



Ventilator-Associated Pneumonia Prevention



Basics of Infection Prevention
2-Day Mini-Course
Updated 2013

Objectives

- Review the pathogenesis of ICU-related ventilator-associated pneumonia (VAP)
- Review the epidemiology of VAP, focusing on modifiable risk factors
- Discuss evidence-based VAP prevention strategies
- Describe surveillance for ventilator-associated events (VAE) and VAP, and the rationale for the VAE/VAP surveillance definition algorithm

Ventilator Associated Pneumonia (VAP)

- VAP is pneumonia that occurs in patients intubated and on mechanical ventilation
- 15% - 50% patients with VAP die
 - varies with patient population and organism type
- Highest VAP mortality occurs inpatients with
 - severe illness **and**
 - infection with non-fermentative Gram negative bacilli e.g. Acinetobacter sp, Burkholderia sp., etc.
- Increases length of stay >6 ICU days
 - Cost \$10,000 - \$40,000



*



Etiology of VAP

Early onset

- Occurs in first 4 days of hospitalization
- More likely to be caused by *Moraxella catarrhalis*, *H. influenzae*, or *S. pneumoniae*

Late onset

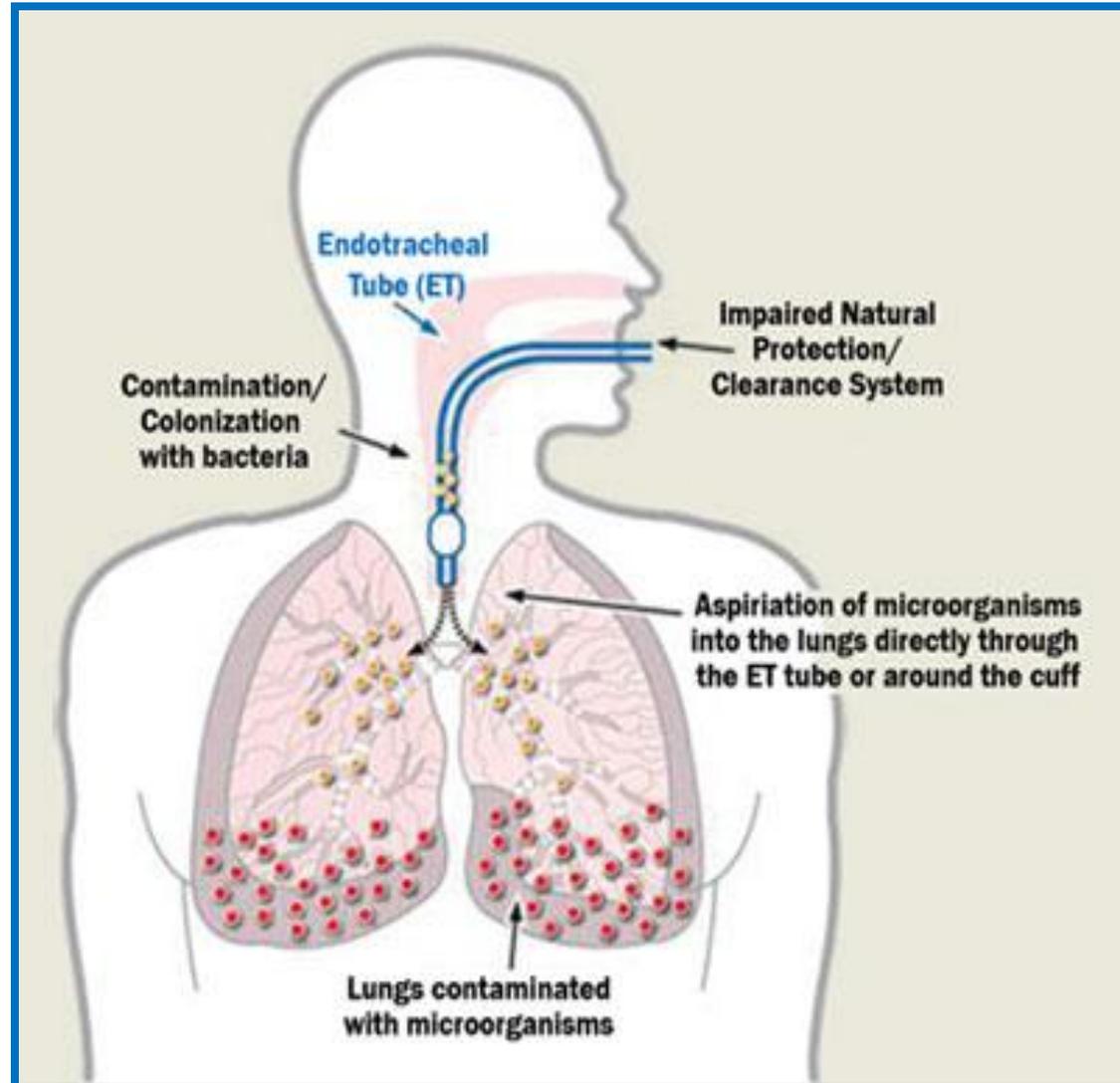
- Occurs 5 or more days into hospitalization
- Often caused by Gram-negative bacilli, or *S. aureus* (including MRSA), yeasts, fungi, *legionellae* and *Pneumocystis carinii*



