

Ventilator-Associated Pneumonia

Arthur Jones, EdD, RRT

<http://www.geocities.com/jonesapjr/index.html>

Learning objective

- ^ Describe current information on the epidemiology, pathogenesis 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

Link to CDC website on VAP
http://www.cdc.gov/ncidod/dhqp/dpac_ventilate.html

VAP Epidemiology

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

VAP Epidemiology

- ^ So what?
 - ◆ Federal government had decided that VAP is a result of error and would not pay.
 - ◆ This decision has been reversed

VAP Etiologies & Pathogenesis

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???

Ventilator circuitry and VAP

- ▲ 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)

Click for information on MRSA T-shirt
<http://www.youtube.com/watch?v=ToYG92jUSas>

VAP Diagnosis

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**
 - f* **fever**
 - f* **leukocyte count**
 - f* **purulence of secretions**
 - f* **oxygenation (PaO₂/FIO₂)**
 - f* **radiographic abnormality**
 - f* **sputum culture and gram stain**

Link to 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**
 - f* **select specific area of CXR infiltrates (VAP frequently RLL)**
 - f* **may be more effective**
 - f* **may reduce unnecessary antibiotics**

Bacteriologic assessment

- △ **Quantitative diagnosis (bronchoscopic technique)**
 - ◆ **disadvantages**
 - f* **invasive**
 - f* **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

Antibiotic Therapy

- ▲ Issues with VAP
 - ◆ Organisms that cause VAP are becoming more drug-resistant
 - f*MRSA
 - f*Klebsiella
 - f*Pseudomonas

Antibiotic Therapy

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

Antibiotic Therapy

- ▲ Early onset, nonresistant strains
 - ◆ Ceftriaxone (Rocef)
 - ◆ Ciproflaxin (Cipro)
 - ◆ Levofloxacin (Levaquin)
 - ◆ Ampicillin
 - ◆ Ertapenem (Invanz)

Antibiotic Therapy

^ Late onset, resistant strains- combinations may be indicated:

- ◆ Cefipime (Maxipime)
- ◆ Imipenem (Primaxim)
- ◆ Piperacillin
- ◆ Ciproflaxin
- ◆ Levoflaxin
- ◆ Vancomycin- MRSA
- ◆ Linezolid (Zyvox)- MRSA

Antibiotic Therapy

^ Late onset, resistant strains- combinations of these may be indicated:

- ◆ Vancomycin - MRSA
- ◆ Linezolid (Zyvox)- MRSA

Antibiotic Therapy

^ Airway delivery

- ◆ evidence
 - f* some benefits
 - f* not recommended for routine use

Antibiotic Therapy

^ Airway delivery

- ◆ evidence
 - f* some benefits
 - f* not recommended for routine use
- ◆ specific agents- for resistant strains
 - f* aerosolized colistin- pseudomonas
 - f* aerosolized gentamycin, tobramycin
 - f* aerosolized amikacin
 - f* instilled tobramycin

VAP Prevention**Environmental Sources**

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

Environmental Sources

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

Preventative measures

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

Preventative measures

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

Link to article on chlorhexidine and VAP
http://www.eurekalert.org/pub_releases/2006-06/ats-rov061306.php

Preventative measures

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

Tracheal tubes

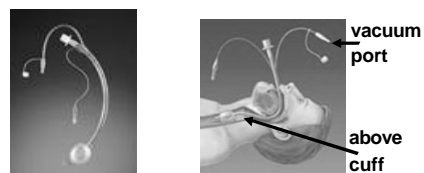
- ▲ Agento™ silver-coated endotracheal tube



Link to Agento endotracheal tube
<http://www.bardmedical.com/products/loadProduct.aspx?prodID=391>

Tracheal tubes

- ▲ Hi-Lo Evac™ tube



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

Link to Hi-Lo Evac tube
<http://www.nellcor.com/prod/Product.aspx?S1=AIR&S2=ETT&id=16>

Preventative Interventions

- ^ ETT cuff pressures
 - ◆ 25-30 cm H₂O to prevent aspiration
 - ◆ avoid MLT, which permits aspiration

Preventative Interventions

- ^ Early tracheotomy- not supported by research
- ^ Noninvasive ventilation- decreased VAP risk, because there is no intubation.

