New Surveillance Definitions for VAP

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The following relationships with commercial interests related to this presentation have occurred during the past 3 years:

No Conflicts to Disclose
Outline

- Background
  - Impact of VAP
  - Problems with current definition of VAP

- Proposed new surveillance paradigm
  - VAC
  - iVAC

- New Data on the morbidity, mortality and preventability of VAC, iVAC and VAP
Why focus on VAP?

- Increased Morbidity
  - Increased ICU LOS (5-9 days)
  - Increased Hospital LOS (up to 12 days)
  - Increased Vent. Duration (4-8 days)

**ICU LOS**

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Year</th>
<th>n[e]/M[e]/SD[e]</th>
<th>n[c]/M[c]/SD[c]</th>
<th>(%)</th>
<th>Association measure with 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papazian</td>
<td>1996</td>
<td>85/27.3/23.7</td>
<td>85/19.7/14.7</td>
<td>12.00%</td>
<td>7.6 (1.67 to 13.53)</td>
</tr>
<tr>
<td>Rello</td>
<td>2002</td>
<td>842/14.3/15.5</td>
<td>2243/4.7/7.7</td>
<td>15.00%</td>
<td>9.6 (8.51 to 10.69)</td>
</tr>
<tr>
<td>Leone</td>
<td>2002</td>
<td>58/11.6/1.7</td>
<td>58/9.4/1.3</td>
<td>16.00%</td>
<td>2.2 (1.65 to 2.75)</td>
</tr>
<tr>
<td>Kallel</td>
<td>2004</td>
<td>57/13/4</td>
<td>57/8/3.4</td>
<td>15.00%</td>
<td>4.7 (2.25 to 7.15)</td>
</tr>
<tr>
<td>Cocanour</td>
<td>2005</td>
<td>70/17.7/2</td>
<td>70/5.6/1</td>
<td>15.00%</td>
<td>11.9 (11.36 to 12.42)</td>
</tr>
<tr>
<td>Nseir</td>
<td>2005</td>
<td>77/24/15</td>
<td>77/13/11</td>
<td>14.00%</td>
<td>11 (6.85 to 15.15)</td>
</tr>
<tr>
<td>Cavalcanti</td>
<td>2006</td>
<td>62/17/14</td>
<td>62/11/16</td>
<td>13.00%</td>
<td>6 (0.71 to 11.29)</td>
</tr>
</tbody>
</table>

**META-ANALYSIS:** n=1251 n=2652

**Vent. Duration**

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Year</th>
<th>n[e]/M[e]/SD[e]</th>
<th>n[c]/M[c]/SD[c]</th>
<th>(%)</th>
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</tbody>
</table>

**META-ANALYSIS:** n=2952

- **ICU LOS:** 8.7 days
- **Vent. Duration:** 7.6 days

Muscedere et al, CID, 2010
Why the focus on VAP?

- Increased Mortality
  - Depends on population
  - Adequacy and timeliness of antibiotic treatment

Melsen et al, Crit Care Med, 2009
Baekert et al, AJRCCM, 2011

Melsen et al, SR and MA of 52 Obs. studies, 17,000 patients

Relative: 4-6% of ICU Mortality
Absolute: 1–1.5% Mortality

Melsen et al, Crit Care Med, 2009
Baekert et al, AJRCCM, 2011
Why the focus on VAP?

- Empiric and definitive treatment for VAP drives antibiotic utilization
  - Estimated that a large percentage of antibiotics prescribed in ICU given for VAP

- Increased hospital costs
  - >$10,000 US in additional costs
  - >$11,000 Cdn using Canadian data

Safdar et al, Crit Care Med, 2005
Why the focus on VAP?