Pathogenesis of VAP

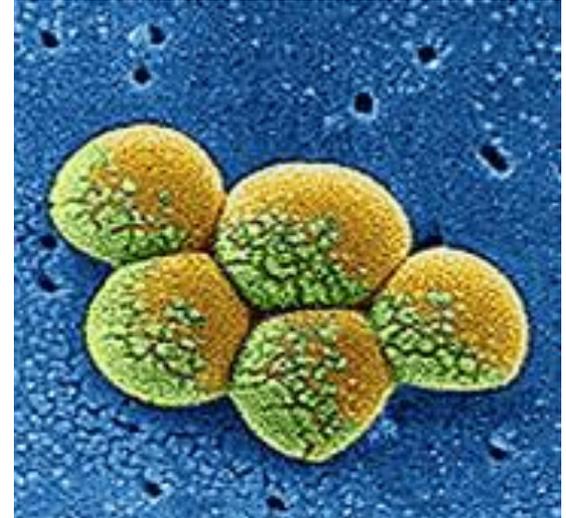
Results from

- Aspiration of secretions
- Colonization of aerodigestive tract
- Contaminated respiratory or other medical equipment



VAP Pathogens

- *Staphylococcus aureus* - 24.4%
- *Pseudomonas aeruginosa* - 16.3%
- *Enterobacter spp* - 8.4%
- *Acinetobacter baumannii* - 8.4%
- *Klebsiella pneumoniae* - 7.5%
- *Escherichia coli* - 4.6%
- *Candida spp* - 2.7%
- *Klebsiella oxytoca* - 2.2%
- *Coagulase-negative staphylococci* - 1.3%



Challenges in VAP Prevention

Pre-existing conditions (Non-modifiable risk factors)

- Head trauma
- Coma
- Nutritional deficiencies
- Immunocompromised
- Multi organ system failure
- Acidosis
- Co-morbidities
- History of smoking or pulmonary disease

VAP Prevention Strategies (Modifiable Risk Factors)

1. Prevent aspiration of secretions

- Maintain elevation of head of bed (HOB) (30-45 degrees)
- Avoid gastric over-distention
- Avoid unplanned extubation and re-intubation
- Use cuffed endotracheal tube with in-line or subglottic suctioning
- Encourage early mobilization of patients with physical/occupational therapy

2. Reduce duration of ventilation

- Conduct “sedation vacations”
- Assess readiness to wean from vent daily
- Conduct spontaneous breathing trials



