VENTILATOR-ASSOCIATED PNEUMONIA (VAP) outline

- Definitions and epidemiology
- Risk factors
- Diagnosis
- Treatment
VAP: Why should be care?

- Most common infection in the ICU (Occurs in 9-27% of intubated patients)
- Cumulative incidence of about 10-25% and accounts for approximately 25% of ICU infections
- Over 50% of antibiotics in ICU prescribed for VAP
- Estimated health care costs about $40,000/case
- Crude mortality rates reported to be between 20-70% (attributable mortality controversial)

Craven D: Chest 2006
Chastre and Fagon: AJRCCM 2002
Safdar N et al: Critical Care Medicine 2005
VAP: Why should we care

- VAP increases
  - Ventilator days
  - ICU and hospital length of stay
  - Medical costs

VAP rates in NHSN participating hospitals ranged from 2.1 - 11.0 per 1000 ventilator days

VAP rate 1-3% per day of mechanical ventilation

90% of all hospital acquired infections in ventilated patients are pneumonias


• HAP is the second most common nosocomial infection
• Incidence 5-10 cases per 1000 admissions
• HAP accounts for 25 % of ICU infections,
• >50% of prescribed antibiotics
• Risk of VAP is 3% per day of intubation, occurs in 9-27% of all intubated patients
• Attributal mortality for VAP 33-50%
• Prolongs hospital stay by 7-9 days, increases cost by $40,000 per patient

Hospital acquired pneumonia remains an important cause of morbidity and mortality, despite advantages in antimicrobial therapy, better supportive care modalities and the use of wide-range of preventing measures.

Ventilator associated pneumonia

- **Prevalence**
  - 10-20% on MV (6-21 times the risk of contracting pneumonia)

- **Mortality**
  - 1st cause of death from hospital acquired infections
  - Case fatality rate 13-55%
  - Attributable mortality: 30%

- **Hospital Length of stay**
  - 9 days longer (increase by 62%)

- **Hospital cost**
  - > US$40,000 per patient

Chastre J et al. AJRCCM. 2002; Kollef MH. Chest. 1999
VAP Guidelines

• European Task Force - 2001
• Centers for Disease Control and Prevention (CDC)-2003
• Canadian Critical Care Society (CCCS) – 2004
• American Association Respiratory Care -2005
• American Thoracic Society / Infectious Diseases Society of America (IDSA) -2005
Consensus on Nosocomial Pneumonia

History

- 54-year-old male
- Past medical history: hypertension, chronic obstructive pulmonary disease (COPD) and non-insulin-dependent diabetes
- Recent discharge (9 days ago) from hospital for COPD exacerbation for which he received ceftriaxone and azithromycin for 7 days
- Re-presented to the emergency department with increased fever and dyspnoea
Summary of clinical progression and onset of pneumonia

1

Diagnosed as COPD, started oral azithromycin
WBC: 13.7 x 10⁹/L
37.3°C

3

The patient is intubated, started IV cefepime 1 g q 12 h/
gentamicin 100 mg q 12 h
WBC: 25.9 x 10⁹/L, 38.7°C

5

Worsening pneumonia, bronchoscopy performed
On day 5, the patient is diagnosed with ventilator associated pneumonia (VAP)

**Pneumonia definitions**

- **Hospital-acquired pneumonia (HAP)**
  - pneumonia occurring $\geq 48$ hours post-hospital admission and not incubated on admission

- **VAP**
  - pneumonia occurring $\geq 48-72$ hours post-intubation

- **Health-care associated pneumonia (HCAP)**
  - includes HAP and VAP
  - pneumonia in patients
    - hospitalization for $\geq 2$ days in preceding 90 days
    - Residence in a nursing home or long term care (LTC) facility home
    - Infusion therapy (including antibiotics)
    - Chronic dialysis within 30 days
    - Home wound care
    - Family member with multi-drug resistant (MDR) pathogen

