

Guidelines for the Prevention of Ventilator Associated Pneumonia

1st Edition

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Acknowledgement

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KEY TO EVIDENCE STATEMENTS AND GRADES OF RECOMMENDATIONS

LEVELS OF EVIDENCE

- 1++ High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
- 1+ Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias
- 1- Meta-analyses, systematic reviews, or RCTs with a high risk of bias
- 2++ High quality systematic reviews of case control or cohort or studies
High quality case control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
- 2+ Well-conducted case control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
- 2- Case control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
- 3 Non-analytic studies, e.g. case reports, case series
- 4 Expert opinion

GRADES OF RECOMMENDATIONS

A At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; *or*

A body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results

B A body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results; *or*

Extrapolated evidence from studies rated as 1++ or 1+

C A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; *or*

Extrapolated evidence from studies rated as 2++

D Evidence level 3 or 4; *or*

Extrapolated evidence from studies rated as 2+

GOOD PRACTICE POINTS (GPP)

 Recommended best practice based on the clinical experience of the guideline development group

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Chapter 1 Introduction

A. Definition

Ventilator-associated pneumonia (VAP) is defined as pneumonia that are ventilator-associated at the time of, or within 48 hours before, the onset of the event after endotracheal intubation, remains the most common and fatal healthcare associated intensive care unit (ICU) infection among mechanically ventilated patients.^{1,2} There is no minimum period of time that the ventilator must be in place in order for the pneumonia to be considered ventilator-associated.

B. Pathogenesis of VAP

Impaired host immunity and displacement of normal oropharyngeal flora by pathogens predispose the critically ill, mechanically ventilated patient to VAP. Normal nonspecific host responses, such as the epiglottis, vocal cords, cough reflex, and ciliated epithelium and mucus of the upper airways are bypassed or rendered ineffective during intubation. Bacteria gain access to the lower respiratory tract via aspiration through the endotracheal tube (where they may establish colonies impervious to the effects of antibiotics in the glycocalyx biofilm that coats the lumen of the artificial airway devices), migration around it (particularly if cuff inflation pressure is not maintained), or, in rare instances, hematogenous spread from blood stream infections. Displacement of normal flora by pathogens is also necessary for the development of VAP. The facial sinuses and stomach may serve as potential pathogen reservoirs, but measures to minimize passage of pathogens from these sources into the lower airways have provided mixed results.³ The specific effects of the endotracheal tube (ETT) include 'the direct impact of the cuff on the local mucosa, an enhanced capacity of tracheobronchial cells to bind Gram-negative organisms, the creation of additional binding sites for bacteria due to exposure of the basement membrane of the bronchial tree, the creation of a biofilm in the ETT serving as

a reservoir for bacteria, and the presence of pooled sub-glottic secretions that accumulate between the cuff of the ETT and the tracheal wall leading to increased aspiration.⁴

Pathogens vary from unit to unit and between hospitals, but in the USA the most common pathogens isolated from patients with VAP are methicillin-resistant *Staphylococcus aureus* (MRSA), *Pseudomonas*, *Enterobacter*, *Escherichia coli* and *Acinetobacter*.³ These pathogens are also frequently isolated from patients admitted to ICUs in Singapore. Multidrug-resistant organisms (MDROs) are on the increase both locally and internationally.

C. Risk factors

Risk factors for the development of VAP include the following:³⁻⁶

I. Interventional factors:

- Increased duration of mechanical ventilation
- Prolonged hospital stay
- Presence of invasive devices (e.g. ETT, central venous pressure, urinary catheters)
- Prior use of antibiotics (indiscriminate use of broad- spectrum antibiotics)
- Red cell transfusions (immunomodulatory effects)
- Supine position
- Surgery
- Medications (e.g. stress ulcer prophylaxis therapy).

II. Host factors:

- Advanced age

- Co-morbid disease:
- Depressed level of consciousness
- Pre-existing/chronic lung disease (e.g. tuberculosis, chronic obstructive pulmonary disease, bronchiectasis)
- Colonisation of the oropharyngeal cavity with hospital-acquired pathogens
- Sinus colonisation or sinusitis
- Possibly gastric colonisation and aspiration
- Large-volume gastric aspiration
- Immune suppression from disease (e.g. HIV) or medication (e.g. steroids)
- Malnutrition, with a decreased serum albumin level
- Sepsis
- Acute respiratory distress syndrome (prolonged ventilation, devastated local airway host defenses)
- Organ failure
- Neurological/neuromuscular disease
- Burns, trauma

D. Epidemiology

VAP is described as the most common healthcare associated infection of intensive care and is often fatal, although attributable mortality varies.^{2,3,4} The incidence differs between units [ICUs,

HDs (high-dependency units)], hospitals (public and private sector) and countries (developed and developing). The range varies from 9% to 27% in Europe and America.^{2,3,6} Mortality rates in patients with VAP range from 20% to 50% and may be as high as 70% when the infection is caused by MDROs.⁶ VAP-attributable mortality is difficult to quantify because of confounding effects of associated conditions but has been estimated to increase mortality by 30% and even twofold in critically ill patients.^[6,8,9] Making a timely and accurate diagnosis of VAP is critical as delayed administration of appropriate antibiotics increases mortality.² And inappropriate use of antibiotics increases cost, incurs the risk of adverse drug reactions, and selects for resistant microbial flora that increase morbidity and mortality.² VAP is associated with increased mortality and morbidity, increased duration of mechanical ventilation, prolonged ICU and hospital stay, and increased cost of hospitalisation.^{2,6,9,10} In 2005, Safdar et al. calculated the cost of VAP at more than US\$10 000 per patient at 2003 dollar value cost estimates at a university-affiliated US teaching hospital.⁹ In 2003, Warren et al. found the attributable cost of VAP to be US\$11, 897 in their study, which was conducted in a non-teaching US hospital at a suburban community medical centre.¹⁰