Preventative Interventions

- ^ Ventilator weaning protocols - earlier extubation
- ^ Metered-dose inhalers, instead of nebulizers for aerosolized drugs
- ^ Resuscitators, etc.
 - ◆ store in clean containers
 - ◆ discard when contaminated

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

Link to Institute for Healthcare Improvement
<http://www.ihl.org/IHI/>

END

References

- ◆ Ventilator-associated Conference proceedings I. *Respir Care* 2005;50:714-838.
- ◆ Ventilator-associated conference proceedings II. *Respir Care* 2005;50:892-983.
- ◆ Craven DE. Preventing ventilator-associated pneumonia in adults: Sowing seeds of change. *Chest* 2006;130:251-260.
- ◆ Mayhall CG. Ventilator associated pneumonia or not? Contemporary diagnosis. *Emerging infectious disease* 2001;7:200-204
- ◆ Chastre J, Fagon J. Ventilator-associated pneumonia. *Am J Respir Crit Care Med.* 2002;165:867-903.
- ◆ Rea-Neto A, et al. Diagnosis of ventilator-associated pneumonia: a systematic review of the literature. *Crit Care.* 2008 Apr 21;12(2):R56.

References

- ◆ Kaynar AM et al. Attitudes of respiratory therapists and nurses about measure to prevent ventilator-associated pneumonia: A multicenter cross-sectional survey study. *Respir Care* 2007;52:1687-1694.
- ◆ Sud S, Sud M, Friedrich JO, Adhikari NK. Effect of mechanical ventilation in the prone position on clinical outcomes in patients with acute hypoxemic respiratory failure: a systematic review and meta-analysis. *CMAJ.* 2008 Apr 22;178(9):1153-61.
- ◆ Siempos II, Vardakas KZ, Kopterides P, Falagas ME. Impact of passive humidification on clinical outcomes of mechanically ventilated patients: A meta-analysis of randomized controlled trials. *Crit Care Med.* 2007 Oct. 16.

References

- ◆ Siempos II, Vardakas KZ, Falagas ME. Closed tracheal suction systems for prevention of ventilator-associated pneumonia. *Br J Anaesth.* 2008 Mar;100(3):299-306. Epub 2008 Feb 4.
- ◆ Papadimos TJ, Hensley SJ, Duggan JM, Khuder SA, Borst MJ, Fath JJ, Oakes LR, Buchman D. Implementation of the "FASTHUG" concept decreases the incidence of ventilator-associated pneumonia in a surgical intensive care unit. *Patient Saf Surg.* 2008 Feb 12;2:3.
- ◆ Parker LB, et al. Aerosolized antibiotics and ventilator-associated tracheobronchitis in the intensive care unit. *Crit Care Med.* 2008 Jul;36(7):2008-13.

References

- ◆ Kollef MH, et al. Silver-coated endotracheal tubes and incidence of ventilator-associated pneumonia: the NASCENT randomized trial. *JAMA.* 2008 Aug 20;300(7):805-13.
- ◆ Bouza E, Pérez MJ, Muñoz P, Rincón C, Barrio JM, Hortal J. Continuous aspiration of subglottic secretions in the prevention of ventilator-associated pneumonia in the postoperative period of major heart surgery. *Chest.* 2008 Nov;134(5):938-46. Epub 2008 Jul 18.
- ◆ Caruso, P, Denari S, Ruiz S, Demarzo SE, Deheinzeln D. Saline instillation before tracheal suctioning decreases the incidence of ventilator-associated pneumonia. *Critical Care Medicine.* 37(1):32-38, January 2009.