Ventilator Associated Pneumonias: New vs Old Definitions

Ventilator associated event:
A New and Better (?) Concept for VAP surveillance

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July 2013 CDC/NHSN Protocol Clarifications

(NOTE: These protocol clarifications have been added to the current posted NHSN protocols)

- Protocol Clarifications [PDF - 291 KB] July 2013
CDC/NHSN definitions of pneumonia 2013

PNU1
● Clinically-defined pneumonia

PNU2
● Pneumonia with specific laboratory findings
  ➢ Common Bacterial or Filamentous Fungal Pathogens and Specific Laboratory Findings
  ➢ Viral, Legionella, and other Bacterial Pneumonias with Definitive Laboratory Findings

PNU 3
● Pneumonia in immunocompromised patients
CDC/NHSN definitions of pneumonia (PNU1)

Two or more serial chest radiographs with at least one of the following:

- New or progressive and persistent infiltrate
- Consolidation
- Cavitation
- Pneumatoceles, in infants ≤1 year old

In patients **without** underlying pulmonary or cardiac disease, one definitive chest radiograph is acceptable.
Clinically-defined pneumonia (PNU1)

<table>
<thead>
<tr>
<th>Signs/Symptoms/Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOR ANY PATIENT, at least <strong>one</strong> of the following:</td>
</tr>
<tr>
<td>• Fever (&gt;38°C or &gt;100.4°F)</td>
</tr>
<tr>
<td>• Leukopenia (&lt;4000 WBC/mm³) or leukocytosis (≥12,000 WBC/mm³)</td>
</tr>
<tr>
<td>• For adults ≥70 years old, altered mental status with no other recognized cause and at least <strong>two</strong> of the following:</td>
</tr>
<tr>
<td>• New onset of purulent sputum³, or change in character of sputum⁴, or increased respiratory secretions, or increased suctioning requirements</td>
</tr>
<tr>
<td>• New onset or worsening cough, or dyspnea, or tachypnea⁵</td>
</tr>
<tr>
<td>• Rales⁶ or bronchial breath sounds</td>
</tr>
<tr>
<td>• Worsening gas exchange (e.g., O₂ desaturations (e.g., PaO₂/FiO₂ ≤240)⁷, increased oxygen requirements, or increased ventilator demand)</td>
</tr>
</tbody>
</table>

Alternate criteria for infants ≤ 1 year old and for children > 1 year old or ≤ 12 year old
European commission 2012

COMMISSION IMPLEMENTING DECISION
of 8 August 2012
amending Decision 2002/253/EC laying down case definitions for reporting communicable diseases
to the Community network under Decision No 2119/98/EC of the European Parliament and of the Council

(notified under document C(2012) 5538)

(Text with EEA relevance)
(2012/506/EU)
ECDC-definitions of pneumonia

- Two or more serial chest X-rays or CT-scans with a suggestive image of pneumonia for patients with underlying cardiac or pulmonary disease

- In patients without underlying cardiac or pulmonary disease one definitive chest X-ray or CT-scan is sufficient

Plus .....
AND at least one of the following symptoms

Fever > 38 °C with no other cause

Leucopenia (< 4 000 WBC/mm³) or leucocytosis (≥ 12 000 WBC/mm³)

AND at least one of the following (or at least two if clinical pneumonia only = PN 4 and PN 5)

— New onset of purulent sputum, or change in character of sputum (colour, odour, quantity, consistency)

— Cough or dyspnoea or tachypnea

— Suggestive auscultation (rales or bronchial breath sounds), ronchi, wheezing

— Worsening gas exchange (e.g. O₂ desaturation or increased oxygen requirements or increased ventilation demand)

and according to the used diagnostic method
According to the used diagnostic method

- PN 1
- PN 2
- PN 3
- PN 4
- PN 5
Diagnosis and definition of VAP

- There is currently no valid, reliable definition for VAP, and even the most widely used VAP criteria and definitions are neither sensitive nor specific.
- No gold standard exists

Klompas M. JAMA 2007;297:1583-93.
Vincent J-L. Drugs 2010;70:1927
Diagnosis and definition of VAP

