Ventilator-Associated Pneumonia
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Learning objective
- Describe the epidemiology, pathogenesis, diagnosis, management and prevention of ventilator-associated pneumonia.

VAP Epidemiology
- Pneumonia has accounted for:
  - 15% of all hospital-associated infections and
  - 27% ICU infections
  - 24% CCU infections
  - 2nd most common nosocomial infection (after UTI)
- Primary risk factor - mechanical ventilation and endotracheal tube

FYI - Link to CDC website on VAP
http://www.cdc.gov/HAI/vap/vap.html

VAP Epidemiology
- So what?
  - Costs of VAP
    - prolonged intubation & ventilation
    - patient discomfort
    - greater ICU and hospital stay
    - medications; e.g., antibiotics
    - estimated cost/case = $40,000
    - estimated yearly cost = $50 million/yr

VAP Etiologies & Pathogenesis

- Federal government had decided that VAP is a result of error and would not pay.
- This decision has been reversed
Normal status
- Aerodigestive tract above vocal cords is heavily colonized.
- Lower respiratory tract is normally sterile.
- Normal adults aspirate during sleep, without complications.

Defense mechanisms
- Anatomic barriers
- Cough
- Mucociliary clearance
- Cellular and humoral immunity
- Alveolar macrophages

Compromise of defenses
- Intratracheal tube
  - Provides a direct conduit for microorganisms
  - Impairs cough
  - Impairs mucociliary clearance
  - Airway injury

Compromise of defenses
- Critical illness
- Comorbidities
- Malnutrition

Routes for development
- Aspiration
  - Direct from oropharynx
  - Reflux from GI tract
- Extension of existing infection
- Inhalation of contaminants; e.g., aerosols
- Blood-borne from other sites

Causative factors
- Aerodigestive colonization
- Contaminated respiratory therapy equipment & aerosols
- Contaminated tap water (pseudomonas, legionella)
- Contaminated ambient air (fungi, TB, SARS, coronavirus)
Causative factors
- Biofilms on intratracheal tubes
- Sinusitis- infection spreads to lung
- Gastric colonization- reflux & aspiration

Risk factors
- Duration of mechanical ventilation (longer intubation)
- Prolonged hospitalization before mechanical ventilation
- Smoking- impaired clearance
- COPD- impaired clearance

Risk factors
- Age (extremes)
- Coma, neurosurgery, head trauma
- Steroids- immunosuppression
- Gross aspiration
- Prior antibiotics- resistant strains

Ventilator circuitry and VAP
- Frequent circuit changes do not reduce risk for VAP
- Humidification type does not affect risk for VAP.
- Closed suction does not reduce risk of VAP- does it increase it???
- Contaminated nebulizers increase risk of VAP
- Manual resuscitators, tracheostomy collars, t-pieces

Endotracheal tubes and VAP
- Rather than VAP, it should be called, 'ETT associated pneumonia.'
  - lower airways contaminated with oral secretions during intubation
  - leakage of oral, gastric secretions around tube cuff

Endotracheal tubes and VAP
- Biofilm on lumen
  - results in re-inoculation with pathogen
  - instilled NSS for suctioning may increase re-inoculation??
Causative organisms
- Often, a polymicrobial infection
- *Pseudomonas aeruginosa* (24%)
- *Staphylococcus aureus* (20%)
- *Enterobacteriae* (14%)
- *Hemophilus influenza* (10%)

Causative organisms
- *Pseudomonas aeruginosa* (24%)
- *Staphylococcus aureus* (20%)
- *Enterobacteriae* (14%)
- *Hemophilus influenza* (10%)
- *Streptococcus species* (8%)
- *Acinetobacter* (8%)
- *Streptococcus pneumoniae* (4%)
- *Enterobacter* (3%)
- Other (4%)

Causative organisms
- Early onset (4-7 D post-intubation)
  - *hemophilus species*
  - *streptococci*
  - *staphylococci*
  - *enterobacter*

Causative organisms
- Late onset (>7 D post-intubation)
- multiple drug-resistant pathogens
  - *pseudomonas*
  - *methicillin-resistant staphylococcus aureus* (MRSA)

FYI - Click for information on MRSA T-shirt (humor)
http://www.youtube.com/watch?v=ToYG92jUSas&feature=player_embedded

VAP Diagnosis
- Diagnosis is difficult- no gold standard
- May be helpful:
  - clinical criteria
  - sputum cultures, gram stains
  - cytologic data- inflammatory cells
  - C-protein
VAP Diagnosis
- Not helpful
  ◆ blood cultures
  ◆ procalcitonin levels

Clinical pulmonary infection score
- Each assessment scored 0-2 points
  ◆ Assessments
    ▶ fever
    ▶ leukocyte count
    ▶ purulence of secretions
    ▶ oxygenation (PaO2/FIO2)
    ▶ radiographic abnormality
    ▶ sputum culture and gram stain

FYI - Download article on clinical pulmonary infection score
http://ajrccm.atsjournals.org/cgi/content/full/168/2/173

