Prevention of Ventilator-Associated Pneumonia
Robert Garcia, MMT(ASCP), CIC
Infection Control Professional

1. National Quality Issues
- Agency for Healthcare Research & Quality (AHRQ)
  - Issued review of 73 patient care practices; addressed CRBSI prevention
- Institute of Medicine’s (IOM) 1999 “To Err is Human: Building A Safer Health System”
  - Indicated that up to 98,000 Americans die each year as a result of medical errors
- The National Quality Forum

2. Regulatory Issues
- Joint Commission on Accreditation of Healthcare Organizations (JCAHO)
  - 2004 Standard: IC.1.10 “The organization uses a coordinated process to reduce the risks of nosocomial infections in patients and health care workers ...

The Practice Arena of Interventional Epidemiologists
Clinical
Financial
Customer Satisfaction

3. Global Infection Control Issues
Let’s Talk Prevention of Ventilator-Associated Pneumonia

VAP Facts
- Mechanical ventilation increases risk of pneumonia 6-21 times (1% per day)
- Attributable mortality is 27% and increases to 43% when etiologic agent is *P. aeruginosa* or *Acinetobacter* sp.
- LOS with VAP is 34 days and 21 days without VAP

High Risk, High Morbidity

VAP Facts
- Mechanical ventilation increases risk of pneumonia 6-21 times (1% per day)
- Attributable mortality is 27% and increases to 43% when etiologic agent is *P. aeruginosa* or *Acinetobacter* sp.
- LOS with VAP is 34 days and 21 days without VAP

Hospital-Onset Infection Rates in NNIS Intensive Care Units, 1990-1999

<table>
<thead>
<tr>
<th>Type of ICU</th>
<th>BSI*</th>
<th>VAP*</th>
<th>UTI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary</td>
<td>43%</td>
<td>42%</td>
<td>40%</td>
</tr>
<tr>
<td>Medical</td>
<td>44%</td>
<td>56%</td>
<td>46%</td>
</tr>
<tr>
<td>Surgical</td>
<td>31%</td>
<td>38%</td>
<td>30%</td>
</tr>
<tr>
<td>Pediatric</td>
<td>32%</td>
<td>26%</td>
<td>59%</td>
</tr>
</tbody>
</table>

* BSI = central line-associated bloodstream infection rate
VAP = ventilator-associated pneumonia rate
UTI = catheter-associated urinary tract infection rate

Source: National Nosocomial Infections Surveillance (NNIS) System

Prevalence of Antimicrobial-Resistant (R) Pathogens Causing Hospital-Onset Intensive Care Unit Infections: 1999 versus 1994-98

<table>
<thead>
<tr>
<th>Organism</th>
<th># Isolates</th>
<th>% Increase*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoroquinolone-R Pseudomonas spp.</td>
<td>2657</td>
<td>49%</td>
</tr>
<tr>
<td>3rd generation cephalosporin-R <em>E. coli</em></td>
<td>1551</td>
<td>48%</td>
</tr>
<tr>
<td>Methicillin-R <em>Staphylococcus aureus</em></td>
<td>2546</td>
<td>40%</td>
</tr>
<tr>
<td>Vancomycin-R enterococci</td>
<td>4744</td>
<td>40%</td>
</tr>
<tr>
<td>Imipenem-R Pseudomonas spp.</td>
<td>1839</td>
<td>20%</td>
</tr>
</tbody>
</table>

* Percent increase in proportion of pathogens resistant to indicated antimicrobial

Source: National Nosocomial Infections Surveillance (NNIS) System

ICU Rates of VAP, NNIS Study, Jan 2002-Jun 2004

| Pooled means: Medical – 4.9 Med-Surg – 5.4 Surgical – 9.3 |
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#### Cost of VAP

<table>
<thead>
<tr>
<th>Study/Year</th>
<th>Pts with VAP</th>
<th>Measure</th>
<th>ICU Type</th>
<th>Cost with VAP</th>
<th>Cost without VAP</th>
<th>Cost per VAP Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warren</td>
<td>127</td>
<td>Attribute cost</td>
<td>Med, surg (hospital)</td>
<td>$67,053</td>
<td>$10,033</td>
<td>$11,087</td>
</tr>
<tr>
<td>Rello</td>
<td>842</td>
<td>Charges</td>
<td>Med, surg, trauma</td>
<td>$101,600</td>
<td>$60,169</td>
<td>$23,019</td>
</tr>
<tr>
<td>Cocanour</td>
<td>78</td>
<td>Attribute cost</td>
<td>Trauma</td>
<td>$52,595</td>
<td>$20,537</td>
<td>$17,156</td>
</tr>
</tbody>
</table>