- A particular difficulty with many VAP definitions, is that they require radiographic findings of pneumonia.
- Evidence suggests that chest radiograph findings do not accurately identify VAP.
Diagnosis and definition of VAP

- The subjectivity and variability inherent in chest radiograph technique, interpretation, and reporting make chest imaging ill-suited for inclusion in a definition algorithm for public reporting, inter-facility comparisons, and pay-for-reporting and pay-for-performance programs.
Another major difficulty with available VAP definitions is their reliance on specific clinical signs or symptoms, which are subjective and may be poorly or inconsistently documented in the medical record.
Diagnosis and definition of VAP

- The limitations of VAP surveillance definitions have implications for prevention.
- Valid and reliable surveillance data are necessary for assessing the effectiveness of prevention strategies.
Diagnosis and definition of VAP

- It is notable that some of the most effective measures for improving outcomes of patients on mechanical ventilation do not specifically target pneumonia prevention.

Interobserver variability in ventilator-associated pneumonia surveillance

Michael Klompas, MD, MPH
Boston, Massachusetts

Three infection control personnel and 1 physician independently evaluated 50 ventilated patients for ventilator-associated pneumonia through retrospective chart reviews. The infection control reviewers used Centers for Disease Control and Prevention criteria: the physician used clinical judgment. Infection control personnel labelled between 11 and 20 patients with VAP ($\kappa = 0.40$). The physician diagnosed 7 cases. Interobserver variability in the assessment of ventilator-associated pneumonia is high.

Key Words: Ventilator-associated pneumonia; infection surveillance; health care-associated infections.

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### Diagnosis and definition of VAP by different assessors

<table>
<thead>
<tr>
<th></th>
<th>Infiltrate or consolidation</th>
<th>Fever</th>
<th>Abnormal WBC</th>
<th>Change in sputum</th>
<th>Worsening exchange</th>
<th>VAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional assessor 1</td>
<td>17</td>
<td>25</td>
<td>35</td>
<td>19</td>
<td>36</td>
<td>11</td>
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<tr>
<td>Conventional assessor 2</td>
<td>26</td>
<td>26</td>
<td>27</td>
<td>22</td>
<td>32</td>
<td>20</td>
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<tr>
<td>Quantitative assessor</td>
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<td>33</td>
<td>38</td>
<td>30</td>
<td>44</td>
<td>15</td>
</tr>
<tr>
<td>Physician</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

Klompas M. AJIC 2010;38:237
### Diagnosis and definition of VAP by different assessors

<table>
<thead>
<tr>
<th></th>
<th>Consensus of all three infection control assessors, n (%)</th>
<th>Agree</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltrate or consolidation</td>
<td>25/50 (50)</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>30/50 (60)</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>Abnormal WBC</td>
<td>31/50 (32)</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Change in sputum</td>
<td>19/50 (38)</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Impaired gas exchange</td>
<td>28/50 (56)</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>VAP</td>
<td>31/50 (62)</td>
<td>0.40</td>
<td></td>
</tr>
</tbody>
</table>

Klompas M. AJIC 2010;38:237
Commentary

Eight initiatives that misleadingly lower ventilator-associated pneumonia rates

Michael Klompas MD, MPH\textsuperscript{a,b,*}

\textsuperscript{a} Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, MA.
\textsuperscript{b} Infection Control Department, Brigham and Women’s Hospital, Boston, MA
1. Interpret clinical signs as strictly as possible
2. Interpret chest radiographs as strictly as possible
3. Require consensus between 2 or more infection preventionists.
4. Seek endorsement of intensivists before “certifying” suspected cases as VAP

Klompas M. AJIC 2012;40:408
Initiatives that misleadingly lower ventilator-associated pneumonia rates

5. Require bronchoalveolar lavage for diagnosis.
6. Set quantitative growth thresholds for endotracheal aspirate and BAL cultures.
7. Transfer patients who require prolonged mechanical ventilation.
8. Expand surveillance to include uncomplicated postoperative patients.

