Issues in Infection Control

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Objectives

- Discuss some of the science behind infection control (IC) practices
- Discuss the pertinent data supporting the prevention of surgical site infections (SSI)
- Discuss the pertinent data supporting the prevention of central line associated bloodstream infections (CLABSI)
- Discuss the epidemiology, clinical syndromes, treatment and preventative strategies associated with Ventilator Associate Pneumonia (VAP)
Defining a New Category of Infection: Healthcare-Associated (HCA) Infections

Guideline Definitions (Pneumonia)

• **Community-acquired (CA) pneumonia**\(^1\)
  - Pneumonia in patient not hospitalized or residing in a long-term-care facility for \(\geq 14\) days before onset of symptoms

• **Healthcare-associated (HCA) pneumonia**\(^2\)
  - Patients who were hospitalized in an acute care hospital for \(\geq 2\) days within previous 90 days
  - Patients who reside in a nursing home or long-term-care facility
  - Patient who received recent intravenous antibiotic therapy, chemotherapy or wound care within previous 30 days
  - Patients who attended a hospital or hemodialysis clinic

• **Hospital-acquired (HA) pneumonia**\(^2\)
  - Occurs \(\geq 48\) hours after admission, not incubating at the time of admission

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Impact of Health Care Associated (HCA) Infections

Recent studies have established that HCA infections are associated with increased risk of mortality compared to CA infections¹,²


* P < .0001 vs CA infection.  
* P < .01 vs CA infection.
Healthcare Associated Infection (HAI) Legislation

- 26 US states have passed HAI related legislation.

- The Deficit Reduction Act of 2005
  - Major change in federal (Medicare) law which went into effect October 1, 2008.
  - Hospitals will **NOT get paid by CMS** (Centers for Medicare and Medicaid services) for 11 conditions or events which were not “Present On Admission” (POA)

- Front line staff – especially nurses and physicians-now have an active role in this major reimbursement change for hospitals.
The: “No Pay” (“No Way”) Events

1. Objects left during surgery (retained foreign objects)
2. Air embolism
3. Blood incompatibility
4. Catheter associated urinary tract infections (CA-UTIs)
5. Pressure ulcers
6. Vascular catheter-associated infections
7. Surgical site infections after coronary artery bypass graft (CABG) surgery
8. Falls and Trauma – Fractures, dislocations, intracranial injuries, crushing injuries, and burns
9. Surgical site infections following certain elective procedures, including certain orthopedic surgeries, and bariatric surgery for obesity
10. Certain manifestations of poor control of blood sugar levels
11. Deep vein thrombosis or pulmonary embolism following total knee replacement and hip replacement procedures
Implications of “the 11” for Patients

- Longer hospitalization
- Longer recovery – or no recovery at all
- Pain, scars, disability, fear of recurrence
- Contagious illness, such as infection
- Complications from treatment of these conditions or errors
- Eventual higher cost of care to the patient
- More cost and burden of care for family
Few New Antibiotics Approved


Of 89 drugs approved in 2002, none was an antimicrobial

"The patient in the next bed is highly infectious. Thank God for these curtains."
Hand Hygiene Works!

Hand contamination after patient contact (A) and after washing with an alcohol based sanitizer (B)  

NEJM. 2009
Alcohol is more effective than plain soap and water

- Alcohol based hand sanitizers
  - $5 \log_{10}$ reduction in bacteria after 15 s application
- Soap and water
  - 0.6-1.1 $\log_{10}$ after 15 s application
- More effective at reducing MDROs from hands than soap and water
- Potential for added emollients = comfort
- DOES NOT have activity against spores
  - e.g. *Clostridium difficile*, *Bacillus anthracus*, etc.
Microorganisms Survive on Surfaces

- **Acinetobacter** 3 days – 5 months
- **C. difficile** 5 months
- **E. coli** 1.5 hrs – 16 months
- **Enterococcus sp.** 5 days - 4 months
- **Pseudomonas** 6 hrs – 16 months
- **S. aureus** 7 days – 7 months
- **Influenza** 1- 2 days

Contamination of Gowns, Gloves, and Stethoscopes with VRE During Routine Patient Examination (n=49)

- Wiping the stethoscope with alcohol decreased the contamination rate to only 2%

Zachary Infect Control Hosp Epidemiol 2001 Sep;22(9):560-4
Glove Contamination Occurs Regardless of Patient Contact (n=38)