VAP is the most common healthcare associated infection in intensive care units.¹ A systematic review revealed that VAP occurs in 10-20% of all patients mechanically ventilated for more than 48 hours.² Crude mortality rates in patients with VAP range from 24-50%, increasing to 76% if infection is caused by multi-drug resistant organisms.³ Patients who develop VAP are twice as likely to die as those without VAP.² VAP is also associated with prolonged length of ICU stay and increased healthcare costs.^{2,4, 5, 6} Its prevention is therefore, a critical part in the quality care of the ICU patient.

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Chapter 2 Prevention of VAP

A. VAP Bundle

A. VAP Bundle

The Institute of Health Improvement (IHI) Ventilator Bundle¹ is a series of evidence based interventions that when implemented together will achieve significant outcomes of reducing VAP in patients on mechanical ventilation.

The components of the VAP Bundle are:

- 1) Elevation of head of bed
- 2) Daily 'sedation vacations' and assessment for readiness to extubate
- 3) Peptic Ulcer Disease prophylaxis
- 4) Deep Venous Thrombosis prophylaxis
- 5) Daily oral care with chlorhexidine

The critical success factor for the reduction of VAP is to use all the above components together.

B. VAP Bundle Components

- 1) Elevation of head of bed

This is an integral component. A semi-recumbent position with head elevated to 30-45⁰ reduces the potential for aspiration and increases capacity of the lungs for breathing. Drakulovic et al ² in 1998 conducted a randomized controlled trial of 86 mechanically ventilated patients. Patients were randomly assigned to semi recumbent or supine

position. Results showed suspected cases of VAP in 34% of patients in supine position and 8% in the semi-recumbent position ($p=0.003$). Confirmed cases of pneumonia were 23% and 5% respectively ($p=0.018$).

2) Daily 'sedation vacations' and assessment for readiness to extubate

Daily review of sedation with the aim to lighten it helps to prepare patient for readiness to extubate. It becomes easier to wean off the ventilator as patient is more alert to cough and control secretions. Early extubation also decreases the time spent on mechanical ventilation and directly reduces the risk of VAP. In a randomized controlled trial by Kress et al, 128 mechanically ventilated adult patients irrespective of clinical condition and clinician's discretions, were randomized to receive daily interruption of sedation. This resulted in a significant reduction in mechanical ventilation time from 7.3 to 4.9 days ($P=0.004$)³.

Considered as one of the mandatory component of the VAP bundle, sedation vacations are not without risk. Careful assessment and graduated lightening of sedation should be practiced to prevent self extubation, keep patient comfortable with minimal pain and anxiety while allowing return of self-breathing and synchrony with the ventilator and avoiding episodes of desaturation.

3) Peptic Ulcer Disease prophylaxis

Peptic ulcer disease prophylaxis is another mandatory component of the VAP Bundle. Stress ulcerations are common causes of gastrointestinal bleeding resulting in increased mortality and morbidity to intensive care unit patients, Applying peptic ulcer disease prophylaxis is therefore necessary. However, agents used to prevent stress ulceration

may raise gastric pH and promote the growth of bacteria in the stomach, particularly Gram negative bacilli.

ICU patients are also prone to aspiration of gastric contents and secretions. Critically ill intubated patients lacking the ability to cough and clear secretions may be at risk to silent esophageal reflux and aspiration of gastric contents. These contents collecting along the endotracheal tube may lead to endobronchial colonization and pneumonia.

The 'Surviving Sepsis Campaign Guidelines' ⁴ recommended that "H2 receptor inhibitors are more efficacious than sucralfate and are the preferred agents for peptic ulcer disease prophylaxis. Proton pump inhibitors have not been assessed in a direct comparison with H2 receptor antagonists. Their relative efficacy is therefore unknown though they do demonstrate equivalency in ability to increase gastric pH."

However, it is still unclear that peptic ulcer disease prophylaxis has any direct effect on reducing VAP rates. The intervention still remains an excellent practice in the general care of ventilated patients. When applied as a package of interventions for the prevention of VAP, the rate of pneumonia seems to decrease.

4) Deep Venous Thrombosis prophylaxis

Deep venous thrombosis prophylaxis is another essential part of the VAP Bundle. The risk of venous thromboembolism is reduced if prophylaxis is consistently applied. A clinical practice guideline issued as part of the Seventh American College of Chest Physicians Conference on Antithrombotic and Thrombolytic Therapy recommends prophylaxis for patients admitted to the intensive care unit besides those undergoing surgery, trauma patients and acutely ill medical patients.⁵

While it is unclear if there is any association with decreasing rates of VAP, the correlation is highly possible. When applied collectively with other components of the VAP Bundle, the rate of pneumonia decreases. DVT prophylaxis hence remains an integral practice in the general care of ventilated patients in the ICU.