---

#### Cost of VAP (cont’d)

- **Study of 819 adult ICU pts. to determine attributable cost of VAP**
- **Comparison of uninfected vent pts. to vent pts. with VAP**
  - ICU LOS: 26 vs. 4 days
  - Hospital LOS: 38 vs. 13 days
  - Mortality: 50% vs. 34%
  - Costs: $70,568 vs. $21,620
- **Attributable cost of VAP: $11,897**

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#### What strategies have been advocated in preventing VAP?

- Ventilator circuit replacement
- Closed suction catheter replacement
- Heat and moisture exchanger replacement
- Semirecumbent positioning of patients
- Selective digestive decontamination
- Stress ulcer prophylaxis
- Enteral feeding methodologies
- Weaning
- Oral and dental care

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#### Outbreaks & Contaminated Environment

HICPAC Guidelines on Preventing Pneumonia

- Issued 3/26/04
- Evidence-based
- Expert review
- Recommendations categorized

HICPAC Categories

- **Category IA.** Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.
- **Category IB.** Strongly recommended for implementation and supported by certain clinical or epidemiologic studies and by strong theoretical rationale.
- **Category IC.** Required for implementation, as mandated by federal or state regulation or standard.
- **Category II.** Suggested for implementation and supported by suggestive clinical or epidemiologic studies or by strong theoretical rationale.
- **No recommendation; unresolved issue.** Practices for which insufficient evidence or no consensus exists about efficacy.

Ventilator Circuits

- **Humidifier vs. HME technology**
  - HICPAC:
    - Do not change routinely, on the basis of duration of use, the ventilator circuit (i.e., ventilator tubing and exhalation valve, and the attached humidifier) that is in use on an individual patient. Change the circuit when it is visibly soiled or mechanically malfunctioning. Cat IA [same as for HME - Cat II].

Heat & Moisture Exchangers (HME)

- Is filter hydroscopic or hydrophobic?
- HICPAC:
  - No recommendation can be made for the preferential use of either HMEs or heated humidifiers to prevent pneumonia in patients receiving mechanically assisted ventilation. (Unresolved Issue).
  - Change an HME that is in use on a patient when it malfunctions mechanically or becomes visibly soiled. Cat IIC.
  - Do not routinely change more frequently than every 48 hours an HME that is in use on a patient. Cat II.
  - Do not change routinely (in the absence of gross contamination or malfunction) the breathing circuit attached to an HME while it is in use on a patient. Cat II.
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Circuits & HMEs: VAP Outcome

- Study to determine if vent circuits are needed to be changed periodically when an HME is used
- Randomized, controlled trial in 24 adult ICU
- Results:
  - Group 1 (143 pts.; vent circuit changes every 48 hrs.): 1.71/1000 VD
  - Group 2 (161 pts.; no circuit changes): 1.25/1000 VD


Closed Suction Catheters

- Manufacturers: replace at 24 hours
- HICPAC:
  - No recommendation can be made about the frequency of routinely changing the in-line suction catheter of a closed-suction system in use on one patient. (Unresolved issue)

Closed vs. Open Suctioning

- Randomized, controlled study aimed at measuring VAP outcome in pts. using either closed or open suctioning
  - 24 bed med surg ICU; 443 pts.
  - No differences in percentage of patients developing VAP (20.47% vs. 18.02%) or VAP per 1000 vent days (17.59 vs. 15.84)


Closed Suction Catheter Replacement

- Study designed to measure impact of decreasing the frequency of in-line suction catheters changes
- MICU; Before/after observation trial
- Results:
  - VAP rate, daily change: 0.19/100 VD
  - VAP rate, 7 day change: 0/100 VD
  - Annual cost savings: $18,782


New Intervention: Redefining the Ventilator Circuit

- Ventilator circuitry was defined by three separate devices: tubing, HME, in-line suction catheter
- Revised policy to consider circuitry as single closed system; change when soiled, malfunction, patient transport
- Saved >$15,000 per year

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Airway Suctioning
- Subglottic suctioning
  - Yankauers don’t reach
  - Routinely done every 2 hours
  - Before repositioning ETT
  - Special ETT tubes???

