Ventilator Associated Pneumonia

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Objectives

- Understand basic terminology of Healthcare Associated Pneumonia (HAP/HCAP)
- Understand the impact of HAP
- Understand difficulties surrounding counting and surveillance of HAP
- Understand the basic pathophysiology of HAP
- Understand basic prevention methodologies used for HAP
- Special circumstances (outbreaks, pseudo-outbreaks)
Some definitions…..

• Healthcare acquired pneumonia
  • Ventilator associated pneumonia (VAP)
  • Non-ventilator associated pneumonia

• Ventilator settings
  • PEEP (positive end expiratory pressure)
    • Normal PEEP = 5
  • Fraction of inspired oxygen (FiO2)
    • Normal FiO2 = 27%

UCLA Health System
How big is the problem?

• SENIC Study in 1988
  • Estimated 275,000 cases of nosocomial pneumonia per year in US
  • Rate of 0.5 to 1.0 infections per 100 patients or 0.76 infections per 1,000 patient days.
  • Ventilator associated pneumonia
    • Incidence 9-65%
    • EPIC study in 1995: 10K total pt
      • 4500 (45%) had at least 1 infection
        • Pneumonia 47% of all HAIs
        • Lower respiratory infections 17.8%
      • Pneumonia doubled the risk of death in ICU
How much do HAPs cost?

• Double rate of death in ICU
  • Mortality rate may exceed 10%
• Secondary bacteremia is common (4-38%)
• Increase ICU stay by 4-21 days
• Excess cost of $5,800 per event in the 1990s
  • Total cost $5,800 X 275,000 cases per year = $1.6 billion per year
• Currently not publicly reported in California
• CDC changed definitions in 2013 for potential use as public measure in the future.
How do we survey for pneumonia? With much difficulty….

- Definitions prior to 2013 were very subjective
  - Operator dependent
  - Variable definitions used in research yield vastly different rates
- Clinical diagnosis of pneumonia is difficult
  - Pneumonia vs. atelectasis
  - Aspiration pneumonia vs. aspiration pneumonitis
- 2013 CDC changed definition of VAP for adults
  - Based upon FiO2 and PEEP
Figure 1: Ventilator-Associated Events (VAE) Surveillance Algorithm

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

*Daily minimum defined by lowest value of \( \text{FiO}_2 \) or PEEP during a calendar day that is maintained for at least 1 hour.

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 ≥ 0.20 (20 points) over the daily minimum \( \text{FiO}_2 \) in the baseline period, sustained for ≥ 2 calendar days.
2) Increase in daily minimum PEEP values of ≥ 0.5 cmH\(_2\)O over the daily minimum PEEP in the baseline period\( ^6 \), sustained for ≥ 2 calendar days.
3) Change in work of breathing\( ^7 \) (see appendix for eligible work of breathing changes) sustained for ≥ 2 calendar days.

\( \text{Daily minimum defined by lowest value of \( \text{FiO}_2 \) or PEEP during a calendar day that is maintained for at least 1 hour.} \)

\( \text{Daily minimum PEEP values of 0-3 cmH}2\text{O are considered equivalent for the purposes of VAE surveillance.} \)

Ventilator-Associated Condition (VAC)

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 < 35°C, OR white blood cell count ≥ 12,000 cells/mm\(^3\) or ≤ 4,000 cells/mm\(^3\).

AND

2) A new antimicrobial agent(s) (see appendix for eligible antimicrobial agents) is started, and is continued for ≥ 4 calendar days.

Infection-related Ventilator-Associated Complication (VAIC)

On or after calendar day 2 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 ≤3 squamous epithelial cells per low power field [e.g., x100].
   - If the laboratory reports semi-quantitative results, those results must correspond to the above quantitative thresholds.
   - See additional instructions for using the purulent respiratory secretions criterion in the VAE Protocol.

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

On or after calendar day 2 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)
   - 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/g or equivalent semi-quantitative result
   - Positive culture of protected specimen brush*, ≥ 10\(^3\) CFU/ml or equivalent semi-quantitative result
   - Same organism exclusions as noted for Possible VAP.

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 NCT 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

Possible Ventilator-Associated Pneumonia

Probable Ventilator-Associated Pneumonia
CDC Diagnosis of VAP in adults

- 2 day period of stability (stable or decreasing FiO2 and PEEP)
- At least 2 days of worsening PEEP and FiO2
- Elevated (or low) temp
- Antibiotic treatment for 4 or more days
- Purulent secretions
- Positive sputum culture
How do patients get hospital acquired pneumonia?

- **Endogenous routes**
  - Gastric colonization—gastropulmonary route (4-24% cause)
    - Lower pH of gastric secretions in ill pts, meds
  - Oropharyngeal colonization (majority reservoir)
  - Intestinal colonization—rectopulmonary route (uncommon route)
    - Patients’ skin or HCW hands
    - Gastro-duodenal reflux in ill patients

- **Exogenous routes**
  - Sinks, faucets, vent circuits, air handling systems
  - Tend to cause epidemics of GNRs, Legionella, Aspergillus, etc.
All pneumonia is aspiration pneumonia...

• Colonization of the upper respiratory tract w pathogens
  • Early infections (first 3 days)
    • Pneumococcus, Moraxella, H. flu
  • Later infections
    • GNRs: Pseudomonas, Acinetobacter, etc.

