lavage should be performed for a patient suspected to have VAP. The question of which method is optimal for specimen collection of lower respiratory tract secretions for diagnosis of VAP is controversial.[22,37,40-42]

iv. Information technology, such as electronic surveillance tools, can assist in the identification of patients with possible VAP but cannot provide definitive identification and are not yet widely available.[43,44]

SECTION 3: STRATEGIES TO PREVENT VAP

1. Existing guidelines and recommendations

a. Guidelines to prevent VAP have been published by several expert groups and, when fully implemented, improve patient outcomes and are cost-effective.[45-51]

b. Because few studies have evaluated the prevention of VAP in children, the majority of these recommendations stem from studies that were performed in adults. The core recommendations are designed to interrupt the 3 most common mechanisms by which VAP develops:

i. Aspiration of secretions

ii. Colonization of the aerodigestive tract

iii. Use of contaminated equipment

2. General strategies that have been found to influence the risk of VAP

a. General strategies

i. Conduct active surveillance for VAP.[52,53]

ii. Adhere to hand-hygiene guidelines published by the Centers for Disease Control and Prevention or the World Health Organization.[52,53]

iii. Use noninvasive ventilation whenever possible.[54-61]

iv. Minimize the duration of ventilation.[53,62,63]

v. Perform daily assessments of readiness to wean[5,50] and use weaning protocols.[57,62,64-69]

vi. Educate healthcare personnel who care for patients undergoing ventilation about VAP.[52,53,70,71]

b. Strategies to prevent aspiration

i. Maintain patients in a semirecumbent position (30°-45° elevation of the head of the bed) unless there are contraindications.[28,50,52,53,57,65,72-76]

(a) Experimental trials have demonstrated that backrest elevation is associated with a reduced risk of pulmonary aspiration.[72,75]

(b) Multivariable analysis of risk factors associated with VAP found up to a 67% reduction in VAP among patients maintained in semirecumbency during the first 24 hours of mechanical ventilation.[28]

(c) The impact of semirecumbency was confirmed in an observational study[50] and a randomized trial.[73]

(d) However, recent studies indicate that semirecumbent positioning is rarely maintained[77] and may not be associated with a reduced rate of tracheal colonization[77] or VAP.[78]

ii. Avoid gastric overdistention.[26,57,79,80]

iii. Avoid unplanned extubation and reintubation.[7,25,52,53]

iv. Use a cuffed endotracheal tube with in-line or subglottic suctioning.[52,57,81-86]

(a) Meta-analysis demonstrated that subglottic secretion drainage was effective in preventing early-onset VAP.[85]

v. Maintain an endotracheal cuff pressure of at least 20 cm H_2O.[87]

c. Strategies to reduce colonization of the aerodigestive tract

i. Orotracheal intubation is preferable to nasotracheal intubation.

(a) Nasotracheal intubation increases the risk of sinusitis,[88,89] which may increase the risk for VAP.[90,91]

ii. Avoid histamine receptor 2 (H2)–blocking agents and proton pump inhibitors for patients who are not at high risk for developing a stress ulcer or stress gastritis.[53,57,76,92]

(a) Acid-suppressive therapy may increase the col-

onization density of the aerodigestive tract with potentially pathogenic organisms.

(b) Seven meta-analyses have yielded inconsistent results regarding the magnitude of risk associated with the colonization of the aerodigestive tract.[93-98] Healthcare Infection Control Practices Advisory Committee Guidelines identified the preferential use of sucralfate or H2-blocking agents as an unresolved issue.[52]

(c) A single retrospective study of children undergoing ventilation found that the rate of VAP did not vary according to the strategy used to prevent gastrointestinal bleeding.[99]

iii. Perform regular oral care[57,100-103] with an antiseptic solution.[101,104-108] The optimal frequency for oral care is unresolved.

d. Strategies to minimize contamination of equipment used to care for patients receiving mechanical ventilation

i. Use sterile water to rinse reusable respiratory equipment.[52]

ii. Remove condensate from ventilatory circuits. Keep the ventilatory circuit closed during condensate removal.[52,53,57,109]

iii. Change the ventilatory circuit only when visibly soiled or malfunctioning.[21,52,110-114]

iv. Store and disinfect respiratory therapy equipment properly.[52] (See the Appendix.)