Subglottic Secretion Suctioning
- HICPAC:
  - If feasible, use an endotracheal tube with a dorsal lumen above the endotracheal cuff to allow drainage (by continuous or frequent intermittent suctioning) of tracheal secretions that accumulate in the patient’s subglottic area. Cat. II

Effect of Subglottic Suctioning
- Meta-analysis of five studies, 896 pts.
- In pts expected to require >72 hrs. of ventilation, subglottic secretion suctioning shortened:
  - Duration of ventilation by 2 days
  - Length of stay by 3 days
  - Delayed onset of pneumonia by 6.8 days


Semirecumbent Positioning
- HICPAC:
  - In the absence of medical contraindication(s), elevate at an angle of 30°-45° the head of the bed of a patient at high risk for aspiration (e.g., a person receiving mechanically assisted ventilation and/or who has an enteral tube in place) Cat II

How high is 30 degrees?
- A lot higher than you might think
- Look at objective gauges or LCD readouts

Head of Bed
- How high is 30 degrees???
  - A lot higher than you might think
  - Look at objective gauges or LCD readouts

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Can’t make it to 30 degrees?

- Situations when HOB up 30 degrees may not be possible
- Low BP/unstable VS
- Agitated and at risk of falling out of bed
- Compromised circulation due to femoral lines
- Spinal clearance/Spinal cord injury patients
- **MUST** have a physician’s order identifying the degree of elevation allowed
- Use combination of HOB up and reverse Trendelenburg to obtain a 30 degree angle

Stress Ulcer Prophylaxis

- Theory has it that modifying stomach acid effects the bacterial colonization level
- **HICPAC:**
  - No recommendation can be made for the preferential use of sucralfate, H2-antagonists, and/or antacids for stress-bleeding prophylaxis in patients receiving mechanically assisted ventilation. (Unresolved Issue)
  - “...after all of this time and study, it is likely that neither drug has any advantage in significantly maintaining gastric flora and reducing VAP.”

Selective Digestive Decontamination

- Preventive decolonization on the theory that the gut is a major source of VAP
- **HICPAC:**
  - No recommendation can be made for the routine selective decontamination of the digestive tract (SDD) of all critically-ill, mechanically ventilated, or ICU patients. (Unresolved issue)
- 30+ studies to date
  - Eggimann P, Pittet D. Infection control in the ICU. Chest 2001;120:2059-2093:
  - “…this selective pressure on the epidemiology of resistance definitely precludes the systematic use of SDD for critically ill patients”
  - Kollef MH. Selective digestive decontamination should not be routinely employed. Chest 2003;123:464S-48S.

Weaning

- Duration, duration, duration!!!

- Evidence-Based Guidelines for Weaning and Discontinuing Ventilatory Support. A Collective Task Force comprised of members of the American College of Chest Physicians, the American Association for Respiratory Care and the American College of Critical Care Medicine. Chest 2001;120:375S-395S.

Cost of Mechanical Ventilation

- Retrospective, cohort study designed to examine costs associated with mechanical ventilation
- Data from 253 hospitals, 51,009 pts.
- Mean cost with vent = $31,574
- Mean cost without vent = $12,931
- Incremental cost of mech. vent per day = $1,552

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Active Weaning Protocols
- Effect of a protocol-driven vent weaning on outcomes
- Results:
  - Vent use: from 0.47 to 0.33 (VD/ICU days)
  - VAP: 17 in 2000 to 5 in 2002


Multidisciplinary Approaches
- Study conducted in 3 adult ICUs (med surg, neuro, cardiac) in a Level II trauma facility
- Ventilator bundle:
  - Comprehensive oral care protocol
  - HOB
  - Daily sedation holiday
  - Daily assessment of readiness to extubate
- Results:
  - 21/1523 vent days in Q2
  - 3/1734 vent days in Q4 (26% reduction)


(cont’d)
- Study conducted in a Medical ICU and Surgical ICU
- Interventions:
  - Elevated HOB
  - Sterile water and replacement of stopcocks with enteral valves for NG tubes
  - Prolongation of changing closed suction catheters from 24 hours to as needed
- Results:
  - MICU: decrease by 10.8/1000 VD
  - SICU: decrease by 17.2/1000 VD
  - Net cost savings: $349,899


Is there scientific evidence that links oropharyngeal and dental colonization with respiratory illness?