DVT prophylaxis can take the form of sequential compression stockings or devices or anticoagulant therapy. When using anticoagulants, precautions have to be taken to prevent the risk of bleeding.

5) Daily oral care with chlorhexidine

The recommended chlorhexidine solution strength used is 0.12%. In mechanically ventilated patients, dental plaque occurs because of the lack of mechanical chewing and absence of saliva production. This minimizes the development of biofilm on the teeth and the existence of these plaques serve as significant reservoirs for potential respiratory pathogens that cause VAP.

It is well known that the practice of good oral hygiene and the use of antiseptic oral decontamination reduce bacteria on the mouth. This in turn prevents bacterial colonization in the upper respiratory tract and reduces the potential for the development VAP in mechanically ventilated patients.

Chlorhexidine antiseptic has proven to inhibit the development of dental plaque formation and gingivitis. A study in 1996 by DeRiso and colleagues demonstrated that

the use of 0.12% chlorhexidine oral rinse reduces nosocomial respiratory tract infections in cardiac surgery patients.⁶

Chan and colleagues in 2007 reported in a meta-analysis, the evaluation of eleven studies for effect of oral decontamination on the incidence of ventilator-associated pneumonia and mortality in mechanically ventilated adults. Results concluded that oral decontamination using chlorhexidine is associated with a lower risk of ventilator-associated pneumonia in mechanically ventilated patients.⁷

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B. Implementation of the VAP Bundle

Prevention of healthcare-associated infection, including VAP, should be prioritized by the Department of Senior Management and all healthcare staff. Because of the high costs associated with VAP and its negative impact on patients, the Institute for Healthcare Improvement (IHI) created an initiative to reduce VAP incidence in critical care. Within its 100,000 Lives Campaign, the IHI recommends safety interventions deployed at the patient care, health-care team, and leadership levels, thereby maximizing the potential for successful implementation of the patient safety initiative.

Why use the care bundle?

This care bundle is derived from evidence-based guidance and expert advice. The purpose is to act as a way of improving and measuring the implementation of key elements of care. The risk of VAP increases when one or more elements are excluded or not performed.

Goals: Eliminate or reduce ventilator-associated pneumonia

Implementation of the VAP Bundle

- 1) Form a multidisciplinary team approach to ventilator care - assembly of a VAP Task Force including representatives from:
 - Hospital Leadership
 - Medical and Nursing Directors for each ICU
 - Allied Healthcare personnel e.g. Respiratory Therapists (RT)
 - Hospital's Quality Improvement Unit

- 2) Literature review

3) Develop a VAP Bundle audit tool:

- Design of a standardized Adult VAP bundle and gradual implementation of the VAP bundle
- The bundle includes a checklist of task and procedures to be conducted daily in every ICU patient receiving mechanical ventilation
- Development of a standardized ventilator order set, including all elements of the ventilator bundle
- Developed respiratory therapy-driven weaning protocol to reduce impact of varying physician practice in this area
- Developed standard intensive glycemic control protocol

4) Dissemination of the new bundle in all ICUs:

- Provide adequate levels of suitably qualified nursing and medical staff in all critical care areas caring for mechanically ventilated patients
- Introduction of the checklist
- Training of personnel and follow up to ensure familiarity with the new policy and process of care
- Visual controls developed for head of bed (HOB) scale to ensure adequate 30⁰ elevation
- Visual control set-up for glucometers, as well as purchase of additional glucometers to reduce non-value added time staff was spending searching for machines

5) Monitoring of unit VAP rates before and after implementation with feedback given to each specific ICU.

- ICU checks to assess adherence to the VAP recommended procedures
- Begin interdisciplinary rounds
- Monthly audits with the results posted in a highly visible area for the staff to see
- Re-educate staff that are not compliant.

6) Celebrate the success!

The implementation process can be launched successfully if the health-care system is effectively designed, with cooperative efforts of a multi-disciplinary team and champions from administration, leadership, doctors, nurses, pharmacy, respiratory therapists, and infection control team to maintain the initiative's momentum. Strong emphasis on teamwork to plan, design, implements and enforce changes.

Adequate time should be allowed for the change process. Avoid setbacks during the implementation by starting with small trials of the change, using Plan-Do-Check-Act (PDCA) cycles to refine the process before spreading to a larger population.

Multidisciplinary rounds with the involvement of an intensivist and use of a daily goal sheet. Standard order sets were developed to standardize care of ventilated patients. Revision of ventilator protocols to include initiating weaning upon intubation for all patients in ICU. Revised ICU orders for ventilated patients to include evidence-based improvements: HOB elevation greater than 30°, oral care, RT to begin weaning the patient immediately based on RT-driven protocol, daily evaluation of readiness to extubate, glycemic control, deep vein thrombosis prophylaxis, and peptic ulcer disease prophylaxis.

Include the Ventilator bundle documentation into the computerized clinical documentation, where available. The electronic tool will:

- Collect, collate and produce different views of the information
- Clearly identify when actions within the care bundle have or have not been performed
- Provide information to support the development of plans to resolve any issues and improve the quality of care
- Support a culture of continuous improvement

Conduct appropriate audits to collect data and track compliance with the use of the daily goal sheet and the bundle interventions, reeducating and reinforcing as necessary to address any noncompliance issues. Once data are available, analyze the findings and report the data graphically to visually reinforce the staff's efforts. In addition, maintain a weekly schedule for team meetings to allow for open communication, encourage participation, and gain buy-in from doctors and nurses.