VAP Prevention Strategies - continued

3. Reduce colonization of aero-digestive tract

- Use non-invasive ventilation methods when possible
 - i.e. CPAP, BiPap
- Use oro-tracheal over naso-tracheal intubation
 - Naso-racheal may cause sinusitis, which increases VAP risk
- Use cuffed Endotracheal Tube (ETT) with inline or subglottic suctioning
 - Minimizes secretions above cuff; prevents contamination of lower airway
- Avoid acid suppressive therapy for patients not at high risk for stress ulcer or stress gastritis
 - Increases colonization of the digestive tract



VAP Prevention Strategies - continued

3. Reduce colonization of aero-digestive tract (continued)
 - Perform regular oral care with an antiseptic agent
 - Reduce the opportunities to introduce pathogens into the airway
 - Good hand hygiene
 - Glove use for contact with respiratory secretions or contaminated objects; follow with hand hygiene
 - Educate staff to avoid contaminating the ETT from patient's mouth, HCW hands, introducing pathogens from patient's other body sites or the environment



VAP Prevention Strategies - continued

4. Prevent exposure to contaminated equipment
 - Use sterile H₂O to rinse reusable respiratory equipment
 - Remove condensate from ventilatory circuits
 - Change ventilatory circuit only when malfunctioning or visibly soiled
 - Store and disinfect respiratory equipment effectively



Measure Adherence to VAP Prevention Practices

Consider monitoring

- Compliance with hand hygiene
- Compliance with daily sedation vacation/interruption and assessment of readiness to wean
- Compliance with regular antiseptic oral care
- Compliance with semi-recumbent position of all eligible patients

NOTE: Even though California has no mandate for reporting VAP, hospitals are required to have CDC VAP prevention strategies in place (SB 739, Chap. 526, Sec. 1288.9b)



VAP Surveillance

- Follow NHSN protocols
- Work with ICU and respiratory therapy staff to develop alerting process
- Monitor ventilated patient for
 - Positive cultures
 - Temperature chart/log
 - Pharmacy reports of antimicrobial use
 - Change in respiratory secretions



Surveillance Changes, 2013

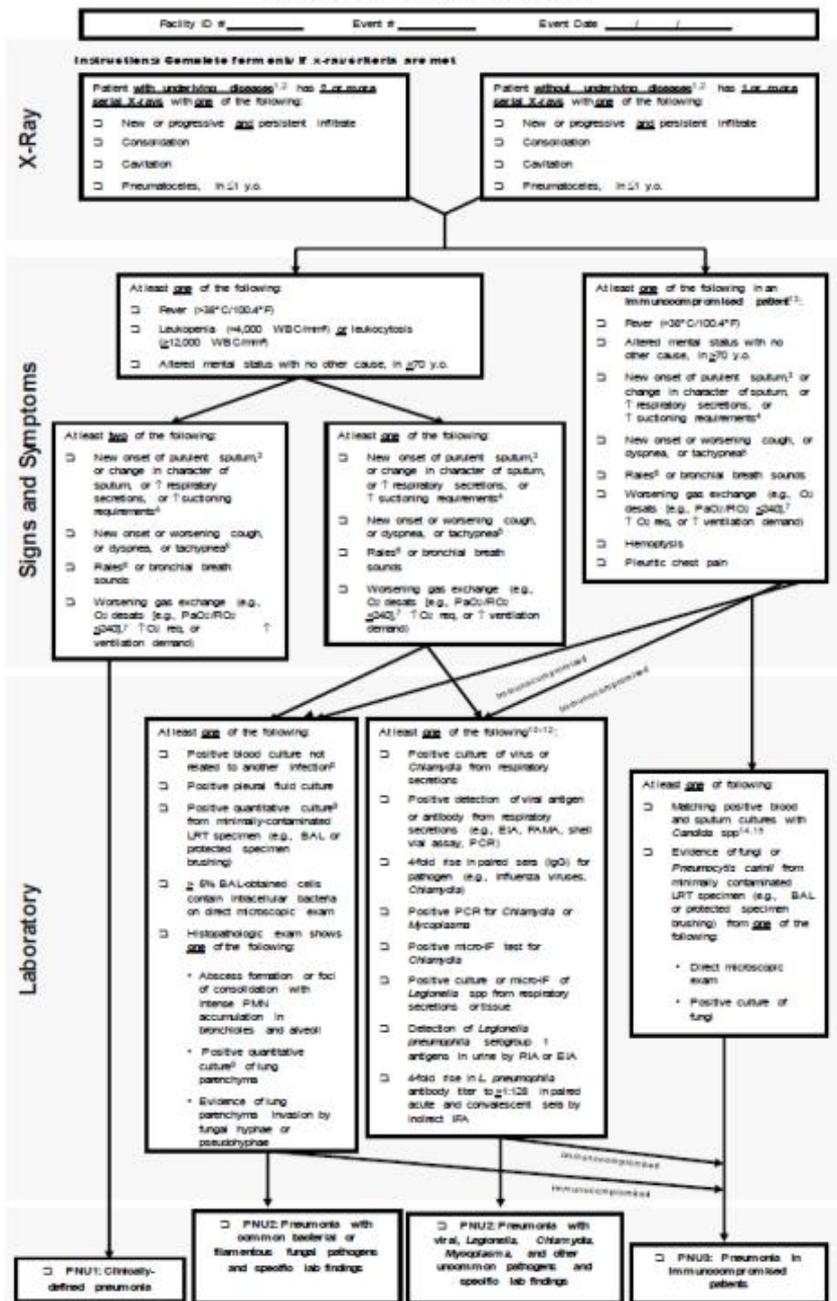
- VAP/Pneumonia definition subjective and complex
- No gold standard, valid, reliable surveillance definition could be identified despite years of effort
- New approach: a surveillance definition **algorithm** that detects a broad range of conditions/complications that occur in mechanically ventilated patients
- Referred to as **“Ventilator-associated events” (VAE)**
 - Includes criteria for
 - Ventilator-associated conditions (**VAC**)
 - Infection-related ventilator-associated conditions (**IVAC**)
 - **Possible VAP**
 - **Probable VAP**