SECTION 4: RECOMMENDATIONS FOR IMPLEMENTING PREVENTION AND MONITORING STRATEGIES

Recommendations for preventing and monitoring VAP are summarized in the following section. They are designed to assist acute care hospitals in prioritizing and implementing their VAP prevention efforts. Criteria for grading the strength of recommendation and quality of evidence are described in the Table.

I. Basic practices for prevention and monitoring of VAP: recommended for all acute care hospitals

A. Education

1. Educate healthcare personnel who care for patients undergoing ventilation about VAP, including information about the following (A-II):
   a. Local epidemiology
   b. Risk factors
   c. Patient outcomes

2. Educate clinicians who care for patients undergoing ventilation about noninvasive ventilatory strategies (B-III).

B. Surveillance of VAP

1. Perform direct observation of compliance with VAP-specific process measures (B-III).
   a. VAP-specific process measures include hand hygiene, bed position, daily sedation interruption and assessment of readiness to wean, and regular oral care.
   b. Use structured observation tools at regularly scheduled intervals.

2. Conduct active surveillance for VAP and associated process measures in units that care for patients undergoing ventilation who are known or suspected to be at high risk for VAP on the basis of risk assessment (A-II).
   a. Collect data that will support the identification of patients with VAP and calculation of VAP rates (ie, the number of VAP cases and number of ventilator-days for all patients who are undergoing ventilation and in the population being monitored).

C. Practice

1. Implement policies and practices for disinfection, ster-

TABLE. Strength of Recommendation and Quality of Evidence

Category/grade	Definition
Strength of recommendation	
A	Good evidence to support a recommendation for use
B	Moderate evidence to support a recommendation for use
C	Poor evidence to support a recommendation
Quality of evidence	
I	Evidence from $\geqslant$1 properly randomized, controlled trial
II	Evidence from $\geqslant$1 well-designed clinical trial, without randomization; from cohort or case-control analytic studies (preferably from >1 center); from multiple time series; or from dramatic results from uncontrolled experiments
III	Evidence from opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees

NOTE. Adapted from the Canadian Task Force on the Periodic Health Examination.[115]

ilization, and maintenance of respiratory equipment that are aligned with evidence-based standards (eg, guidelines from the Centers for Disease Control and Prevention and professional organizations) (A-II).[52]

a. See the Appendix for a list of recommended practices.

2. Ensure that all patients (except those with medical contraindications) are maintained in a semirecumbent position (B-II).

3. Perform regular antiseptic oral care in accordance with product guidelines (A-I).

4. Provide easy access to noninvasive ventilation equipment and institute protocols to promote the use of noninvasive ventilation (B-III).

D. Accountability

1. The hospital's chief executive officer and senior management are responsible for ensuring that the healthcare system supports an infection prevention and control program to effectively prevent VAP.

2. Senior management is accountable for ensuring that an adequate number of trained personnel are assigned to the infection prevention and control program.

3. Senior management is accountable for ensuring that healthcare personnel, including licensed and nonlicensed personnel, are competent to perform their job responsibilities.

4. Direct healthcare providers (such as physicians, nurses, aides, and therapists) and ancillary personnel (such as housekeeping and equipment-processing personnel) are responsible for ensuring that appropriate infection prevention and control practices are used at all times (including hand hygiene, standard and isolation precautions, cleaning and disinfection of equipment and the environment, aseptic techniques when suctioning secretions and handling respiratory therapy equipment, patient positioning, sedation and weaning protocols, and oral care).

5. Hospital and unit leaders are responsible for holding their personnel accountable for their actions.

6. The person who manages the infection prevention and control program is responsible for ensuring that an active program to identify VAP is implemented, that data on VAP are analyzed and regularly provided to those who can use the information to improve the quality of care (eg, unit staff, clinicians, and hospital administrators), and that evidence-based practices are incorporated into the program.

7. Personnel responsible for healthcare personnel and patient education are accountable for ensuring that appropriate training and educational programs to prevent VAP are developed and provided to personnel, patients, and families.

8. Personnel from the infection prevention and control program, the laboratory, and information technology departments are responsible for ensuring that systems are in place to support the surveillance program.

II. Special approaches for the prevention of VAP

Perform a VAP risk assessment. These special approaches are recommended for use in locations and/or populations within the hospital that have unacceptably high VAP rates despite implementation of the basic VAP prevention procedures listed above.