Boyce ICHE 1997 18:622
Environmental Contamination and Risk of VRE Acquisition

- 14 month study in 2 ICUs
- Weekly environmental & twice weekly patient surveillance cultures obtained
- 1330 patients admitted to the 2 study ICUs
  - 9% were colonized with VRE on admission
  - 8% acquired VRE during stay
- Multivariate analysis suggests that environmental contamination was greatest risk factor for acquisition

Surgical Site Infections (SSI)

~300,000 SSIs/yr (17% of all HAI)
- 2%-5% of patients undergoing inpatient surgery

3 % mortality
- 2-11 times higher risk of death
- 75% of deaths among patients with SSI are directly attributable to SSI

Morbidity
- long-term disabilities

Anderson DJ, et al. ICHE. 2008;29:S51-S61
Surgical Site Infections (SSI)

- Length of Hospital Stay
  - ~7-10 additional postoperative hospital days

- Cost
  - $3000-$29,000/SSI depending on procedure & pathogen
  - Up to $10 billion annually
  - Most estimates are based on inpatient costs at time of index operation and do not account for the additional costs of rehospitalization, post-discharge outpatient expenses, and long term disabilities

Anderson DJ, et al. ICHE. 2008;29:S51-S61
SSI Prevention Strategies

- Surgical site preparation with hair removal and antisepsis
- Antibiotic prophylaxis within 1 hour prior to surgical excision and discontinuation within 24 hours after surgery
- Tight control of post-operative blood sugars in patients with DM
- Good infection control practices and proper wound care
The Goals of Antibacterial Prophylaxis

- To provide optimal coverage by targeting suspected micro-organisms and minimising the development of resistance
- To reduce the incidence of post-operative SSIs
- To reduce morbidity associated with SSIs
- To reduce mortality due to SSIs developing into systemic illnesses
- To avoid prolonged hospital stay

Time of Administration of Surgical Prophylaxis Related to Time of Incision

Effects of Prolonged Antibiotic Prophylaxis
Among Surgical ICU Patients

- 250 trauma patients in a surgical ICU treated with:
  - 1 antibiotic for 24 hours (SHORT group, n=133)
  - 1 or more antibiotics for >24 hours (LONG group, n=117)

- LONG group experienced higher incidence of resistant infections (50% vs 35%, P=0.02)

- Patients with resistant infections:
  - longer hospital stay (33±18d vs 15±11d, P<0.001)
  - higher mortality (13% vs 1%, P<0.001)

- Prolonged prophylaxis with multiple antibiotics was an independent risk factor for resistance (OR = 2.13)

Velmahos GC et al. Arch Surg 2002; 137: 537-541
Detecting and Isolating the Reservoirs: What About the Colonized Patients?

Infected Patients

Undetected Colonized Reservoir
UCH - MRSA Data

MRSA as Percentage of Total *Staphylococcal aureus* Isolates

Year | Total # S. aureus Isolates | % MRSA of Total S. aureus Isolates
--- | --- | ---
1998 | 340 | 16%
1999 | 400 | 16%
2000 | 464 | 28%
2001 | 516 | 30%
2002 | 508 | 28%
2003 | 592 | 31%
2004 | 620 | 34%
2005 | 741 | 36%
2006 | 770 | 41%
2007 | 727 | 37%
2008 | 733 | 42%
2009 | 830 | 33%

0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100%
MRSA Screening in ICU Patients

- Retrospective study SICU pts with MRSA infection in hospital with universal screening for MRSA on admission#
  - Sensitivity of nasal swab detection of MRSA was 69.5%
  - Sensitivity improved to 79% if done within 6 days prior to onset of infection
  - 30% of MRSA infections were not preceded by nasal colonization

- Prospective, interventional cohort study (n=10,193)*
  - Rapid screening on admission + IC measures vs standard IC measures alone
  - Rate of MRSA SSI and nosocomial MRSA acquisition did not decrease in the rapid screening group

Prevention of SSI in Carriers of S. aureus

- Randomized, double-blind, placebo controlled trial
  - 4030 patients enrolled; 3864 included in the ITT analysis
  - Randomized 1:1 to nasal mupirocin ointment vs placebo
- S. aureus nasal carriage was eliminated in 83.4% of pts in nasal mupirocin group vs 27.4% in placebo group (p<0.001)
- Post-operatively, 5.9% of placebo group had S. aureus nasal carriage vs. 1% of mupirocin group (p<0.001)
- SSI rate between mupirocin and placebo groups was 7.9% and 8.5% respectively
- However, mupirocin significantly decreased the rate of nosocomial infections due to S. aureus in carriers