Surveillance Changes, 2013 - continued

- **VAE** criteria must be used for mechanically ventilated patients \geq 18 years old
- **VAP/PNEU** criteria must be used for mechanically ventilated patients $<$ 18 years old
- **PNEU** criteria must be used for surveillance of patients not ventilated, such as for determining whether a BSI is primary or secondary to pneumonia





Pneumonia Surveillance Definition

Surveillance definition can be met by 3 different criteria

Clinically defined pneumonia (PNU1)

Pneumonia with specific laboratory findings (PNU2)

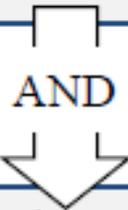
Pneumonia in immunocompromised patients (PNU3)

VAE/VAP Surveillance Definition

- Patient must be ventilated more than 2 calendar days
- Patient must have ≥ 2 calendar days of stability or improvement of oxygenation followed by ≥ 2 calendar days of worsening oxygenation.
- Earliest date of event for VAE is mechanical ventilation day 3 (first day of worsening oxygenation).
- First possible day that VAC criteria can be fulfilled is mechanical ventilation day 4

Ventilator Associated Condition (VAC)

Patient has a baseline period of stability or improvement on the ventilator, defined by ≥ 2 calendar days of stable or decreasing daily minimum FiO_2 or PEEP values. The baseline period is defined as the two calendar days immediately preceding the first day of increased daily minimum PEEP or FiO_2 .



After a period of stability or improvement on the ventilator, the patient has at least one of the following indicators of worsening oxygenation:

- 1) Increase in daily minimum FiO_2 of ≥ 0.20 (20 points) over the daily minimum FiO_2 in the baseline period, sustained for ≥ 2 calendar days.
- 2) Increase in daily minimum PEEP values of ≥ 3 cmH_2O over the daily minimum PEEP in the baseline period, sustained for ≥ 2 calendar days.

Infection-related Ventilator-Associated Complication (IVAC)

Patient meets criteria for VAC

AND

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, the patient meets both of the following criteria:

- 1) Temperature $> 38^{\circ}\text{C}$ or $< 36^{\circ}\text{C}$, **OR** white blood cell count $\geq 12,000$ cells/mm³ or $\leq 4,000$ cells/mm³.