VAP is a preventable disease

- ETT with Subglottic Secretion Drainage
- Chlorhexidine

Labeau et al, Lancet ID, 2011
Muscedere et al, CCM, 2011
VAP as a patient safety metric

- Because of impact on patients and the health care system regarded as a patient safety metric
- Mandatory reporting in many jurisdictions
  - Canada - Public reporting in Ontario
  - US – 32 states
Paradigm for Diagnosis of VAP

Clinical

- Purulent secretions
- Increasing oxygen requirements
- Core temp $> 38.0^\circ$ C or $< 34^\circ$ C
- WBC $< 3.5$ or $> 11.0$

Chest X-Ray

Microbiology

Pathogenic Bacteria

New or Persistent Infiltrates
Correlation between Clinical Diagnosis and Pathological Diagnosis

- Tejerina et al comparison histological diagnosis of VAP in 253 patients with:
  - Clinical Diagnosis (CXRay + 2/3: Temp, WBC and Purulent Secretions)
  - Rigorous Clinical Diagnosis (CXRay + 3/3: Temp, WBC and Purulent Secretions)
  - Rigorous Clinical Diagnosis plus pathogenic bacteria in ETA

Tejerina, JCC 25: 62 - 68
# Correlation between Clinical Diagnosis and Pathological Diagnosis

Table 3: Diagnostic accuracy of clinical definitions for ventilator-associated pneumonia

<table>
<thead>
<tr>
<th>Definition</th>
<th>Histological pneumonia (true positive)</th>
<th>No histological pneumonia (false positive)</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose definition (n = 163)</td>
<td>92</td>
<td>71</td>
<td>65 (57-72)</td>
<td>36 (28-45)</td>
</tr>
<tr>
<td>With diffuse chest infiltrate (n = 156)</td>
<td>88</td>
<td>68</td>
<td>62 (54-69)</td>
<td>39 (30-48)</td>
</tr>
<tr>
<td>With localized chest infiltrate (n = 25)</td>
<td>16</td>
<td>9</td>
<td>11 (7-17)</td>
<td>92 (85-96)</td>
</tr>
<tr>
<td>Loose definition plus pathogen microorganism in tracheal aspirate (n = 30)</td>
<td>22</td>
<td>8</td>
<td>15.5 (10.5-22)</td>
<td>93 (86-96)</td>
</tr>
<tr>
<td>Rigorous definition (n = 32)</td>
<td>22</td>
<td>10</td>
<td>15.5 (10.5-22)</td>
<td>91 (84-95)</td>
</tr>
<tr>
<td>With diffuse chest infiltrate (n = 29)</td>
<td>19</td>
<td>10</td>
<td>13 (9-20)</td>
<td>91 (84-95)</td>
</tr>
<tr>
<td>With localized chest infiltrate (n = 3)</td>
<td>3</td>
<td>0</td>
<td>2 (1-6)</td>
<td>100 (97-100)</td>
</tr>
<tr>
<td>Rigorous definition plus pathogen microorganism in tracheal aspirate (n = 8)</td>
<td>7</td>
<td>1</td>
<td>5 (2-10)</td>
<td>99 (95-100)</td>
</tr>
<tr>
<td>CPIS &gt;6 points (n = 109)</td>
<td>65</td>
<td>44</td>
<td>46 (38-54)</td>
<td>60 (51-69)</td>
</tr>
</tbody>
</table>

CI indicates confidence interval.
Current VAP diagnostic paradigm as a quality metric

- Subjective
- Non-specific
- Inconsistent association with patients’ outcomes
- Proposed new surveillance definitions in the ICU
An alternative approach to surveillance

- Broaden the focus from pneumonia alone to the syndrome of ventilator complications in general
  - More accurate description of what can be reliably determined using surveillance definitions
  - Emphasizes the importance of preventing all complications of mechanical ventilation, not just pneumonia

- Streamline the definition using quantitative criteria
  - Reduce ambiguity
  - Improve reproducibility
  - Enable electronic collection of all variables
Possible pneumonia

Probable pneumonia

New and sustained respiratory deterioration
ventilator-associated condition

New respiratory deterioration with concurrent infection
Infection-related ventilator-associated complication