Prevention or Modulation of Oropharyngeal Colonization
- HICPAC:
  - Oropharyngeal cleaning and decontamination with an antiseptic agent: develop and implement a comprehensive oral-hygiene program (that might include the use of an antiseptic agent) for patients in acute-care settings or residents in long-term-care facilities who are at high risk for health-care-associated pneumonia. Cat. II


1. Oral Cavity vs. Gastric Colonization
- Prospective study of 86 mechanically vented ICU patients to assess relationship between oropharyngeal colonization and subsequent occurrence of pneumonia
- Patients oral and gastric specimens were collected on admission and twice weekly
- When pneumonia suspected, bronchoscopic specimens were taken with protected specimen brush
  - In 31 cases of pneumonia identified, DNA genomic analysis demonstrated that oropharyngeal colonization was the predominant factor in the development of pneumonia compared with gastric colonization

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Acquired bacterial colonization: Location of the microorganisms in the 44 carrier patients

<table>
<thead>
<tr>
<th>Colonizing microorganisms</th>
<th>Patients with OC</th>
<th>Patients with GC</th>
<th>Patients with BC</th>
<th>Colonized patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. baumannii</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>K. pneumoniae</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>9</td>
<td>5</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>Pseudomonadaceae</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>S. aureus</td>
<td>17</td>
<td>0</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Enterococcus sp.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>5</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

OC = oropharyngeal colonization; GC = gastric colonization; BC = both OC/GC colonization

Oropharyngeal rather than gastric colonization: further support

2. Decontamination of the Oropharynx
- Prospective, randomized, double-blind study of ICU patients to determine VAP while manipulating oropharyngeal colonization and without influencing gastric or intestinal colonization
- 87 given topical antibiotics (study group), 139 given placebo (control group)
- Results:
  - VAP in study group: 10%
  - VAP in control group: 27%


Additional Studies and Reviews using Antibiotic Pastes or Solutions

3. Oral Decolonization: Use of Chlorhexidine
- Prospective, randomized, double-blind, placebo-controlled trial testing the effectiveness of oral decontamination on nosocomial infection
- 353 pts undergoing coronary bypass surgery
- Used chlorhexidine gluconate (0.12%) as oral rinse to prevent nosocomial infections
- Randomized to receive CHG or placebo
- Results:
  - Overall reduction in nosocomial infections of 65% when using CHG
  - Respiratory infections were reduced 69% in CHG group


4. Link Between Oral Pathogens & Respiratory Infection
- A review article
- 6 articles cited as support for a relationship between poor oral health and respiratory infection
- Bacteria from colonized dental plaque may be aspirated into the lower airway

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5. Dental Plaque as a Bacterial Source of VAP

- Study on dental plaque colonization and ICU nosocomial inf.
- 57 patients studied
- Results:
  - Dental plaque occurred in 40% of pts.
  - Colonization of dental plaque was highly predictive of nosocomial infection
  - Salivary, dental, and tracheal aspirates cultures were closely linked


Additional Evidence Linking Colonized Dental Plaque and Respiratory Infection


A Case Study

Reduction of Microbial Colonization in the Oropharynx and Dental Plaque Reduces VAP

R Garcia, L Jendresky, L Colbert
Brookdale University Medical Center, Brooklyn NY

Abstract presented at the 2004 APIC Education Conference, Phoenix, AZ
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The Brookdale University Medical Center

Prioritization & Action
- Comparison of VAP rates with NNIS data indicated MICU rate above 50th percentile (6.0 cases per 1000 VD)
- Interventions taken prior to 2002 did not have sufficient effect to reduce rate below the benchmark
- ICP conducting VAP surveillance
- Intervational Epidemiology methodology applied: interviews and observations

VAP Reduction Task Force
- Director of Nursing, Critical Care
- Nurse Manager, Critical Care
- Front line nurses
- Medical Director, Critical Care
- Emergency Room physicians
- Respiratory Therapy
- Materials Management
- Infection Control

Assessment
- Interviews of front line workers
- Observation of procedures
- Review of products
- Review of policies
- Review of literature, guidelines
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Identification of Needs
- A uniform education program for nurses and respiratory therapists
- Standards for oral assessment
- Standards for oral care
- Standards for dental care
- Standardization of oral care solutions
- Keeping a closed system CLOSED
- Reduce environmental exposure

Key Strategy #1: Education
- Handout created, includes answers to the following questions:
  - Why is prevention of VAP important?
  - What is hospital's (unit's) current rate?
  - How do you compare with national benchmark?
  - What are major interventions implemented to date?
  - What role does bacterial colonization play in the development of respiratory infection?
  - What new products/techniques will be implemented to address oral bacterial colonization?