AND

- 2) A new antimicrobial agent(s)* is started, and is continued for ≥ 4 calendar days.

*See [Appendix](#) for eligible agents.

Patient meets criteria for VAC and IVAC

AND

Possible VAP

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

- 1) Purulent respiratory secretions (from one or more specimen collections)
 - Defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field [lpf, x100].
 - If the laboratory reports semi-quantitative results, those results must be equivalent to the above quantitative thresholds.

OR

- 2) Positive culture (qualitative, semi-quantitative or quantitative) of sputum*, endotracheal aspirate*, bronchoalveolar lavage*, lung tissue, or protected specimen brushing*

**Excludes the following:*

- Normal respiratory/oral flora, mixed respiratory/oral flora or equivalent
- *Candida* species or yeast not otherwise specified
- Coagulase-negative *Staphylococcus* species
- *Enterococcus* species

Probable VAP

Patient meets criteria for VAC and IVAC

AND

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

1) Purulent respiratory secretions (from one or more specimen collections—and defined as for possible VAP)

AND one of the following (see Table 2):

- Positive culture of endotracheal aspirate*, $\geq 10^5$ CFU/ml or equivalent semi-quantitative result
- Positive culture of bronchoalveolar lavage*, $\geq 10^4$ CFU/ml or equivalent semi-quantitative result
- Positive culture of lung tissue, $\geq 10^4$ CFU/g or equivalent semi-quantitative result
- Positive culture of protected specimen brush*, $\geq 10^3$ CFU/ml or equivalent semi-quantitative result

**Same organism exclusions as noted for Possible VAP.*

OR

2) One of the following (without requirement for purulent respiratory secretions):

- Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube)
- Positive lung histopathology
- Positive diagnostic test for *Legionella* spp.
- Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus

NHSN VAE Calculator

1. Enter ventilator data, follow instructions

www.cdc.gov/nhsn/VAE-calculator/



Ventilator-Associated Event Calculator

Start Over

Go to IVAC

Explain...

A Ventilator-Associated Condition (VAC) was found on day 2/11/2013. Click on the "Go To IVAC" button to move to the next part of the protocol or click on the "Explain" button to see how this determination was made.

MV Day	Date	Min. PEEP (cmH ₂ O)	Min. FiO ₂ (%; 21-100)	VAE
1	2/8/2013	5	80	
2	2/9/2013	5	80	
3	2/10/2013	5	80	
4	2/11/2013	5	100	VAC
5	2/12/2013	8	100	
6	2/13/2013	8	100	
7	2/14/2013	8	80	
8	2/15/2013	6	80	
9	2/16/2013			
10	2/17/2013			

Meets VAC Criteria.
"Go to IVAC"

Legend: VAE Window VAE Date Qualifying Antimicrobial Day (QAD) Cumulative QAD

Close Window

NHSN VAE Calculator

2. Enter temperature, WBC count, antibiotics

www.cdc.gov/nhsn/vae-calculator/



Ventilator-Associated Event Calculator

Start Over Calculate IVAC Explain... Go to VAP

The temperature and/or WBC criteria have been met during the VAE Window Period, and there are 5 Qualifying Antimicrobial Days (QADs) in a row. This meets the definition of an IVAC. Click on "Go to VAP" button to determine if this case conforms to a Possible or Probable Ventilator-Associated Pneumonia (VAP) definition.

