Ventilator-Associated Event (VAE): Impact of New Definitions

Maureen K. Bolon, MD, MS
Medical Director of Healthcare Epidemiology and Infection Prevention
Northwestern Memorial Healthcare
Chicago, IL
May 9, 2013

No disclosures

Outline

• VAP
  – Significance
  – Prevention efforts
  – VAP definition

• VAE
  – Rationale for alternative to VAP
  – Studies to establish VAC
  – Nuts and bolts of VAE definition
  – One institution’s efforts to implement VAE definition
  – Implications of VAP→VAE
VAP Significance

- Infection is the greatest cause of mortality in ICU patients
- The lung is the most common site of infection (64%)
- U.S. VAP rates: 1 - 4 cases per 1,000 ventilator days

Vincent et al. JAMA 2009; 302: 2323-9
Coffin et al. ICHE 2008; 29: S31-40
Image, JAMA 2011

VAP Significance

- VAP associated with:
  - Longer hospitalization (32.6 vs 19.5 days)
  - Longer ICU stays (20.5 vs 11.6 days)
  - Prolonged ventilation (21.8 vs 10.3 days)
  - Increased costs (+$39,828)

Kollef et al. ICHE 2012; 33: 250-6
VAP and Public Reporting: We’re not there yet

- Public reporting
  - Only 4 states mandate reporting of VAP
- VAP as a “never event”
  - considered, not yet added
- VAP as a National Patient Safety Goal

---

CMS Nonpayment & HAI Trends: Unrelated?

Lee et al. NEJM 2012; 367: 1428-37
VAP Prevention

• Interrupt 3 most common mechanisms:
  – Aspiration of secretions
  – Colonization of the aerodigestive tract
  – Use of contaminated equipment

Coffin et al. ICHE 08; 29: 531-40.

VAP Prevention Strategies

General strategies
• active surveillance
• HH
• noninvasive ventilation
• minimize vent duration
• assess readiness to wean & use weaning protocols
• education

Prevent aspiration
• elevate HOB
• avoid gastric overdistention
• avoid unplanned extubation
• cuffed ETT with in-line or subglottic suctioning
• maintain cuff pressure

Reduce colonization
• orotracheal > nasotracheal intubation
• avoid H2-blockers & PPIs
• oral care

Minimize contamination
• sterile water to rinse equipment
• remove condensate from circuits
• change circuit only when necessary
• store & disinfect equipment properly

Coffin et al. ICHE 08; 29: 531-40.
Ventilator Bundle

- Elevation of the head of the bed
- Daily “Sedation Vacations” and assessment of readiness to extubate
- Peptic ulcer disease prophylaxis
- Deep venous thrombosis prophylaxis
- Daily oral care with chlorhexidine

VAP Bundle Success!

International Nosocomial Infection Control Consortium: VAP Bundle Success Goes Global

What are the “real” VAP rates?

What are the “real” VAP rates?

“One wonders whether the US’s vanishingly low rates tell us more about the influence of this country’s regulatory, reporting, and financial pressures on surveillance than about or quality of care for ventilated patients”

Table 1. Centers for Disease Control and Prevention's clinical surveillance definition for ventilator-associated pneumonia (PNU1)

<table>
<thead>
<tr>
<th>Radiologic criteria (two or more serial radiographs with at least one of the following)</th>
<th>1. New or progressive and persistent infiltrate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Consolidation</td>
</tr>
<tr>
<td></td>
<td>3. Cavitation</td>
</tr>
<tr>
<td>Systemic criteria (at least one)</td>
<td>1. Fever (&gt;38°C or &gt;100.4°F)</td>
</tr>
<tr>
<td></td>
<td>2. Leukopenia (&lt;4,000 WBC/mm³) or leukocytosis (≥12,000 WBC/mm³)</td>
</tr>
<tr>
<td></td>
<td>3. For adults ≥70 yrs old, altered mental status with no other recognized cause</td>
</tr>
<tr>
<td>Pulmonary criteria (at least two)</td>
<td>1. New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements</td>
</tr>
<tr>
<td></td>
<td>2. Worsening gas exchange (e.g., desaturations, increased oxygen requirements, or increased ventilator demand)</td>
</tr>
<tr>
<td></td>
<td>3. New onset or worsening cough, or dyspnea, or tachypnea</td>
</tr>
<tr>
<td></td>
<td>4. Rales or bronchial breath sounds</td>
</tr>
</tbody>
</table>