*ATS/ADSI, AJRCCM 2005; 171:388-416*
Differentiating Pneumonia Types

PNEUMONIA
7th leading cause of death in the United States¹
Traditionally categorized into 3 acquisition site–based groups

CAP²
Acute pulmonary infection in a patient who is not hospitalized or residing in a long-term care facility 14 or more days prior to presentation

HAP³
New infection occurring 48 or more hours after hospital admission

VAP³
New infection occurring 48 or more hours after endotracheal intubation

HCAP³
- Newly differentiated 4th category
- Etiologically similar to HAP and requires HAP-like treatment
- Like CAP patients, HCAP patients are ambulatory and often present to the ED

Risk factors for MDR pathogens causing HAP, HCAP and VAP.

Prior antimicrobial therapy in preceding 90 days
Current hospitalization of ≥ 5 days
High frequency of antibiotic resistance in the community or in the specific hospital unit
Presence of risk factors for HCAP:
- hospitalization for ≥ 2 days in the preceding 90 days
- residence in a nursing home or extended care facility
- home infusion therapy (including antibiotics)
- chronic dialysis within 30 days
- home wound care
- family member with multi-drug-resistant pathogen
Immunosuppressive disease and/or therapy

HCAP: Guideline Definition

- Pneumonia is considered healthcare associated in individuals meeting any one of the following conditions:
  - Infection developing within 90 days of a 2-or-more-day hospitalization in an acute care facility
  - Infections in nursing-home residents
  - Infections in long-term-care residents
  - Infection within 30 days of receiving in-hospital or at-home IV antibiotic therapy, chemotherapy, or wound care
  - Infection following a visit to a hospital or hemodialysis clinic

- All patients meeting these criteria should also be considered at risk for infection with atypical and/or MDR organisms
VAP: Definition

- Nosocomial pneumonia in a patient on mechanical ventilatory support (endotracheal tube / tracheostomy) for greater than or equal to 48 hours
- Revised CDC definition (2007)
  - No minimum time period for ventilator to be in place
- Early onset: Occurring within 96 hours of start of mechanical ventilation
- Late onset: Occurring more than 96 hours after start of mechanical ventilation (Associated with MDR organisms)
Definition: VAP

- Pneumonia (PNEU) that occurs in a patient who was intubated and ventilated at the time of or within 48 hours before the onset of the pneumonia.

- If the PNEU develops in a patient within 48 hours of discharge from a location, indicate the discharging location on the infection report, not the current location of the patient.
VAP
Location of attribution

• The inpatient location where the patient was assigned on the date of pneumonia onset
  (which is defined as the date when the first clinical evidence appeared or the date the specimen was collected, whichever came first)

• Exception: Transfer rule
Definition: Ventilator

- A device to assist or control respiration continuously, inclusive of the weaning period, through a tracheostomy or by endotracheal intubation.

  - **NOTE:** Lung expansion devices such as intermittent positive-pressure breathing (IPPB); nasal positive end-expiratory pressure (PEEP); and continuous nasal positive airway pressure (CPAP, hypoCPAP) are not considered ventilators unless delivered via tracheostomy or endotracheal intubation (e.g., ET-CPAP).
VAP rate

VAP rate per 1000 ventilator days =

\[
\frac{\text{Number of VAPs}}{\text{Number of ventilator days}} \times 1000
\]
<table>
<thead>
<tr>
<th>Date</th>
<th>Number of patients</th>
<th>Number of patients with 1 or more central lines</th>
<th>Number of patients with a urinary catheter</th>
<th>Number of patients on a ventilator</th>
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</tbody>
</table>
• “Early onset” VAP
  4-7 days after intubation
  “community” organisms, MSSA, 
  *Str. pneumoniae*

• “Late onset" VAP
  > 4-7 days of mechanical ventilation
  MRSA, *P. aeruginosa*, A. *baumannii*
Classification of HAP & VAP: Risk Stratification