Klompas M. AJIC 2012;40:408
Ventilator-Associated Event (VAE)

Based on

- objective,
- streamlined,
- potentially automatable criteria

- that will intentionally identify a broad range of conditions and complications occurring in mechanically ventilated adult patients

There are three definition tiers within the VAE algorithm:

1) Ventilator-Associated Condition (VAC);
2) Infection-related Ventilator-Associated Complication (IVAC)
3) Possible and Probable VAP
Ventilator-Associated Event (VAE)
Streamlined, objective algorithms to detect ventilator-associated complications (VAC)

- Are easily implemented
- Can make use of electronic health record systems to automate event detection
- Identify events that are clinically important and associated with outcomes such as
  - ICU and hospital length of stay
  - mortality
Ventilator-Associated Event (VAE)

- Research to date suggests that most VACs are due to
  - pneumonia,
  - ARDS,
  - atelectasis
  - pulmonary oedema

These are significant clinical conditions that may be preventable
Ventilator-Associated Event (VAE)

1. Patient on mechanical ventilation > 2 days
2. Baseline period of stability or improvement, followed by sustained period of worsening oxygenation
3. Ventilator-Associated Condition (VAC)
4. General, objective evidence of infection/inflammation
5. Infection-Related Ventilator-Associated Complication (IVAC)
6. Positive results of laboratory/microbiological testing
7. Possible or Probable VAP

Designed to be suitable for use in potential future public reporting, inter-facility comparisons, pay-for-performance programs.

Designed to be suitable for use in internal quality improvement.
Note

- The VAE definition algorithm is for use in surveillance.
- It is not a clinical definition algorithm and is not intended for use in the clinical management of patients.
VAEs are identified by using a combination of objective criteria:

- Deterioration in respiratory status after a period of stability or improvement on the ventilator
- Evidence of infection or inflammation
- Laboratory evidence of respiratory infection
Definition of VAE (2)

- Patients must be mechanically ventilated for more than two calendar days to be eligible for VAE.
- The earliest day on which VAE criteria can be fulfilled is day 4 of mechanical ventilation, (the day of intubation and initiation of mechanical ventilation is day 1)
- The earliest date of event for VAE, the date of onset of worsening oxygenation, is day 3 of mechanical ventilation
Definition of VAE (3)

- The baseline period of stability or improvement is defined as the 2 calendar days immediately preceding the first day of increased daily minimum PEEP or FiO₂.

<table>
<thead>
<tr>
<th>MV Day</th>
<th>Daily minimum PEEP (cmH₂O)</th>
<th>Daily minimum FiO₂ (oxygen concentration, %)</th>
<th>VAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>1.00 (100%)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>0.50 (50%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>0.40 (40%)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>0.40 (40%)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>0.70 (70%)</td>
<td>VAC</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>0.70 (70%)</td>
<td></td>
</tr>
</tbody>
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<td>0</td>
<td>0.50 (50%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.50 (50%)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>0.50 (50%)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>0.50 (50%)</td>
<td>VAC</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>0.50 (50%)</td>
<td></td>
</tr>
</tbody>
</table>
Note

• Patients on high frequency ventilation
  or extracorporal life support
  are excluded from VAE surveillance
Definition of VAE (4)

Changes that are significant:

- Daily minimum PEEP *: $\geq 3 \text{ cm } H_2O$
- Daily minimum FiO$_2$ **: $\geq 0.2$ (20%)

* PEEP = positive end-expiratory pressure
** FiO$_2$ = fraction of inspired oxygen
Definition of VAE (5)

Date of event:
- The date of onset of worsening oxygenation

VAE window period:
- The period of days around the event date within which other VAE criteria must be met.
- Usually a 5-day period including the 2 days before, the day of, and the 2 days after the VAE event date.
- Can not include days before day 3.
Definition of VAE (6)

Episode of mechanical ventilation:
- Defined as a period of days during which the patient was mechanically ventilated for some portion of each consecutive day.
- A break in mechanical ventilation of at least one full calendar day followed by reintubation and reinitiation of mechanical ventilation during the same hospitalization, defines a new episode of mechanical ventilation.
Definition of VAE (7)

New antimicrobial agent:

- Any agent that is initiated on or after the third calendar day of mechanical ventilation AND in the VAE window period
- The agent is considered new if it was not given to the patient on either of the 2 preceding days
Definition of VAE (8)

Qualifying antimicrobial day (QAD):

- A day on which the patient was administered an antimicrobial agent that was determined to be ”new” within the VAE Window Period.