Tip: Applicable HICPAC Recommendation
- I. Staff Education and Involvement in Infection Prevention
  - Educate health-care workers about the epidemiology of, and infection-control procedures for, preventing health-care—associated bacterial pneumonia to ensure worker competency according to the worker’s level of responsibility in the health-care setting, and involve the workers in the implementation of interventions to prevent health-care—associated pneumonia by using performance improvement tools and techniques. Cat IA

Key Strategy #2: Reduce Oral and Dental Colonization

Maintaining a Closed System

Covered Yankauer
Policy: Use as needed
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Yankauer
- Proper storage
- Keep Yankauer covered when not in use
- Assists in decreasing the risk of environmental contamination
- Replace every day and PRN

Suction Catheter
Policy: Every 4 hrs. or as needed
*The device manufacturer does not market or approve of its use below the vocal cords

Toothbrush with Sodium Bicarbonate
Policy: 2 X per day

Suction Swab with Moisturizer
Policy: Every 6 hrs.

Feeling fuzzy???
Photographs courtesy of D. Ryan

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VAP Rates, MICU, BUMC, 2001-2004

<table>
<thead>
<tr>
<th>Period</th>
<th># Pts</th>
<th># VAP cases</th>
<th>Vent days</th>
<th>Rate (VAP/1000 VD)</th>
<th>% Pts with VAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 2001-Dec 2002</td>
<td>859</td>
<td>44</td>
<td>5262</td>
<td>8.3</td>
<td>5.1</td>
</tr>
<tr>
<td>Jan 2003-Dec 2004</td>
<td>755</td>
<td>20</td>
<td>5147</td>
<td>3.8</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Cost Avoidance

- Attributable cost of a healthcare acquired pneumonia is estimated to be $40,000 (Rello, Chest, 2002).
- Based on the avoidance of approximately 10 VAP cases per year, BUMC estimates that the annual avoided extra cost to the institution to be

\[10 \times 40,000 \text{ (infection cost)} - [56,606 \text{ (product cost)}] = 343,394.\]

Let's Summarize Interventions

- Perform proper cleaning and maintenance of respiratory care equipment
- If HMEs are used, replace vent circuits as needed
- Elevate HOB when not contraindicated
- Perform comprehensive oropharyngeal care
- Establish active weaning protocols

Cost Avoidance, BUMC Study

<table>
<thead>
<tr>
<th>Study, year</th>
<th>Cost per VAP case</th>
<th>X 12 (avoided cases per yr.)</th>
<th>Product cost per yr.</th>
<th>Cost avoided/yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warren, 2003</td>
<td>$11,897</td>
<td>$142,764</td>
<td>-$56,606</td>
<td>$86,158</td>
</tr>
<tr>
<td>Rello, 2003</td>
<td>$41,294</td>
<td>$495,528</td>
<td>-$56,606</td>
<td>$438,922</td>
</tr>
<tr>
<td>Cocanour, 2005</td>
<td>$57,158</td>
<td>$685,896</td>
<td>-$56,606</td>
<td>$629,290</td>
</tr>
</tbody>
</table>

The speaker gratefully acknowledges the supreme effort of all the critical care nursing staff, the resident staff, and especially Mr. Trevor Grazette, Director of Nursing, Ms. Althea Bailey, Nurse Manager, and Ms. Henrietta Basanez, Nurse Educator.

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Robert Garcia, BS, MMT(ASCP), CIC
Assistant Director of Infection Control
Brookdale University Medical Center
One Brookdale Plaza, Brooklyn NY 11212
718-240-5924
rgarcia@brookdale.edu

2006 Teleclass Schedule

Do you have a topic idea for our 2006 teleclass series? We are open to all suggestions and there’s still time to get them in the 2006 schedule (barely)

Contact Paul Webber
paul@webbertraining.com