Prevention of SSI in Carriers of S. aureus

Randomized, double-blind, controlled trial
- 6771 patients screened for S. aureus, 1251 positive for colonization and 917 patients enrolled
- Randomized 1:1 to nasal mupirocin ointment and CHG soap (M-CHG) vs placebo ointment and soap
- 808 pts (88.1%) underwent surgical procedure
- Followed for 6 weeks after discharge

S. aureus infection developed in 3.4% of the M-CHG pts vs. 7.7% for placebo

Deep SSIs less in M-CHG group (0.9%) vs the placebo group (4.4%)

Mean duration 12.2 days in M-CHG group vs 14.0 days in placebo group

No difference in all-cause mortality

Cumulative Hazard of Hospital-Acquired S. aureus Infection

Intervention Program to Reduce MRSA SSIs after CT Surgery

- Intervention included:
  - All CT staff were screened for MRSA nasal carriage and decolonized if identified
  - All pts screened for MRSA 1-3 days prior to surgery and vancomycin given for prophylaxis if positive
  - Nasal mupirocin given to all patients regardless of colonization status
  - All pts rescreened for MRSA on discharge
  - Chest tube sites covered with sterile gauze coated with mupirocin upon removal

- Baseline MRSA SSI rate of 1.6% decreased to 0.08% after intervention (93% reduction; p<0.001)
- Overall SSI rate decreased form 2.1% to 0.8% (p<0.001)

Central Line-Associated Bloodstream Infection (CLABSI) is a primary bloodstream infection (BSI) in a patient that had a central line within the 48-hour period before the development of the BSI.

If the BSI develops in a patient within 48 hours of discharge from a location, indicate the discharging location on the infection report.
How did we get here?

The data tells the clearest story

- 15 million catheter days/year in US ICUs
- CLABSI Rate - 5.3/1000 catheter days
  - 80,000 CLABSIs in ICUs
- 250,000 cases of CLABSI occur annually for entire hospitals
- Attributable mortality: 12-25%
- Attributable cost per infection: $34,508-$56,000
- Annual cost to Health care system: $296 million - $2.3 billion

## CLABSI: Risk Factors

<table>
<thead>
<tr>
<th>Host Factors</th>
<th>Practice Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Extreme of age</td>
<td>➢ Multiple lumens</td>
</tr>
<tr>
<td>➢ Severe Illness</td>
<td>➢ Catheter type</td>
</tr>
<tr>
<td>➢ Malnutrition</td>
<td>➢ Duration of catheterization</td>
</tr>
<tr>
<td>➢ Loss of skin integrity (Burn)</td>
<td>➢ Insertion technique</td>
</tr>
<tr>
<td>➢ Immunosuppression</td>
<td>➢ Insertion Location</td>
</tr>
<tr>
<td>➢ Infection at other site</td>
<td>➢ Guide wire exchanges</td>
</tr>
<tr>
<td></td>
<td><strong>Colonization</strong></td>
</tr>
<tr>
<td></td>
<td>➢ Catheter insertion site</td>
</tr>
<tr>
<td></td>
<td>➢ Catheter hub</td>
</tr>
</tbody>
</table>
Microbiology – CLABSI: NNIS

1986-1989 (%)
- Coagulase-negative Staphylococcus: 27%
- S. aureus: 16%
- Enterococcus: 8%
- E. coli: 19%
- Gram-negative rods: 6%
- Enterobacter: 5%
- P. aeruginosa: 4%
- K. pneumonia: 4%
- Candida spp: 8%

1992-1999 (%)
- Coagulase-negative Staphylococcus: 37%
- S. aureus: 13%
- Enterococcus: 13%
- E. coli: 14%
- Gram-negative rods: 25%
- Enterobacter: 43%
- P. aeruginosa: 8%
- K. pneumonia: 4%
- Candida spp: 8%
Sources of Infection

All sources of infection are potential targets for prevention.