MV Day	Date	Hide... Min. PEEP (cmH ₂ O)	Hide... Min. FiO ₂ (%;21-100)	VAE	36°> T >38°	4,000 cells/mm ³ ≥ WBC ≥ 12,000 cells/mm ³	Add... Remove...	Add... Remove...
1	2/8/2013	5	80		<input type="checkbox"/>	<input type="checkbox"/>		
2	2/9/2013	5	80		<input checked="" type="checkbox"/>	<input type="checkbox"/>		
3	2/10/2013	5	80		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4	2/11/2013	5	100	IVAC	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5	2/12/2013	8	100		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
6	2/13/2013	8	100		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
7	2/14/2013	8	80		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
8	2/15/2013	6	80		<input type="checkbox"/>	<input type="checkbox"/>		
9	2/16/2013				<input type="checkbox"/>	<input type="checkbox"/>		
10	2/17/2013				<input type="checkbox"/>	<input type="checkbox"/>		

Meets IVAC Criteria "Go to VAP"

Legend: VAE Window VAE Date Qualifying Antimicrobial Days

Close Window

Ventilator-Associated Event Calculator

Start Over Explain... Calculate VAP

Check off criteria in table then "Calculate VAP"

Now that an IVAC determination has been made, click the checkbox if the patient experienced any of the listed conditions from 2/10/2013 to 2/13/2013 which is the VAE Window for this patient. Then click on the "Calculate VAP" button.

Row	Conditions occurring within your "VAE Window" from 2/10/2013 to 2/13/2013	Yes/No
1	Purulent respiratory secretions (from one or more specimen collections) Defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field [lpf, x100].	<input type="checkbox"/>
2	Positive culture (qualitative, semi-quantitative or quantitative) of sputum, endotracheal aspirate, bronchoalveolar lavage, lung tissue, or protected specimen brush.	<input type="checkbox"/>
3	Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube).	<input type="checkbox"/>
4	Positive Lung histopathology.	<input type="checkbox"/>
5	Positive diagnostic test for Legionella spp.	<input type="checkbox"/>
6	Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus.	<input type="checkbox"/>

Close Window

Ventilator-Associated Event Calculator

Start Over Explain... Calculate VAP

This conforms to a **Possible Ventilator-Associated Pneumonia** definition and should be reported as such. For a discussion of why, see/click on the Explain button.

Row	Conditions occurring within your "VAE Window" from 2/10/2013 to 2/13/2013	Yes/No
1	Purulent respiratory secretions (from one or more specimen collections) Defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field [lpf, x100].	<input type="checkbox"/>
2	Positive culture (qualitative, semi-quantitative or quantitative) of sputum, endotracheal aspirate, bronchoalveolar lavage, lung tissue, or protected specimen brush.	<input checked="" type="checkbox"/>
3	Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube).	<input type="checkbox"/>
4	Positive Lung histopathology.	<input type="checkbox"/>
5	Positive diagnostic test for Legionella spp.	<input type="checkbox"/>
6	Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus.	<input type="checkbox"/>

In this example, the VAE calculator confirmed "Possible VAP"

Close Window

Summary

- VAP is a common, morbid ICU complication of ventilated patients
- Diagnosis of VAP is very challenging with high inter-observer variability
- Focus on prevention
 - Elevate head of the bed
 - Regular oral care with antiseptic
 - Daily sedation interruption and assessment of readiness to extubate
- Regularly audit prevention practices



References for VAP Prevention and Bundles

- Institute for Healthcare Improvement (IHI):
 - <http://www.ihl.org/knowledge/Pages/Changes/ImplementtheVentilatorBundle.aspx>
- Agency for Healthcare Research and Quality (AHRQ):
 - <http://www.innovations.ahrq.gov/content.aspx?id=2178>
- VAP Getting Started Kit: Safer Healthcare Now (Canada)
 - <http://www.saferhealthcarenow.ca/EN/Interventions/VAP/Documents/VAP%20One%20Pager.pdf>



References and Resources

- Coffin, S, et al. Strategies to Prevent Ventilator-Associated Pneumonia in Acute Care Hospitals. *Infect Control Hosp Epidemiol* 2008; 29:S31-S40.
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- Hidron AI, et.al., *Infect Control Hosp Epidemiol* 2008;29:996-1011
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<http://www.hhs.gov/ash/initiatives/hai/Events/progresstoward-day2-magill.pdf>



Questions?

For more information, please contact any
HAI Liaison Team member.

Thank you