Problems with VAP Definition

- No gold standard
- Confusion related to discrepancy between surveillance and clinical definitions
- Reliance on chest radiography
- Inter-observer variability in both interpretation of CXR and in VAP surveillance

The Dreaded CXR

- Poor inter-observer agreement on interpretation of CXR
- Sensitivity & specificity of new or progressive infiltrate or air bronchograms: – 42% and 46%
- Daily CXR difficult to compare due to inconsistencies in radiologic technique and patient positioning
- NHSN does not allow CT chest interpretations
Inter-observer Variability in VAP Surveillance

Kappa score = 0.40

Gaming the System...

1. Interpret clinical signs as strictly as possible
2. Interpret CXR as strictly as possible
3. Require consensus between 2 or more IPs
4. Seek endorsement of intensivists
5. Require BAL for diagnosis
6. Set quantitative growth thresholds for ET aspirate and BAL cultures
7. Transfer patients who require ventilation
8. Expand surveillance to include uncomplicated post-op patients

Adult VAP/VAE Surveillance Definitions

Working Group Members

- American Association of Critical Care Nurses
- American Association for Respiratory Care
- American College of Chest Physicians
- Association of Professionals in Infection Control & Epidemiology
- American Thoracic Society
- Council of State and Territorial Epidemiologists
- HICPAC Surveillance Working Group
- Infectious Disease Society of America
- Society of Critical Care Medicine
- Society for Healthcare Epidemiology of America
- US Department of Health and Human Services/Office of Healthcare Quality
- National Institutes of Health

Moving beyond VAP...

VAP Surveillance
- Infection is the only complication
- Complex, inconsistently applied
- Relies on CXR
- Relies on clinical signs/symptoms
- Relies on microbiology data
- Time-consuming, chart review necessary
- Correlates with important clinical outcomes

New & Improved Surveillance
- Numerous other complications of mechanical ventilation/ICU care
- Simple, consistently applied
- Does not rely on CXR
- Does not rely on clinical symptoms
- Microbiology data not essential
- Quick, electronic data sources possible
- Correlates with important clinical outcomes

Nuts and Bolts of Surveillance: What to Use as the “Trigger”

VAP Surveillance Options
- Regularly review chart of every patient on ventilation
- Follow daily CXR for a progressive/persistent infiltrate, consolidation, cavitation
- Respiratory culture

New & Improved Surveillance
- Change in ventilatory parameters after two days of stability
Rationale for the choice of VAE Surveillance Trigger (↑FiO2 or PEEP)

- Objective
- Fast
- Amenable to electronic assessment
- “Threshold Effect”
- Potential to detect complications other than pneumonia

Klompas et al. PLoS ONE 6; e18062.

Definitions

- **FiO2** = Fraction of inspired oxygen
  - Room air contains 21% oxygen (FiO2 of 0.21)
  - Oxygen-enriched air has a higher FiO2 than 0.21, up to 1.00 (100% oxygen)
  - FiO2 is typically maintained below 0.5 to avoid oxygen toxicity
- **PEEP** = Positive End-Expiratory Pressure
  - The pressure in the lungs above atmospheric pressure that exists at the end of expiration
  - A small amount of applied PEEP (3 to 5 cmH2O) is used in most mechanically ventilated patients to mitigate end-expiratory alveolar collapse
  - A higher level of applied PEEP (>5 cmH2O) is sometimes used to improve hypoxemia or reduce ventilator-associated lung injury