Use poster storyboards to keep the focus on goals, track progress throughout the initiative, and celebrate the staff's hard work and success at major milestones. Post the compliance data, and the date of last VAP and number of days VAP free.

Reported monthly results to various committees throughout organization and posted results for staff to evaluate. Monthly review of data including action plans to improve outcomes. Conduct Root Cause Analysis (RCA) of each VAP to identify areas of improvement.

The implementation of new protocols and a sense of shared ownership of the change process by all healthcare team members contributed to this success. Process feedback and incorporate suggestions for improvement. Engage in subsequent PDCA cycles to refine the process and make it more reliable.

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C. Education and Training

Education of healthcare personnel is widely viewed as a fundamental measure in reducing VAP. Salahuddin and colleagues found a 51% reduction in VAP incidence through an educational program for VAP prevention¹. The program was a selection of recommended VAP prevention measures, and its benefit was persistent for 12 months. Educational strategies for reinforcement of prevention practices may be effective to reduce VAP rates.

A recent systematic review of educational interventions for Hospital associated infections (HAIs) included six studies, which described the effects of an educational intervention on VAP rates. All six were pre- and post-intervention studies². The review concluded that the implementation of educational interventions may reduce HAIs considerably.

Staff education includes multiple presentations on VAP, the importance of the VAP bundle, discussion on the VAP elements, and engaging the intensivists to adopt a protocol for the sedation vacation. Staff should be appropriately trained and competent in the stated procedure or care process. Assessment of competence is a prerequisite for any care delivered. Therefore education should include mechanisms for assuring training, assessment and recording of competence.

Educate staff on outcome measures by sharing quarterly report of the VAP bundle compliance rates and the VAP rates. Update the rates to the ICU quality improvement committee so as to review deviations and to identify the necessity for re-training of staff and to identify opportunities for improvement in system issues. Engage key people to promote prevention of VAP program was an important patient safety goal. Infection control officers to persist at driving a VAP reduction education program utilizing existing resources and

developing a cross-disciplinary, cross-department team to lead initiatives. A VAP reduction training video could be created and required every staff member to view the video or an on line training program.

RECOMMENDATIONS

- 1. Engage key people to support VAP educational program as an important patient safety goal (GPP)***
- 2. Educate consistently by disseminating bundle compliance rates and VAP results and review deviations to identify the need for re-training of staff (GPP).***

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D. Route of Endotracheal Intubation

While the causality between sinusitis and VAP has not been firmly established, aspiration of infected secretions from nasal sinuses would, intuitively, predispose to the development of VAP.

In a prospective randomized study (n=300), Holzapfel et al demonstrated that orotracheal intubation is associated with lower VAP rates as compared to nasotracheal intubation (RR 0.52; 95% confidence interval 0.24- 1.13).¹

This study, together with 4 other trials showed a decreased incidence of sinusitis with orotracheal intubation. Of note, patients who do not develop sinusitis have a lower incidence of VAP.²⁻⁵

RECOMMENDATION

We recommend that, where possible, orotracheal intubation should be used in preference to nasotracheal intubation (Level1++, Grade A).

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E. Systematic search for maxillary sinusitis

Maxillary nosocomial sinusitis as a complication of endotracheal intubation has been reported. The incidence of infectious sinusitis is estimated at 20% after 8 days of mechanical ventilation in patients orotracheally or nasotracheally intubated¹. Clinical signs are not specific. Sinusitis is usually searched for in patients with unexplained fever and is diagnosed by sinus radiograph or sinus CT scan.

Reported risk factors for sinusitis include head trauma, prior high dose steroids, sedation, nasotracheal intubation, nasogastric tubes and duration of endotracheal and gastric intubation².

No recommendation can be made for the systematic search for maxillary sinusitis because of insufficient evidence. There is only one randomised controlled trial that demonstrated that a systematic search for maxillary sinusitis in patients who are intubated by the nasotracheal route may decrease the incidence of VAP⁴.

RECOMMENDATION

A search for sinusitis is not recommended routinely for the prevention of VAP (GPP).

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F. Frequency of ventilator circuit changes

The relation between the frequency of ventilator tubing change and the incidence of ventilator associated pneumonia has been investigated by several groups¹⁻⁵. No benefit in terms of reducing infection has been demonstrated by routinely changing ventilator circuits. The randomized trials found that when circuits were changed when visibly soiled or mechanically defective, they were associated with rates of VAP similar to or modestly lower than rates occurring with regularly scheduled changes.

Handling and disposing of the condensate that forms on the inspiratory phase tubing of the ventilator circuits poses a risk of pneumonia in patients undergoing mechanical ventilation with humidification. This condensate rapidly becomes colonized flora and if not appropriately drained, contaminated fluid may be accidentally washed directly into the patient's trachea when the tubing is manipulated.

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 (IA)^{9,10}.

RECOMMENDATIONS

- 1. *The ventilator circuit should only be changed when defective or physically soiled (Level 1+, Grade A)***
- 2. *Breathing-circuit-tubing condensate***
 - a) *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 (Level I, Grade B)*⁷.**

b) Wear gloves to perform the previous procedures and/or when handling the fluid (Level I, Grade B)^{8,9}.