Time from Hospitalization (days)

0 1 2 3 4 5 6 7

Early-onset HAP  Late-onset HAP

Time from Intubation (days)

0 1 2 3 4 5 6 7

Early-onset VAP  Late-onset VAP

VAP: Pathogenesis

Colonization of aerodigestive tract

Aspiration

Bronchiolitis

Transthoracic infection
Primary bacteremia
Possible gastrointestinal translocation
Secondary bacteremia
Systemic inflammatory response syndrome
Nonpulmonary organ dysfunction

Focal or multifocal bronchopneumonia

Confluent bronchopneumonia

Lung abscess

Host systemic and lower respiratory tract defense mechanisms

Contaminated water, medication solutions, respiratory-therapy equipment

Inhalation

Medications altering gastric emptying and pH

Pathogenesis of HAP / VAP

**Sources of Microorganisms Causing HAP and VAP**

**Endogenous**
- Oropharynx
- Trachea
- Nasal carriage
- Sinusitis
- Gastric fluids

**Exogenous**
- Healthcare workers
- Ventilatory circuits
- Nebulizers
- Biofilms

**Aspiration**

**Inhalation**

**Blood**

**HAP and VAP**
VAP: Pathogenesis

- Microbial invasion of sterile lower respiratory tract and lung parenchyma
  - Defect in host defenses
  - Challenge by a particularly virulent microbe
  - Overwhelming inoculum
- Most commonly
  - Bacterial colonization of the aero-digestive tract
  - Aspiration of contaminated secretions into the lower airway

Fagon and Chastre: AJRCCM 2002
This is a normal defense mechanism

• Normal individual aspires during sleep

but

• No germs in the lower respiratory track and pulmonary arechyma because of; Cough reflex, Mucus, Mucocilliary clearence

The aspirate: Supravocal cords bacteria

• Blood defence: Leukocytes Immunogloboulins complement
BUT

In the intubated patient a number of factors compromise the normal host defence mechanisms
Routes of colonization/infection in mechanically ventilated patients

- **Endogenously** (stomach, oropharynx)
- **Exogenously** may result in primary colonization of the oropharynx or may be the result of direct inoculation into the lower respiratory tract during *manipulations of respiratory equipment*, during using of *respiratory devices* or from *contaminated aerosols*
PATHOGENESIS OF VAP

Common Sources of VAP Pathogens:
- Aspiration
- Intubation Procedure
- Biofilm Formation
- Contaminated Secretions
- Contaminated respiratory equipment

Intubation procedure

Microorganisms in the oropharyngeal cavity
Epiglottis

Biofilm formation on inner and outer surface of the endotracheal (ET) tube
Dislodged biofilm
ET tube upon extubation
Carinal contaminated secretions
Contaminated respiratory equipment
Contaminated secretions
Define the risk factors

*Kollef M. NEJM 2006; 355:2691*

- Recent hospitalization
- Admission from a chronic care environment
- Current hemodialysis
- Immunocompromised state
- Later-onset infection
- Prior use of antimicrobial agents during current period of hospitalization
- Sicker the patient, more “chance” to get VAP
- Longer the intubation period, higher the risk of developing VAP
Silver-Coated Endotracheal Tubes and Incidence of Ventilator-Associated Pneumonia: The NASCENT Randomized Trial

Marin H. Kollef; Bekele Afessa; Antonio Anzueto; et al.