Bacteriologic assessment
- Qualitative tracheal aspirates
  ◆ faster diagnosis
  ◆ greater sensitivity than BAL
  ◆ earlier treatment

Bacteriologic assessment
- Quantitative diagnosis (bronchoscopic technique)
  ◆ advantages
    ▶ select specific area of CXR infiltrates (VAP frequently RLL)
    ▶ may be more effective
    ▶ may reduce unnecessary antibiotics

Bacteriologic assessment
- Quantitative diagnosis (bronchoscopic technique)
  ◆ disadvantages
    ▶ invasive
    ▶ expense

Final diagnosis
- Clinical assessment to decide when to initiate treatment
- Qualitative tracheal aspirates to select antibiotics
VAP Management

Antibiotic Therapy

Issues with VAP
- Lung tissue concentrations vary—does drug reach the microbe?
- Local lung conditions reduce effectiveness of some drugs
- ETT biofilm organisms are not exposed to systemic antibiotics

Early onset, nonresistant strains
- Ceftriaxone (Rocef)
- Ciprofloxin (Cipro)
- Levofloxin (Levaquin)
- Ampicillin
- Ertapenem (Invanz)

De-escalation strategy
- Endorsed by American Thoracic Society (ATS)
- Start with aggressive broad-spectrum regimen
- Narrow the spectrum as data on susceptibility are available

Late onset, resistant strains—combinations may be indicated:
- Cefipime (Maxipime)
- Imipenem (Primaxim)
- Piperacillin
- Ciprofloxin
- Levofloxin
- Vancomycin- MRSA
- Linezolid (Zyvox)- MRSA
Antibiotic Therapy

- Late onset, resistant strains - combinations of these may be indicated:
  - Vancomycin - MRSA
  - Linezolid (Zyvox) - MRSA

Airway delivery

- Some benefits
- Not recommended for routine use

Specific agents for resistant strains:
- Aerosolized colistin - pseudomonas
- Aerosolized gentamicin, tobramycin
- Aerosolized amikacin
- Instilled tobramycin

VAP Prevention

Environmental Sources

- Reusable ventilator probes and sensors
- Ventilator circuits, humidifiers
- Nebulizers
- Manual resuscitators
- Bronchoscopes - pseudomonas
- Hands, fingernails, stethoscopes - MRSA, etc.

Preventative measures

- Adequate staffing - caregivers pressed for time are less likely to adhere to infection control guidelines

Environmental Sources

- Infected patients
- Infected caregivers
- Ice and water - pseudomonas, legionella
- Ambient air - fungi, TB, SARS
Preventative measures

Mouth care
- reduce colonization of oropharynx
- chlorhexidine mouth-swabbing appears to reduce VAP

FYI - Download article on chlorhexidine and VAP
http://ajcc.aacnjournals.org/cgi/reprint/18/5/428

Preventative measures

Caregiver interface
- alcohol-based hand rubs
- routine gloving between patients
- dedicated equipment-stethoscopes
- patient isolation - often done too late

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http://ajcc.aacnjournals.org/cgi/reprint/18/5/428

Tracheal tubes

Agento™ silver-coated endotracheal tube

FYI - Link to image of Agento endotracheal tube
http://www.itnonline.com/sites/default/files/imagecache/node_image/photo_article/21759_1.jpg

Tracheal tubes

Hi-Lo Evac™ tube

Reprinted by permission from Nellcor Puritan Bennett LLC Boulder, CO, part of Covidian

Preventative Interventions

ETT cuff pressures
- 25-30 cm H2O to prevent aspiration
- avoid MLT, which permits aspiration
- Early tracheotomy - not supported by research
- Noninvasive ventilation - decreased VAP risk, because there is no intubation.
- Ventilator weaning protocols-

Preventative Interventions

Metered-dose inhalers, instead of nebulizers for aerosolized drugs
- Resuscitators, etc.
- store in clean containers
- discard when contaminated

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Preventative Interventions

- Prophylactic antibiotics
  - Aerosolized antibiotics prevent VAP in intubated patients with tracheobronchitis
  - Routine use is not supported by research
  - Excess antibiotics increase VAP risk
- Rotational beds - not supported by research

VAP Bundle

- Series of interventions related to ventilator care to reduce VAP
- Key components:
  - Elevate head of the bed
  - Daily "sedation vacations" to expedite extubation
  - Peptic ulcer disease prophylaxis
  - Deep venous thrombosis prophylaxis

FYI - Link to Institute for Healthcare Improvement
http://www.ihi.org/IHI/

Summary & Review

- VAP epidemiology and costs
- Etiologies & pathogenesis
  - Compromised defenses
  - Causative factors
  - Risk factors
  - Ventilator circuitry
  - Endotracheal tubes
  - Causative microorganisms

Summary & Review

- VAP diagnosis
  - Clinical diagnosis
  - Qualitative tracheal aspirates
  - Bronchoscopic, quantitative technique
- VAP management
  - Early onset
  - Late onset

Summary & Review

- VAP prevention
  - Environmental sources
  - Preventative measures
    - Mouth care
    - Caregiver interface interventions
    - ETT care
  - VAP Bundle

References

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