• Bypass of normal host defense mechanisms
Contamination/Colonization with bacteria

Endotracheal Tube (ET)

Impaired Natural Protection/Clearance System

Aspiration of microorganisms into the lungs directly through the ET tube or around the cuff

Lungs contaminated with microorganisms
VAP Pathogens

- Staphylococcus aureus 24%
- Pseudomonas aeruginosa 16.3%
- Enterobacter 8.4%
- Acinetobacter 8.4%
- Klebsiella 7.5%
- E. coli 4.6%
Risk factors for developing HAP

ICU acquired PNA

• Severity of illness
• COPD
• Trauma, Neuro disease, abdominal/chest surgery
• Age
• Coma/depressed consciousness
• Antacids (PPIs)
• NG tube
• Impaired cough reflex
• Bronchoscopy

Vent Assoc PNA

• Emergent intubation
• Duration of intubation (2%/d to 5 days)
• COPD
• Trauma, Neuro disease, abdominal/chest surgery
• Age
• Antacids (PPIs)
• NG tube
• Reintubation
• Supine position
• Paralytic agents
• Inadequate cuff pressure
Prevention of HAP/VAP

• Directly linked to risk factors:
  • Inoculation of bacteria into lungs (intubation, reintubation)
  • Cleanliness of patient and hand hygiene of HCW
  • Aspiration w poor mental status
  • Poorly maintained or dirty or faulty equipment
  • Continued intubation
  • Higher than normal gastric pH
  • Supine position
  • Poor mental status
  • Lack of mobility
Prevention of transmission of microorganisms to patients

• All medical devices should be cleaned and disinfected
  • Ventilator
  • Endotracheal tube
  • Laryngoscope (JC requirement)
    • High level disinfection
    • Sterile packaging until use
  • Nebulizers should be kept clean
  • Only use sterile medications and solutions for aerosolization
  • Clean anesthesia machines between cases
  • Pulmonary function testing equipment
  • Bronchoscopy equipment cleaned between procedures
  • Air handlers, humidifiers, etc.
Prevention of person to person transmission of microorganisms

- **Standard precautions**
  - Hand hygiene
  - Gloving/face mask/gowns
  - Change gloves between contaminated and clean activities

- **Maintenance of the airway**
  - Remove ET tube ASAP!
  - Aseptic vs. sterile gloves
  - Closed vs open suctioning
    - With open suctioning, use sterile, single use system
    - Use sterile fluid for suctioning
Increasing host defenses against infection

• Remove endotracheal tube ASAP!
• Pneumococcal vaccination
• Avoid steroids if possible
• Avoid unnecessary antibiotic use
• Avoid proton pump inhibitor (PPI) use if possible (sucralfate less problematic)
Preventing aspiration

• Use non-invasive ventilation if possible instead of intubation.
• Avoid re-intubation
• Consider subglottic suction catheter to remove secretions
• Ensure adequate ETT balloon inflation pressures
• Prior to extubating, suction subglottic secretions
Remove endotracheal tube ASAP

- Lower levels of sedation
- Sedation vacation daily
- Daily weaning trials
- Ambulation, out of bed to chair early with ETT
Preventing aspiration, cont.

• Prevent aspiration w enteral feeding
  • Elevate angle of bed 30-45%
  • Verify placement of feeding tube before use
• Prevent oropharyngeal aspiration
  • Chlorhexidine oral rinse
  • CHG bath treatment
  • Good dental hygiene
Preventing post-op pneumonia

• Ambulate early
• Encourage deep breathing with incentive spirometer
• Decrease sedation as much as possible
• ?chest physiotherapy
Putting it all together…
the IHI ventilator bundle

- Elevation of the head of the bed 30-45%
- Daily sedation vacation
- Daily assessment for weaning
- Peptic ulcer prophylaxis
- Deep venous thrombosis prophylaxis
- Daily oral care with CHG
Outbreak vs. pseudo-outbreak

**Outbreak**
- Increased incidence of organism or syndrome causing disease in multiple patients in a time window

**Pseudo-outbreak**
- Increased incidence of organism or syndrome causing disease (or not) in multiple patients, but due to enhanced detection or other factors not directly related to infection process.
Outbreaks of hospital acquired pneumonia

- Can be due to environmental contamination
  - Malfunctioning air handling equipment
  - Water sources
- Typically in immunosuppressed patients (transplant, Heme-Onc, COPD)

Up to 10 Legionnaires' cases now as UAB confirms another in outbreak

By Mike Oliver | moliver@al.com
Email the author | Follow on Twitter
on June 12, 2014 at 10:44 AM, updated June 13, 2014 at 8:47 AM

Another patient has been confirmed to be part of the cluster of nine patients and at least one
Outbreaks

• Due to contaminated equipment or medications, but may not cause disease, usually because low virulence.
• Often found on BAL.

• Example:
  • *Pseudomonas flourescens-putida* found in multiple patients who have undergone bronchoscopy
    • Equipment was cleaned with tap water from contaminated tap
    • Cultures were contaminated during procedure
Pseudo-outbreak

• Increase organism in ICU
Pseudo-outbreak

- Increase organism in ICU

- In March, new test for this organism was sent routinely on all sputum cultures…..
Summary of Prevention practices…

• Hand hygiene
• Daily CHG bathing
• Elevation of the head of the bed 30-45%
• Daily sedation vacation
• Daily assessment for weaning
• Daily oral care with CHG