JAMA. 2008;300(7):805-813 (doi:10.1001/jama.300.7.805)

http://jama.ama-assn.org/cgi/content/full/300/7/805
The NASCENT study results
Time to occurrence of microbiologically–confirmed VAP in patients intubated ≥24h

![Graph showing time to occurrence of VAP](image)

Patients With VAP (%)

Time (Days)

- **Silver**

P = 0.005
## Risk factors for VAP

<table>
<thead>
<tr>
<th>Co-morbid Illnesses</th>
<th>ICU Therapies</th>
<th>Injuries</th>
<th>Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer</td>
<td>CPR</td>
<td>Burns</td>
<td>Duration of mechanical ventilation</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease (COPD)</td>
<td>Corticosteroid use</td>
<td>Coma</td>
<td>Intracuff pressure &lt;20 cm H₂O</td>
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<tr>
<td>Chronic cardiac disease</td>
<td>General surgery</td>
<td>Head injury</td>
<td>Reintubation</td>
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<tr>
<td>Sinusitis</td>
<td>Neurosurgery</td>
<td>Multiple organ system failure (MOSF)</td>
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<tr>
<td>Kidney failure</td>
<td>Antacids</td>
<td>Acute respiratory distress syndrome (ARDS)</td>
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<td>Paralytic agents</td>
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<td>Prior antibiotic therapy</td>
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<td>Tracheostomy</td>
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<td>Use of a nasogastric tube</td>
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<td>Large-volume gastric aspiration</td>
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</table>
Epidemiology

VAP-related extended duration of ventilation

- with VAP
- without VAP

N. of ventilation days

Extended length of ICU stay

- without VAP
- with VAP

Period

VAP-related mortality rates

- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%

25%
50%

VENTILATOR ASSOCIATED TRACHEOBRONCHITIS

VAT appears to be an important risk factor for VAP

DE Craven, A Chroneou, N Zias, K Hjalmarsön
Ventilator-Associated Tracheobronchitis (VAT): the impact of targeted antibiotic therapy on patient outcomes

Chest, 2008; Sept 23
VAP: Current views

• No longer un unfortunate effect

• Viewed as a preventable medical error
Changing Views of VAP

• No longer just an “unfortunate” occurrence
• Viewed as medical error
  – Institute of Medicine
  – Leapfrog Group
• JCAHO – hospitals required to show VAP prevention/reduction measures
So, do we have any explanation for this change of view regarding VAP?
Of course we have!

_Pronovost PJ et al. JAMA 2008; 299:2197_

When Medicare patient develop a preventable complication in the hospital (since 2009 VAP is on the list) the hospital will not get additional payments anymore !!!
Physician’s diagnosis of pneumonia alone **is not** an acceptable criterion for health-care associated pneumonia

*CDC March 2009*
Clinical criteria for VAP

• New or progressive infiltrates on CXR

2 or more of the following:

• Fever (> 38.3°C)
• Leukocytosis (> 10 or <4)
• Purulent tracheobronchial secretions.
Table 2. Specific Site Algorithms for Clinically Defined Pneumonia (PNU1)

<table>
<thead>
<tr>
<th>Radiology</th>
<th>Signs/Symptoms/Laboratory</th>
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<tbody>
<tr>
<td>Two or more serial chest radiographs with at least one of the following:</td>
<td>FOR ANY PATIENT, at least one of the following:</td>
</tr>
<tr>
<td>New or progressive and persistent infiltrate</td>
<td>- Fever (&gt;38°C or &gt;100.4°F) with no other recognized cause</td>
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<tr>
<td>Consolidation</td>
<td>- Leukopenia (&lt;4000 WBC/mm³) or leukocytosis (&gt;12,000 WBC/mm³)</td>
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<tr>
<td>Cavitation</td>
<td>- For adults ≥70 years old, altered mental status with no other recognized cause</td>
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<tr>
<td>Pneumatoceles, in infants ≤ 1 year old</td>
<td>and</td>
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<td>at least two of the following:</td>
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<td>- New onset of purulent sputum³, or change in character of sputum⁴, or increased respiratory secretions, or increased suctioning requirements</td>
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<td>- New onset or worsening cough, or dyspnea, or tachypnea⁵</td>
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<td>- Rales⁶ or bronchial breath sounds</td>
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<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>
www.vapaway.eu

European Evidence Based Educational Survey for the prevention of VAP