- Four consecutive QADs are needed to meet the IVAC antimicrobial criterion – starting within the VAE Window Period.
Definition of VAE (9)

Location of attribution:

- The inpatient location where the patient was assigned on the date of the VAE, which is further defined as the date of onset of worsening oxygenation.
Definition of VAE (9)

Location of attribution (contd):

- Exception: *Transfer rule:*
  
  If a VAE develops on the day of transfer or the day following transfer from one inpatient location to another in the same facility or to a new facility, the event is attributed to the transferring location.
Definition of VAE (10a)

**Pathogens:**

- Pathogens may be reported for Possible and Probable VAP events provided they are isolated or identified from appropriate specimen types according to the requirements of the algorithm and are not on the list of excluded organisms and culture results.
Excluded organisms and culture results:

- Candida species or yeast not otherwise specified
- Coagulase negative stapylococci
- Enterococcus species

When isolated from sputum, endotracheal aspirates, BAL or protected brushing

All isolates from lung biopsy or pleural fluid may be reported as pathogens
Threshold values for cultured specimens used in the Probable VAP definition

<table>
<thead>
<tr>
<th>Specimen collection/technique</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung tissue</td>
<td>≥ 10^4 cfu/g tissue*</td>
</tr>
<tr>
<td>Bronchoscopically (B) obtained specimens</td>
<td></td>
</tr>
<tr>
<td>Bronchoalveolar lavage (B-BAL)</td>
<td>≥ 10^4 cfu/ml*</td>
</tr>
<tr>
<td>Protected BAL (B-PBAL)</td>
<td>≥ 10^4 cfu/ml*</td>
</tr>
<tr>
<td>Protected specimen brushing (B-PSB)</td>
<td>≥ 10^3 cfu/ml*</td>
</tr>
<tr>
<td>Nonbronchoscopically (NB) obtained (blind) specimens</td>
<td></td>
</tr>
<tr>
<td>NB-BAL</td>
<td>&gt; 10^4 cfu/ml*</td>
</tr>
<tr>
<td>NB-PSB</td>
<td>≥ 10^3 cfu/ml*</td>
</tr>
<tr>
<td>Endotracheal aspirate (ETA)</td>
<td>≥ 10^5 cfu/ml*</td>
</tr>
</tbody>
</table>

cfu = colony forming units, g = gram, ml = milliliter

*Or equivalent semi-quantitative result.
Ventilator-Associated Condition (VAC)

Figure 2: Ventilator-Associated Condition (VAC)

Patient has a baseline period of stability or improvement on the ventilator, defined by \( \geq 2 \) calendar days of stable or decreasing daily minimum \( \text{FiO}_2 \) or PEEP values. The baseline period is defined as the two calendar days immediately preceding the first day of increased daily minimum PEEP or \( \text{FiO}_2 \).

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 \( \text{FiO}_2 \) of \( \geq 0.20 \) (20 points) over the daily minimum \( \text{FiO}_2 \) in the baseline period, sustained for \( \geq 2 \) calendar days.

2) Increase in daily minimum PEEP values of \( \geq 3 \text{ cmH}_2\text{O} \) over the daily minimum PEEP in the baseline period, sustained for \( \geq 2 \) calendar days.
Infection-related Ventilator-Associated Complication (IVAC)

Figure 3: 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 $\geq 12,000\, \text{cells/mm}^3$ or $\leq 4,000\, \text{cells/mm}^3$.

AND

2) A new antimicrobial agent(s)* is started, and is continued for $\geq 4$ calendar days.

*See Appendix for eligible agents.
Possible Ventilator-Associated Pneumonia (VAP)

Figure 4: Possible Ventilator-Associated Pneumonia (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)
   - Defined as secretions from the lungs, bronchi, or trachea that contain $\geq 25$ neutrophils and $\leq 10$ 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 Ventilator-Associated Pneumonia (VAP)

Figure 5: Probable Ventilator-Associated Pneumonia (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
—— "a piece of cake"

—— thank you