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G. Type of airway humidification

When the upper airway is bypassed, humidification during mechanical ventilation is necessary to prevent hypothermia, inspissation of airway secretions, destruction of airway epithelial cells and atelectasis. This may be accomplished using a heat and moisture exchanger (HME) or heated humidifier.

HMEs operate passively by storing heat and moisture from the patient's exhaled gas and releasing it to the inhaled gas. Heated humidifiers operate actively to increase the heat and water vapour content of inspired gas.

No recommendations can be made for the preferential use of either HMEs or heated humidifiers to prevent pneumonia in patients receiving mechanically assisted ventilation¹⁻⁵.

Use of heat and moisture exchangers may be associated with a slight decrease in incidence of VAP compared with heated humidifiers (II)⁴⁻⁵.

Heat and moisture exchangers are contraindicated in patients with haemoptysis or who require high minute ventilation. Cost considerations favour the use of heat and moisture exchangers.

No recommendations can be made for the preferential use of either HMEs or heated humidifiers to prevent pneumonia in patients receiving mechanically assisted ventilation¹⁻⁵.

RECOMMENDATIONS

HMEs are preferred over heated humidifiers in the prevention of VAP (Level 1-, Grade B).

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H. Frequency of change of airway humidification

Manufacturers state that HME should be changed every 24 hours but there are no clinical data to support this recommendation.

Studies have suggested that the same HME can be safely left in place for longer than 24 hours without adverse patient outcomes¹⁻³. Infrequent changes to heat and moisture exchangers may be associated with a slightly decreased incidence of VAP. Reduction in the frequency of humidifier changes might be considered as a cost-reduction measure.

RECOMMENDATIONS

- 1. *Change an HME that is in use on a patient when it malfunctions or becomes visibly soiled (Level II). Do not change more frequently than every 48 hours an HME that is in use on a patient (Level II) .***
- 2. *Do not change routinely the breathing circuit attached to an HME while it is use on a patient in the absence of gross contamination or malfunction (Level II).***

REFERENCES

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2. Thomachot L, Boisson C, Arnaud S, Michelet P, Cambon S, Martin C. Changing heat and moisture exchangers after 96 hours rather than 24 hours: A clinical and microbiological evaluation. Crit Care Med 2000;28:714-20.

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I. Type of endotracheal suctioning system (Open v Closed)

Endotracheal suctioning is an essential part of care for patients requiring mechanical ventilation, to keep the airways free from bronchial secretions, thereby guaranteeing good ventilation and oxygenation. There are 2 types of suction systems. In the conventional open system, endotracheal suctioning requires opening of the respiratory circuit, which is usually performed by disconnecting the patient from the ventilator and introducing a single-use sterile suctioning catheter into the endotracheal tube. The closed suction system, which was developed in the 1980s, removes the necessity of disconnecting the patient from the respiratory circuit and employs multiuse suction catheters. Suctioning is performed without barrier precautions, because a plastic envelope protects the catheter.

The potential benefits of the closed system, compared with the open system, are:

- a) There is no loss of positive end expiratory pressure and lung volume,
- b) Reduce exogenous contamination of the inside of the endotracheal tube,
- c) Decrease contamination of the environment or of the hands of healthcare workers from respiratory microorganisms.

The main concerns about closed systems are an increase in colonization inside the suction catheter during the multiple uses in 24 hours. There is auto-contamination of a larger number of microorganisms into the trachea each time suctioning is performed.

Although the literature reports several advantages for the closed suction system, the review did not show differences between the two systems in the main outcomes studied. These outcomes were ventilator-associated pneumonia and mortality.

The Centers for Disease Control and Prevention do not establish recommendations about the type of endotracheal suction systems that should be used and the frequency of changing catheters in closed suction systems.

Does the type of endotracheal suctioning system (open or closed) affect the incidence of VAP?

There were 2 trials that concluded the type of suctioning system has no effect on the incidence of VAP. Another 2 studies compared an open endotracheal suctioning system to a closed system. One study reported significantly less environmental contamination with closed suctioning than with open suctioning. Accordingly, the patient usually contaminates the catheter, rather than vice versa. Use of closed suctioning has been recommended as part of a VAP prevention program. Another study, however, reported a 3.5 times greater risk of VAP in patients randomized to receive open suctioning than those receiving closed suctioning. As ventilator circuits do not need to be changed at regular intervals for infection control purposes, this might suggest that in-line suction catheters also do not need to be changed at regular intervals for infection control purposes. One observational study reported no change in VAP rate when in-line suction catheters were changed on a weekly rather than daily basis.

Although the available evidence is not conclusive that closed suctioning decreases the risk of VAP, there is no high-level evidence that use of closed suction catheters increases the risk of VAP. The type of endotracheal suctioning system (open or closed) has no effect on duration of ventilation. Safety considerations (patient and healthcare worker such as exposure to aerosols) support the use of a closed system.

RECOMMENDATION

We do not recommend the routine use of closed endotracheal suctioning for the reduction of VAP (Level 1+, Grade A)

REFERENCES

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J. Frequency of change of endotracheal suctioning system

When closed suction catheters are used, scheduled daily changes or unscheduled changes of the suctioning system have no effect on the incidence of VAP.