From Wikipedia
The Studies

Population: 600 patients from 3 hospitals
Definitions used: VAP vs. VAC variant
  - ↑FiO2 by 15% OR ↑PEEP by 2.5 cm H2O for ≥ 2 days
Results:
  - 9.3% VAP (8.8/1000 vent days)
  - 23% VAC (21.2/100 vent days)
  - Both VAP & VAC had prolonged days to extubation, days to ICU discharge and days to hospital discharge
  - VAC not VAP associated with increased mortality (OR 2.0)
  - VAC assessment much quicker
    • 1.8 minutes per patient (vs. 39 minutes)

• Population: 8123 patients from 8 hospitals
• Purpose: evaluate combination of signs to find definition best associated with adverse outcomes
• 32 candidate definitions composed of combinations of signs: different thresholds for respiratory deterioration, temp, wbc, purulent secretions, positive cultures

VAP incidence ranged from 0.2—26.3 events/1000 vent days depending upon definition

All definitions were associated with increased ventilator days and increased hospital days

Only the definitions requiring sustained evidence of respiratory deterioration were associated with hospital mortality

Requiring a pathogenic organism in culture weakened the association between respiratory deterioration and mortality


Purpose: association between VAC and clinical outcomes

Definitions: VAC variant

— ↑ FiO2 by 15% OR ↑ PEEP by 2.5 cm H2O for ≥ 2 days

Population: ventilated adults in Australian Hospital

— 153 with VAC; 390 without VAC

VAC associated with increased ICU stay, increased duration of ventilation, and increased use of broad spectrum antibiotics

VAC not associated with increased hospitalization or ICU mortality

VAC assessment took < 3 minutes per patient

Logistics of VAE

- VAC
- PEEP
- Hierarchy of Definitions
- VAE Window Period
- Probable VAP
- Qualifying Antimicrobial Days
- FiO2
- IVAC
VAE Algorithm

Patient on mechanical ventilation > 2 days

Baseline period of stability or improvement, followed by sustained period of worsening oxygenation

Ventilator-Associated Condition (VAC)

General, objective evidence of Infection/Inflammation

Infection-Related Ventilator-Associated Complication (IVAC)

Positive results of laboratory/microbiological testing

Possible or Probable VAP

Tier 1 & 2: possible public reporting

Tier 3: Internal use

Hierarchy of Definitions

• If a patient meets criteria for VAC and IVAC, report as IVAC
• If a patient meets criteria for VAC, IVAC and Possible VAP, report Possible VAP
• If a patient meets criteria for VAC, IVAC and Probable VAP, report Probable VAP
• If a patient meets criteria for VAC, IVAC, Possible VAP and Probable VAP, report Probable VAP
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$_2$.

AND

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$_2$O 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 °C or < 36°C, OR white blood cell count ≥ 12,000 cells/mm$^3$ or ≤ 4,000 cells/mm$^3$.

AND

2) A new antimicrobial agent(s)* is started, and is continued for ≥ 4 calendar days.
Possible Ventilator-Associated Pneumonia (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 specimens collected) - Defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≥ 10 squamous epithelial cells per low power field
   - 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 specimens brushing

*Excludes the following:
- Normal respiratory flora, mixed respiratory flora or equivalent
- Cocci/Colon species or yeast not otherwise specified
- Congenital-negative aspergillus species
- Enteroxococcus species

Probable Ventilator-Associated Pneumonia (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 specimens collected) and defined as for Possible VAP

AND one of the following (see Table 2):
- Positive culture of endotracheal aspirate, ≥ 10^3 CFU/mL or equivalent semi-quantitative result
- Positive culture of bronchoalveolar lavage, ≥ 10^3 CFU/mL or equivalent semi-quantitative result
- Positive culture of lung tissue, ≥ 10^3 CFU/mL or equivalent semi-quantitative result
- Positive culture of protected specimens brushing, ≥ 10^3 CFU/mL or equivalent semi-quantitative result

*Some organism exclusions as noted for Possible VAP.