IVAC
<table>
<thead>
<tr>
<th>VAC</th>
<th>iVAC</th>
<th>Possible Pneumonia</th>
<th>Probable Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>New respiratory deterioration</td>
<td>VAC+ evidence of infection</td>
<td>IVAC + possible respiratory source</td>
<td>IVAC + probable respiratory source</td>
</tr>
<tr>
<td>Sustained (\uparrow) PEEP or FiO2 after (\geq 2) days of stable or (\downarrow) PEEP or FiO2</td>
<td>Abnormal temp or WBC AND (\geq 4) days of new antibiotics</td>
<td>Sputum/BAL polys OR Pathogenic culture</td>
<td>Sputum/BAL polys AND Pathogenic culture</td>
</tr>
</tbody>
</table>
An alternative paradigm for surveillance:

Ventilator Associate Conditions (VAC)

Definition:

≥2 days of stable or decreasing daily minimum PEEP or FiO2

followed by

Rise in daily minimum PEEP ≥3 cm H₂O sustained ≥2 days

or

Rise in daily minimum FiO2 ≥20 points sustained ≥2 days

Slated for implementation in NHSN in January 2013
An alternative paradigm for surveillance:

Infection Related Ventilator Associate Conditions (iVAC)

Definition:

VAC associated with alterations in WBC ($\leq 4$ or $\geq 12$) or temperature ($< 36$ or $\geq 38^\circ C$) within 2 days

and

Prescription of antibiotics continued $\geq 4$ days
What is known to date about VAC, iVAC?

- Most cases of VAC are caused by 4 conditions:
  - Pneumonia
  - ARDS
  - Pulmonary edema
  - Atelectasis

- VAC, iVAC associated with increased morbidity and mortality
  - VAC associated with increased duration of mechanical ventilation

- No data to date demonstrating preventability

- No data on relationship to VAP

PLoS ONE 2011;6(3): e18062
Critical Care Medicine 2012; online
Clinical Infectious Disease 2012; in press
Study Objectives

- Compare the incidence and agreement of VAC, iVAC and VAP

- Compare attributable morbidity and mortality of VAC, iVAC vs. VAP

- Assess the responsiveness of VAC vs. VAP to a multifaceted quality improvement initiative
Study Design

- Secondary analysis of the ABATE study dataset

- **ABATE**: 2 year, prospective, multifaceted education program to increase implementation of VAP guidelines in 11 academic and community ICUs

- Each site enrolled the first 30 patients ventilated >48 hours in each of four data collection periods
  - Baseline, 6 months, 15 months, 24 months
  - Tracked guideline concordance and clinical measures for all enrolled patients
  - VAP rigorously adjudicated at multiple levels
Interventions Implemented were as per the Canadian VAP Guidelines

- Prevention Recommendations
  - ETT with subglottic secretion drainage
  - Semi-recumbent positioning (≥45°)
  - Oral care with Chlorhexidine
  - Oral route of intubation
  - Closed suctioning system
  - New ventilator circuit for each patient
  - Ventilator circuit changes only if soiled or damaged
  - Heated humidifier changes every 5-7 days
  - Change suctioning system only if blocked or damaged

Muscedere et al, JCC 2008
### Patient characteristics (N = 1320)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± std dev)</td>
<td>59.6 ± 17.2</td>
</tr>
<tr>
<td>Male</td>
<td>60%</td>
</tr>
<tr>
<td>APACHE II on admission (mean ± std dev)</td>
<td>23.0 ± 7.5</td>
</tr>
<tr>
<td>Ventilator days (median, IQR)</td>
<td>8.6 days (4.6, 28.6)</td>
</tr>
<tr>
<td>ICU days</td>
<td>13.6 days (7.4, und)</td>
</tr>
<tr>
<td>Hospital days</td>
<td>51.3 days (20.5, und)</td>
</tr>
<tr>
<td>Mortality (hospital)</td>
<td>34%</td>
</tr>
</tbody>
</table>
Occurrence of VAC, iVAC and VAP