RECOMMENDATION

In-line catheters for closed endotracheal suction systems should only be changed when defective or soiled (Level 1+, Grade B)

REFERENCES

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K. Subglottic Secretion Drainage (SSD)

Aspiration of oropharyngeal secretions containing bacterial pathogen into the lower respiratory tract is the important process in the pathogenesis of VAP.

SSD is designed with the intent to minimise the pooling and subsequent leakage of secretions around the cuff of the endotracheal tube (ETT).

A randomized, controlled, multicenter study involving 333 patients demonstrated a significant reduction of VAP in the treatment arm (intermittent SSD) as compared to control group (RR 0.42; 95% confidence interval 0.10- 0.63).¹ The beneficial effects of SSD was seen both in the early and late onset VAP patients.

Similarly, a recent meta-analysis with a total of 2442 randomised patients showed a reduction of VAP rates in the SSD arm (RR 0.55; 95% confidence interval 0.46-0.66).² The use of SSD was also associated with decreased length of mechanical ventilator days (-1.08 days; 95% confidence interval -2.04 to -0.12), shortened ICU length of stay (-1.52 days; 95% confidence interval -2.94 to -0.11) and increased time to the first episode of VAP (2.66 days; 95% confidence interval 1.06- 4.26).

Subglottic- suction ETTs are, however, more expensive than standard ETTs and are more likely to benefit patients who need prolonged mechanical ventilation. Various studies analysing the cost effectiveness of such tubes on VAP modelling showed an overall cost savings per episode of VAP prevented with SSD despite a higher acquisition cost.^{3,4}

RECOMMENDATIONS

We recommend the use of SSD in patients who are expected to require mechanical ventilation for more than 72 hours (Level 1++, Grade A)

REFERENCES

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L. Timing of Tracheostomy

Tracheostomy has several advantages in patients who require prolonged intubation and mechanical ventilation. It affords better patient comfort, facilitates oral hygiene and secretion management while reducing anatomical dead space and airway resistance. Early tracheostomy (usually within 7 days of laryngeal intubation) has been postulated to prevent VAP.

Early tracheostomy has been shown to reduce the incidence of VAP in some studies, but not in others.

A prospective randomized trial (n=120) reported early tracheostomy (within 2 days of intubation) was associated with reduced incidence of pneumonia, length of ICU stay and ventilator days when compared to the late group (14-16 days).¹ In contrast, Blot et al found no difference in VAP rates, duration of mechanical ventilation and ICU stay between early tracheostomy (within 4 days) versus prolonged endotracheal intubation.²

In a randomized controlled multicentre trial, early when compared to late tracheostomy did not result in any significant improvement in the incidence of VAP.³

Similarly, the authors of a recent meta-analysis (seven trials, 1044 patients) comparing important outcomes in ventilated patients who received early versus late tracheostomy concluded that early tracheostomy did not reduce incidence of VAP (RR 0.94; 95% confidence interval 0.77-1.15).⁴ The timing of tracheostomy was also not associated with reduced duration of mechanical ventilation nor shortened ICU stay.

Importantly, though, it is noted that the trials till date have significant methodological limitations and heterogeneity. Caution should be taken while interpreting these pooled

results. The yet to be published results of the TracMan trial may, in the future, provide a clearer indication on the role of early tracheostomy in critically ill patients. ⁵

Recommendation

Early tracheostomy is not recommended routinely for the prevention of VAP (Level 1-, Grade A)

REFERENCES

1. Rouby JJ, Laurent P, Gosnach M, et al. Risk factors and clinical relevance of healthcare associated maxillary sinusitis in the critically ill. *Am J Respir Crit Care Med* 1994;150(3):776-83.
2. Lacherage JC, De Jonghe B, Guezennec P, et al. Intermittent subglottic secretion drainage and ventilator-associated pneumonia. *Am J Respir Crit Care Med* 2010;182:910-7.
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Chapter 3 Performance monitoring

Surveillance

Using the NHSN surveillance methodology means that we must use active, patient-based, prospective surveillance of VAPs and their corresponding data by a trained infection control professional (ICP). This means that the ICP shall look out for infections during a patient's stay by screening a variety of data sources, such as laboratory, pharmacy, admission / discharges / transfer and radiology / imaging, and pathology databases, patient charts, including history and physical exam notes, nurses / physician notes, temperature charts, including history and physical examination notes, doctors / nurses notes, temperature charts, etc.

Other personnel may be trained to screen data sources for these infections, but the ICP must make the final determination. Laboratory-based surveillance should not be used alone, unless all possible criteria for identifying an infection are solely determined by laboratory evidence.

Patients should be monitored prospectively during their hospitalization when possible. Retrospective chart reviews should be used only when patients are discharged before all information can be gathered.

Criteria for defining Pneumonia

The CDC has defined pneumonia using three specific sets of criteria. Pneumonia 1 is clinically defined pneumonia (Table 1), Pneumonia 2 is pneumonia with common bacterial pathogens (Tables 2a and 2b), and Pneumonia 3 is used for immunocompromised patients (Table 3). These criteria use a combination of radiologic, clinical, and laboratory criteria.