1. Use an endotracheal tube with in-line and subglottic suctioning for all eligible patients (B-II).

2. Ensure that all ICU beds used for patients undergoing ventilation have a built-in tool to provide continuous monitoring of the angle of incline (B-III).

III. Approaches that should not be considered a routine part of VAP prevention

1. Do not routinely administer intravenous immunoglobulin,[52] white-cell–stimulating factors (filgrastim or sargramostim),[52] enteral glutamine,[52] or chest physiotherapy[52,116] (A-III).

2. Do not routinely use rotational therapy with kinetic or continuous lateral rotational therapy beds (B-II).[52,117]

3. Do not routinely administer prophylactic aerosolized or systemic antimicrobials (B-III).[2,52,118]

IV. Unresolved issues

1. Avoidance of H2 antagonist or proton pump inhibitors for patients who are not at high risk for developing gastrointestinal bleeding[76,93,94,98,119-122]

2. Selective digestive tract decontamination for all patients undergoing ventilation[123-128]

3. Use of antiseptic-impregnated endotracheal tubes[129,130]

4. Intensive glycemic control[131-134]

SECTION 5: PERFORMANCE MEASURES

I. Internal reporting

These performance measures are intended to support internal hospital quality improvement efforts and do not necessarily address external reporting needs.

The process and outcome measures suggested here are derived from published guidelines, other relevant literature, and the opinions of the authors. Report both process and outcome measures to senior hospital leadership, nursing leadership, and clinicians who care for patients at risk for VAP.

A. Process measures

1. Compliance with hand-hygiene guidelines for all clinicians who deliver care to patients undergoing ventilation

a. Collect data on a sample of healthcare personnel from all disciplines who provide hands-on care to patients undergoing ventilation, including physicians, nurses, respiratory therapists, and radiology technicians. Perform observations at regular intervals (eg, 1 set of measurements per week). The frequency of observations can be adjusted on the basis of compliance rates (eg, as compliance improves, less frequent observations may be needed).

b. Preferred measure for hand-hygiene compliance

i. Numerator: number of observed appropriate hand-hygiene episodes performed by healthcare personnel.

ii. Denominator: number of observed opportunities for hand hygiene.

iii. Multiply by 100 so that the measure is expressed as a percentage.

2. Compliance with daily sedation interruption and assessment of readiness to wean

a. Assessment should be performed by chart review of a sample of all patients currently undergoing ventilation. Evidence of daily documentation on the patient's chart, bedside paperwork, or electronic medical record of a sedation interruption and assessment of readiness to wean should be present unless clinically contraindicated. Perform assessments at regular intervals (eg, 1 set of measurements per week). The frequency of observations can be adjusted on the basis of compliance rates (eg, as compliance improves, less frequent observations may be needed).

b. Preferred measure of compliance with sedation interruption and assessment of readiness to wean

i. Numerator: number of patients undergoing ventilation with daily documentation of consideration of sedation interruption and assessment of readiness to wean or contraindication.

ii. Denominator: number of patients undergoing ventilation.

iii. Multiply by 100 so that the measure is expressed as a percentage.

3. Compliance with regular antiseptic oral care

a. Assessment should be performed by chart review of a sample of all patients currently undergoing ventilation. Perform assessments at regular intervals (eg, 1 set of measurements per week). The frequency of observations can be adjusted on the basis of compliance rates (eg, as compliance improves, less frequent observations may be needed).

b. Preferred measure of assessment of compliance with antiseptic oral care

i. Numerator: number of patients undergoing ventilation with daily documentation of regular oral care according to product instructions.

ii. Denominator: number of patients undergoing ventilation.

iii. Multiply by 100 so that the measure is expressed as a percentage.

4. Compliance with semirecumbent positioning for all eligible patients

a. Assessment should be performed for all patients currently undergoing ventilation, by direct observation of the position of the head of bed. Perform assessments at regular intervals (eg, 1 set of measurements per week). The frequency of observations can be adjusted on the basis of compliance rates (eg, as compliance improves, less frequent observations may be needed).

b. Preferred measure of assessment of semirecumbent positioning compliance

i. Numerator: number of patients undergoing ventilation who are in a semirecumbent position (30°-45° elevation of the head of the bed) at the time of observation.

ii. Denominator: number of patients undergoing ventilation who are eligible to be in a semirecumbent position.

iii. Multiply by 100 so that the measure is expressed as a percentage.