- VAC occurred in 139 (10.5%)
  - iVAC occurred in 65 (4.9%) or 47.7% of VAC
- VAP occurred in 148 (11.2%)
- Agreement between VAP and VAC was: $K = 0.18$
- Agreement between VAP and iVAC was: $K = 0.19$
Clinical Outcomes: Mortality

Mortality (%)

VAC
- Cases: 49.6
- Control: 31.7

iVAC
- Cases: 44.6
- Control: 33.0

VAP
- Cases: 32.9
- Control: 31.8

*p < 0.0001
**p = 0.07
***p = 0.83

Legend:
- Cases
- Control (Non VAC, iVAC, VAP respectively)
Clinical Outcomes: ICU LOS

* * * p < 0.0001

<table>
<thead>
<tr>
<th></th>
<th>ICU LOS (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAC</td>
<td>18.9</td>
</tr>
<tr>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>iVAC</td>
<td>22.0</td>
</tr>
<tr>
<td></td>
<td>9.3</td>
</tr>
<tr>
<td>VAP</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>9.0</td>
</tr>
</tbody>
</table>

Cases | Control (Non VAC, iVAC, VAP respectively)
Clinical Outcomes: Hosp LOS

<table>
<thead>
<tr>
<th></th>
<th>VAC Cases</th>
<th>VAC Control</th>
<th>iVAC Cases</th>
<th>iVAC Control</th>
<th>VAP Cases</th>
<th>VAP Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hosp LOS (days)</td>
<td>31.7</td>
<td>21.8</td>
<td>34.6</td>
<td>22.5</td>
<td>30.9</td>
<td>22.2</td>
</tr>
</tbody>
</table>

* * * p < 0.0001
Clinical Outcomes: MV Days

* * * \( p < 0.0001 \)

<table>
<thead>
<tr>
<th></th>
<th>Duration of MV (days)</th>
<th>Case</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAC</td>
<td>15.4</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>iVAC</td>
<td>16.9</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>VAP</td>
<td>13.6</td>
<td>6.2</td>
<td></td>
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Cases: VAC, iVAC, VAP
Control (Non VAC, iVAC, VAP respectively)
Guideline concordance - preventive measures

- Oral Intubation
- ETT with Subglottic Drainage
- Heated Humidifier Changes
- HOB elevation
- Closed Suctioning System
- Vent Circuit Changes
- Suction System Changes
- CHG mouthwash

Concordance (%)

Baseline | 6 months | 15 months | 24 months
---|---|---|---
0 | 0 | 0 | 0
20 | 20 | 20 | 20
40 | 40 | 40 | 40
60 | 60 | 60 | 60
80 | 80 | 80 | 80
100 | 100 | 100 | 100

ETT with SSD
CHG
HOB
# Aggregate prevention guideline concordance

- Aggregate overall and prevention guideline concordance rose throughout the study

<table>
<thead>
<tr>
<th></th>
<th>Baseline n = 330</th>
<th>6 Months n = 330</th>
<th>15 Months n = 330</th>
<th>24 Months n = 330</th>
<th>p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordance with all VAP CPG recommendations (%)</td>
<td>53.1%</td>
<td>57.1%</td>
<td>57.7%</td>
<td>65.4%</td>
<td>0.009</td>
</tr>
<tr>
<td>Concordance with VAP CPG preventive measures (%)</td>
<td>46.2%</td>
<td>50.3%</td>
<td>52.2%</td>
<td>54.2%</td>
<td>0.004</td>
</tr>
</tbody>
</table>
VAC, iVAC and VAP rates over time

- VAC (p value pre and post = 0.12, p value trend = 0.05)
- iVAC (p value pre and post = NS, p value trend = NS)
- VAP (p value pre and post = 0.03, p value trend = 0.06)
Risk factors for VAC (multivariate model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>APACHE II score</td>
<td>0.92 (0.82, 1.04)</td>
<td>0.17</td>
</tr>
<tr>
<td>Hospital days to ICU admission</td>
<td>1.09 (0.99, 1.20)</td>
<td>0.09</td>
</tr>
<tr>
<td>% ventilator days with SBTs</td>
<td>0.97 (0.94, 1.01)</td>
<td>0.10</td>
</tr>
<tr>
<td>% ventilator days with SATs</td>
<td>0.93 (0.99, 1.04)</td>
<td>0.05</td>
</tr>
<tr>
<td>% ventilator days with CHG oral care</td>
<td>1.02 (0.99, 1.04)</td>
<td>0.18</td>
</tr>
</tbody>
</table>
Conclusions