Table 1 Pneumonia 1 - Clinically defined pneumonia

Radiology	Signs/Symptoms/Laboratory
<p>Two or more serial chest radiographs with at least one of the following:</p> <ul style="list-style-type: none"> • New or progressive and persistent infiltrate • Consolidation • Cavitation <p>Pneumatoceles, in infants ≤ 1 year old</p> <p><i>NOTE: In patients without underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable</i></p>	<p>FOR ANY PATIENT, at least one of the following:</p> <ul style="list-style-type: none"> • Fever ($>38^{\circ}\text{C}$ or $>100.4^{\circ}\text{F}$) with no other recognized cause • Leukopenia ($<4000 \text{ WBC}/\text{mm}^3$) or leukocytosis ($>12,000 \text{ WBC}/\text{mm}^3$) • For adults >70 years old, altered mental status with no other recognized cause <p>and at least two of the following:</p> <ul style="list-style-type: none"> • New onset of purulent sputum³, or change in character of sputum⁴, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypneas • Rales or bronchial breath sounds • Worsening gas exchange (e.g. O_2 desaturations (e.g., $\text{PaO}_2/\text{FiO}_2 < 240$), oxygen requirements, or increased ventilator demand) <hr/> <p>ALTERNATE CRITERIA, for infants <1 year old: Worsening gas exchange (e.g., O_2 desaturations [e.g. pulse oximetry $< 94\%$], increased oxygen requirements, or increased ventilator demand)</p> <p>and at least three of the following:</p> <ul style="list-style-type: none"> • Temperature instability with no other recognized cause • Leukopenia ($<4000 \text{ WBC}/\text{mm}^3$) or leukocytosis ($>15,000 \text{ WBC}/\text{mm}^3$) and left shift ($>10\%$ band forms) • New onset of purulent sputum or change in character of sputum, or increased respiratory secretions or increased suctioning requirements • Apnea, tachypnea, nasal flaring with retraction of chest wall or grunting • Wheezing, rales, or rhonchi • Cough • Bradycardia (<100 beats/min) or tachycardia (>170 beats/min) <hr/> <p>ALTERNATE CRITERIA, for child >1 year old or ≤ 12 years old, at least three of the following:</p> <ul style="list-style-type: none"> • Fever ($>38.4^{\circ}\text{C}$ or $>101.1^{\circ}\text{F}$) or hypothermia ($<36.5^{\circ}\text{C}$ or $<97.7^{\circ}\text{F}$) with no other recognized cause • Leukopenia ($<4000 \text{ WBC}/\text{mm}^3$) or leukocytosis ($\geq 15,000 \text{ WBC}/\text{mm}^3$) • New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, apnea, or tachypnea. • Rales or bronchial breath sounds • Worsening gas exchange (e.g. O_2 desaturations [e.g. pulse oximetry $< 94\%$], increased oxygen requirements, or increased ventilator demand)

Table 2a Pneumonia 2 – Specific laboratory findings (1)

Radiology	Signs/Symptoms	Laboratory
<p>Two or more serial chest radiographs with at least one of the following:</p> <ul style="list-style-type: none"> • New or progressive and persistent infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤ 1 year old <p><i>NOTE: In patients without underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.</i></p>	<p>At least one of the following:</p> <ul style="list-style-type: none"> • Fever (>38°C or >100.4°F) with no other recognized cause • Leukopenia (<4000 WBC/mm³) or leukocytosis (>12,000 WBC/mm³) • For adults >70 years old, altered mental status with no other recognized cause <p>and at least one of the following:</p> <ul style="list-style-type: none"> • New onset of purulent sputum³, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea or tachypnea⁵ • Rales⁶ or bronchial breath sounds • Worsening gas exchange (e.g. O₂ desaturations [e.g., PaO₂/FiO₂ < 240]⁷, increased oxygen requirements, or increased ventilator demand) 	<p>At least one of the following:</p> <ul style="list-style-type: none"> • Positive growth in blood cultures not related to another source of infection • Positive growth in culture of pleural fluid • Positive quantitative cultures⁹ from minimally contaminated LRT specimen (e.g., BAL or protected specimen brushing) • ≥5% BAL-obtained cells contain intracellular bacteria on direct microscopic exam (e.g., Gram stain) • Histopathologic exam shows at least one of the following evidences of pneumonia: <ul style="list-style-type: none"> - Abscess formation or foci of consolidation with intense PMN accumulation in bronchioles and alveoli - Positive quantitative cultures of lung parenchyma - Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae

Table 2b Pneumonia 2 – Specific laboratory findings (2)

Radiology	Signs/Symptoms	Laboratory
<p>Two or more serial chest radiographs with at least one of the following:</p> <ul style="list-style-type: none"> • New or progressive and persistent infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤ 1 year old <p><i>NOTE: In patients without underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.</i></p>	<p>At least one of the following:</p> <ul style="list-style-type: none"> • Fever (>38°C or >100.4°F) with no other recognized cause • Leukopenia (<4000 WBC/mm³) or leukocytosis (>12,000 WBC/mm³) • For adults >70 years old, altered mental status with no other recognized cause <p>and at least one of the following:</p> <ul style="list-style-type: none"> • New onset of purulent sputum₃, or change in character of sputum₄, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough or dyspnea, or tachypnea • Rales or bronchial breath sounds • Worsening gas exchange (e.g. O₂ desaturations [e.g., PaO₂/FiO₂ < 240], increased oxygen requirements, or increased ventilator demand) 	<p>At least one of the following:</p> <ul style="list-style-type: none"> • Positive culture of virus or <i>Chlamydia</i> from respiratory secretions • Positive detection of viral antigen or antibody from respiratory secretions (e.g., EIA, FAMA, shell vial assay, PCR) • Fourfold rise in paired sera (IgG) for pathogen (e.g., influenza viruses, <i>Chlamydia</i>) • Positive PCR for <i>Chlamydia</i> or <i>Mycoplasma</i> • Positive micro-IF test for <i>Chlamydia</i> • Positive culture or visualization by micro-IF of <i>Legionella</i> spp, from respiratory secretions or tissue. • Detection of <i>Legionella pneumophila</i> serogroup 1 antigens in urine by RIA or EIA • Fourfold rise in <i>L. pneumophila</i> serogroup 1 antibody titer to ≥1:128 in paired acute and convalescent sera by indirect IFA.