B. Outcome measures

Perform ongoing surveillance of the incidence density of VAP on units that care for patients undergoing ventilation who are known or suspected to be at high risk for VAP, to permit longitudinal assessment of process of care.

1. Incidence density of VAP, reported as the number of episodes of VAP per 1,000 ventilator-days.

a. Preferred measure of VAP incidence density

i. Numerator: number of patients undergoing mechanical ventilation who have VAP, defined using National Healthcare Safety Network definitions.

ii. Denominator: number of ventilator-days.

iii. Multiply by 1,000 so that the measure is expressed as cases per 1,000 ventilator-days.

II. External reporting

There are many challenges in providing useful information to consumers and other stakeholders while preventing unintended adverse consequences of public reporting of healthcare-associated infections.[135] Recommendations for public re-

porting of healthcare-associated infections have been provided by the Hospital Infection Control Practices Advisory Committee,[136] the Healthcare-Associated Infection Working Group of the Joint Public Policy Committee,[137] and the National Quality Forum.[138]

Because of the difficulties in diagnosing VAP,[30] the validity of comparing VAP rates between facilities is poor, and external reporting of rates of VAP is not recommended.[29]

A. State and federal requirements

1. Hospitals in states that have mandatory reporting requirements for VAP must collect and report the data required by the state.
2. For information on local requirements, check with your state or local health department.

B. External quality initiatives

1. Hospitals that participate in external quality initiatives or state programs must collect and report the data required by the initiative or the program.

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APPENDIX

STERILIZATION, DISINFECTION, AND MAINTENANCE OF RESPIRATORY EQUIPMENT, BASED ON HEALTHCARE INFECTION CONTROL PRACTICES ADVISORY COMMITTEE RECOMMENDATIONS

The Healthcare Infection Control Practices Advisory Committee[52] system for categorization of recommendations is as follows:

Category IA: Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.
Category IB: Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale.
Category IC: Required for implementation, as mandated by federal or state regulation or standard.
Category II: Suggested for implementation and supported by suggestive clinical or epidemiological studies or a theoretical rationale.

1. General measures
   a. Thoroughly clean all respiratory equipment to be sterilized or disinfected (category IA).
   b. Whenever possible, use steam sterilization or high-level disinfection by wet heat pasteurization at temperatures higher than 70°C (158°F) for 30 minutes for reprocessing semicritical equipment or devices (ie, items that come into direct or indirect contact with mucous membranes of the lower respiratory tract). Use low-temperature sterilization methods (as approved by the Office of Device Evaluation, Center for Devices and Radiologic Health, US Food and Drug Administration) for equipment or devices that are heat or moisture sensitive. After disinfection, proceed with appropriate rinsing, drying, and packaging, taking care not to contaminate the disinfected items (category IA).
   c. Preferentially use sterile water to rinse reusable semicritical respiratory equipment and devices when rinsing is needed after chemical disinfection. If this is not feasible, rinse the device with filtered water (ie, water that has been through a 0.2-μm filter) or tap water, and then rinse with isopropyl alcohol and dry with forced air or in a drying cabinet (category IB).
   d. Adhere to provisions in the US Food and Drug Administration's enforcement document for single-use devices that are reprocessed by third parties (category IC).

2. Mechanical ventilators
   a. Do not routinely sterilize or disinfect the internal machinery of mechanical ventilators (category II).

3. Breathing circuits, humidifiers, and heat-moisture exchangers
   a. Do not, on the basis of duration of use, routinely change the breathing circuit (ie, ventilator tubing and exhalation valve and the attached humidifier) that is in use by an individual patient. Change the circuit when it is visibly soiled or mechanically malfunctioning (category IA).
   b. Periodically drain and discard any condensate that collects in the tubing of a mechanical ventilator, taking precautions not to allow condensate to drain toward the patient (category IB).
   c. Wear gloves to perform the above procedure or handle the fluid (category IB).
   d. Decontaminate hands with soap and water (if hands are visibly soiled) or with an alcohol-based hand rub, after performing the procedure or handling the fluid (category IA).
   e. Use sterile (not distilled nonsterile) water to fill bubbling humidifiers (category II).
   f. Change a heat-moisture exchanger that is in use by a patient when it malfunctions mechanically or becomes visibly soiled (category II).
   g. Do not routinely change more frequently than every 48 hours a heat-moisture exchanger that is in use by a patient (category II).

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