- VAC and VAP rates similar but agreement is very low
  - Likely measure different pathophysiological processes

- VAC strongly associated with increased length of stay and hospital mortality

- A multifaceted quality improvement initiative was associated with VAC rates but iVAC rates did not change.

- SATs and SBTs may be protective against VAC
Thank You

Questions?
### NHSN surveillance definition for VAP

Patient must fulfill each of the three categories below:

<table>
<thead>
<tr>
<th>Chest Radiograph</th>
<th>Any one of the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. New, progressive, or persistent infiltrate</td>
</tr>
<tr>
<td></td>
<td>2. Consolidation</td>
</tr>
<tr>
<td></td>
<td>3. Cavitation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systemic Signs</th>
<th>Any one of the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Temperature &gt;38°C</td>
</tr>
<tr>
<td></td>
<td>2. WBC &lt;4,000 or &gt;12,000 WBC/mm³</td>
</tr>
<tr>
<td></td>
<td>3. For adults 70 years old, altered mental status with no other recognized cause</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pulmonary Signs</th>
<th>Any two of the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></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. New onset or worsening cough, or dyspnea, or tachypnea</td>
</tr>
<tr>
<td></td>
<td>3. Rales or bronchial breath sounds</td>
</tr>
<tr>
<td></td>
<td>4. Worsening gas exchange, increased oxygen requirements, or increased ventilation demand</td>
</tr>
</tbody>
</table>
Interobserver agreement in VAP surveillance

50 ventilated patients with respiratory deterioration

Kappa = 0.40

Klompas, *AJIC* 2010:38:237
Impact of diagnostic technique on VAP rates
53 patients with clinically suspected VAP

% of patients with positive cultures

Endotracheal aspirate (any growth)
Endotracheal aspirate $>10^6$ CFU/ml
Bronchoalveolar lavage $>10^4$ CFU/ml

VAPs per 1000 ventilator-days

Morris, Thorax 2009;64:516
Ways to lower VAP rates
Without meaningfully changing patient care

1. Narrowly interpret subjective clinical signs
2. Narrowly interpret radiographs
3. Seek consensus between multiple IP’s
4. Allow clinicians to veto surveillance determinations
5. Increase use of quantitative BAL for diagnosis

National VAP rates
United States, 2004-2010

Source: CDC NNIS and NHSN
International VAP Rates

Source: CDC Europe and CDC USA
Increasing gap between clinical and surveillance VAP rates

Thomas et al. *Am Surgeon* 2011;77:998
Vincent et al. *JAMA* 2009;302:2323

15% of ICU pts on VAP Rx on cross-sectional surveys
Prospective study: 134 patients receiving MV:

<table>
<thead>
<tr>
<th>Diagnostic Criteria (n=134)</th>
<th>VAP Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Diagnosis</td>
<td>22%</td>
</tr>
<tr>
<td>ACCP</td>
<td>29%</td>
</tr>
<tr>
<td>CPIS</td>
<td>25%</td>
</tr>
<tr>
<td>NNIS (active)</td>
<td>31%</td>
</tr>
<tr>
<td>NNIS (passive)</td>
<td>2%</td>
</tr>
</tbody>
</table>

“CONCLUSION: Despite increasing support for public disclosure of nosocomial infection rates, the optimal criteria to diagnose VAP are controversial. This is illustrated by the low correlation between the four strategies most commonly used to diagnose VAP. These data highlight how dramatically VAP rates are affected by the choice of diagnostic criteria and the intensity of VAP surveillance.”

Morrow et al, Chest 2006