Table 3 Pneumonia 3 – Immunocompromised patient

Radiology	Signs/Symptoms	Laboratory
<p>Two or more serial chest radiographs with at least one of the following:</p> <ul style="list-style-type: none"> • New or progressive and persistent infiltrate • Consolidation • Cavitation <p>Pneumatoceles, in infants ≤ 1 year old</p> <p><i>NOTE: In patients without underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.</i></p>	<p>Patient who is immunocompromised¹³ has at least one of the following:</p> <ul style="list-style-type: none"> • Fever (>38°C or >100.4°F) with no other recognized cause • For adults >70 years old, altered mental status with no other recognized cause • New onset of purulent sputum₃, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea₅ • Rales or bronchial breath sounds • Worsening gas exchange (e.g. O₂ desaturations [e.g., PaO₂/FiO₂ < 240], increased oxygen requirements, or increased ventilator demand) • Hemoptysis • Pleuritic chest pain 	<p>At least one of the following:</p> <ul style="list-style-type: none"> • Matching positive blood and sputum cultures with <i>Candida</i> spp. • Evidence of fungi or <i>Pneumocystis carinii</i> from minimally contaminated LRT specimen (e.g., BAL or protected specimen brushing) from one of the following: <ul style="list-style-type: none"> - Direct microscopic exam - Positive culture of fungi

Legend: Abbreviations used in Pnuemonia laboratory criteria

BAL – bronchoalveolar lavage

LRT – lower respiratory tract

EIA – enzyme immunoassay

PCR – polymerase chain reaction

FAMA – fluorescent-antibody staining of
membrane antigen

PMN – polymorphonuclear leukocyte

IFA – immunofluorescent antibody

RIA – radioimmunoassay

VAP Denominator Data

Using the denominator form that is appropriate for the location, at the same time each day, someone on the monitored unit records the number of patients on ventilators on that unit. Sample of format is seen in Appendix 1.

Appendix 1
Denominators for Intensive Care Unit (ICU)

Date	Number of Patients	Number of patients on a ventilator
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
Totals		
	Patient-days	Ventilator-days

VAP Rate will be calculated as:

$$\text{VAPs identified} / \text{Ventilator days} \times 1000$$

**Appendix 2
VAP Bundle Audit Tools**

ICU: _____

Month: _____

DATE	PATIENT	COMPONENT				
		Weaning Assessment in the last 24 H	Sedation Hold	HOB Elevated 30°-45°	Chlorhexidine Mouth Care	Subglottis Secretion Drainage
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No
		Yes / Unable No	Yes / Unable / NA No	Yes / Unable No	Yes / Unable No	Yes / Unable No

Total Number of Yes: _____ Potential Number of Yes: _____

Compliance Rate: Total Yes / Potential Yes _____

Appendix 3
VAP Audit Summary Report

Date			
Location			
Compliance Rating			
Audit Tool		VAP Bundle Audit Tool	
Question	Result	Positive Comments	Negative Comments

RECOMMENDATIONS

1. *Engage key people to support VAP educational program as an important patient safety goal (GPP)*
2. *Educate consistently by disseminating bundle compliance rates and VAP results and review deviations to identify the need for re-training of staff (GPP).*
3. *A search for sinusitis is not recommended routinely for the prevention of VAP (GPP).*
4. *The ventilator circuit should only be changed when defective or physically soiled (Level 1+, Grade A)*
5. *Breathing-circuit-tubing condensate*
 - a. *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 (Level I, Grade B)*
 - b. *Wear gloves to perform the previous procedures and/or when handling the fluid (Level I, Grade B)*
6. *HMEs are preferred over heated humidifiers in the prevention of VAP (Level 1-, Grade B).*
7. *Change an HME that is in use on a patient when it malfunctions or becomes visibly soiled (Level II). Do not change more frequently than every 48 hours an HME that is in use on a patient (Level II) .*
8. *Do not change routinely the breathing circuit attached to an HME while it is use on a patient in the absence of gross contamination or malfunction (Level II).*
9. *We do not recommend the routine use of closed endotracheal suctioning for the reduction of VAP (Level 1+, Grade A)*

10. In-line catheters for closed endotracheal suction systems should only be changed when defective or soiled (Level 1+, Grade B)

11. We recommend the use of SSD in patients who are expected to require mechanical ventilation for more than 72 hours (Level 1++, Grade A)

12. Early tracheostomy is not recommended routinely for the prevention of VAP (Level 1-, Grade A)