OR

2) One of the following (identifying requirement for purulent respiratory secretions):
- Positive Gram stain culture (when specimens were obtained during the necropsy or initial placement of the tube and NPT from an non-bleeding egress tube)
- Positive lung histology
- Positive diagnostic test for Legionella spp.
- Positive diagnostic test on respiratory secretions for adenovirus, respiratory syncytial virus, parainfluenza viruses, chlamydia, hansen metaphrophages, cytomegalovirus
Window Period

VAE early in admission....

<table>
<thead>
<tr>
<th>MV Day No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worsening exaggeration</td>
<td>---</td>
<td>Day 1 of stability or improvement</td>
<td>Day 1 of stability or improvement</td>
<td>Day 1 of worsening exaggeration</td>
<td>Day 1 of worsening exaggeration</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Temperature abnormality or white blood cell count abnormality</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Antiretroviral agent</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Persistent respiratory secretions, positive culture, positive virology</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Window Period

VAE later in admission....

<table>
<thead>
<tr>
<th>MV Day No.</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worsening exaggeration</td>
<td>---</td>
<td>Day 1 of stability or improvement</td>
<td>Day 1 of stability or improvement</td>
<td>Day 1 of worsening exaggeration</td>
<td>Day 1 of worsening exaggeration</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Temperature abnormality or white blood cell count abnormality</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Antiretroviral agent</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Persistent respiratory secretions, positive culture, positive virology</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- An abnormal temperature or white blood cell count, according to the algorithm parameters, must be documented within this shaded period.
- New agent must be started on any day within this shaded period, and then continued for at least 4 days.
- Specimen must be collected on any day within this shaded period.
# Suggested Data Collection Worksheet

<table>
<thead>
<tr>
<th>Patient</th>
<th>MV Day</th>
<th>PEEP min</th>
<th>FIO2 min</th>
<th>Temp min</th>
<th>Temp max</th>
<th>WBC min</th>
<th>WBC max</th>
<th>ABX Specimen</th>
<th>Polys/Epis</th>
<th>Organism</th>
<th>VAE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Ventilator-Associated Event Calculator

New enter PEEP or FIO2 values and when done, click the “Calculate VAE” button. You do not need to enter data for every day. Concentrate on the days where you believe a ventilator-associated event may be likely. If your values meet the ventilator-associated Condition (VAC) definition, the event day will be identified and the VAE position will be entered.
VAP Surveillance at My Institution

- Current State: Follow CDC/NHSN VAP definitions
- Report VAP to NDNQI, do not report to NHSN
- Transition to VAE: September 2013
VAP Surveillance Using TheraDoc
Experience with Electronic Surveillance for VAE

<table>
<thead>
<tr>
<th>Row</th>
<th>Fin Number</th>
<th>MRN</th>
<th>Patient Name</th>
<th>Date of Event</th>
<th>Hospital</th>
<th>Nurse Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>3/5/2013</td>
<td>ICU</td>
<td>CTICU</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>3/10/2013</td>
<td>ICU</td>
<td>ICU</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>3/17/2013</td>
<td>ITU</td>
<td>ITU</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>3/30/2013</td>
<td>ICU</td>
<td>ICU</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>3/7/2013</td>
<td>ICU</td>
<td>ICU</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>3/30/2013</td>
<td>ICU</td>
<td>ICU</td>
</tr>
</tbody>
</table>

Developed by NSIH (ncatlab) using data from the Northwestern Medicine Enterprise Data Warehouse.
• Program Number: 038  Day / Time: Sunday, Jun 9, 9:45 AM – 10:00 AM
• The Impact of a New Surveillance Protocol for Ventilator-associated Events (VAE) at a Large Academic Medical Center
• Kristen Metzger MPH, CIC et al.

Implications of Moving from VAP to VAE

• Clinical relevance
• Preventability
• Relevance of current VAP bundles
• Benchmarking
• Who has the expertise?
Questions?/Comments?

Thank you