Critically ill patient: 2-4 vascular access devices

Jarvis WR, CRBSI: Prevention is Primary, April 24, 2006
Existing Best Practices

The NEW ENGLAND JOURNAL of MEDICINE

Established in 1812
December 28, 2006
Vol. 355
No. 26

An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU

Peter Pronovost, M.D., Ph.D., Dale Needham, M.D., Ph.D., Sean Hailao Chu, M.D., Ph.D., Sara Cosgrove, M.D., Bryan Sexton, Gary Roth, M.D., Joseph Bander, M.D., John Kepros, M.D.

Central Line Bundle

100K Lives Campaign

Using Real-Time Problem Solving to Eliminate Central Line Infections

Richard P. Shannon, M.D.
Diane Finkiel, M.B.A., P.A.-C.
Nadia Guedes
Jon C. Lloyd, M.D.
Cheryl Herbert, R.N.
Sharon Rent, R.N.
Daniel Carr
Alexander H. Star
Paul H. O'Donnell
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The 100,000 Lives Campaign: A Scientific and Policy Review

Institute for Healthcare Improvement

Robert M. Wachter, M.D.
Peter Pronovost, M.D., Ph.D.

Morbidity and Mortality Weekly Report

Guidelines for the Prevention of Intravascular Catheter-Related Infections

August 9, 2002
Vol. 51
No. RR-10

100K Lives Campaign

Hann Associates, Goodman Media
(202) 576-2700 ext. 2244

IH ANNOUNCES THAT HOSPITALS PARTICIPATING IN 100,000 LIVES CAMPAIGN HAVE SAVED AN ESTIMATED 122,300 LIVES
Evidence-Based Measures - Central Line Bundle

Implemented on Dec 14th 2004 by Institute of Healthcare Improvement (IHI) through 100K Lives Campaign

...is a group of interventions related to patients with intravascular central catheters that, when implemented together, result in better outcomes than when implemented individually.
Elements of Central Line Bundle

- Hand Hygiene
- Chlorhexidine Skin Prep
- Maximal Barrier Precautions
- Optimal Site Selection – Use of Subclavian Vein and avoidance of Femoral Vein if possible
- Daily Review of Line Necessity
Since 1977, 7 prospective studies have shown that improvement in hand hygiene significantly decreases a variety of infectious complications.

### Table 1: Quasi-experimental, sequential hospital-based studies of the effect of hand hygiene on risk of infection.

<table>
<thead>
<tr>
<th>Ref.</th>
<th>Year</th>
<th>Author(s)</th>
<th>Hospital setting</th>
<th>Significant results</th>
</tr>
</thead>
<tbody>
<tr>
<td>[36]</td>
<td>1977</td>
<td>Caswell and Phillips</td>
<td>Adult critical care (UK)</td>
<td>Reduced rates of nosocomial infection due to endemic Klebsiella specis</td>
</tr>
<tr>
<td>[37]</td>
<td>1982</td>
<td>Maki</td>
<td>Adult critical care</td>
<td>Reduced rates of nosocomial infection</td>
</tr>
<tr>
<td>[38]</td>
<td>1984</td>
<td>Massanari and Hierholzer</td>
<td>Adult critical care</td>
<td>Reduced rates of nosocomial infection for some units</td>
</tr>
<tr>
<td>[23]</td>
<td>1990</td>
<td>Simmons et al.</td>
<td>Adult critical care</td>
<td>No effect</td>
</tr>
<tr>
<td>[40]</td>
<td>1994</td>
<td>Webster et al.</td>
<td>Neonatal intensive care</td>
<td>Elimination of methicillin-resistant Staphylococcus aureus</td>
</tr>
<tr>
<td>[41]</td>
<td>1995</td>
<td>Zafar et al.</td>
<td>Newborn nursery</td>
<td>Elimination of methicillin-resistant S. aureus</td>
</tr>
</tbody>
</table>

### Table 2: Significant characteristics of hand hygiene products

<table>
<thead>
<tr>
<th>Option</th>
<th>Antimicrobial activity</th>
<th>Sustained activity</th>
<th>Resistance to emerge</th>
<th>Microbial shedding of skin squames</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-antimicrobial soaps and detergents</td>
<td>Minimal</td>
<td>None</td>
<td>None</td>
<td>Maximal</td>
</tr>
<tr>
<td>Antimicrobial products*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermittent use only</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Continuous general use</td>
<td>Maximal</td>
<td>Maximal</td>
<td>Maximal</td>
<td>Maximal</td>
</tr>
<tr>
<td>Alcohol based products, intermittent use for degerming</td>
<td>Maximal</td>
<td>None</td>
<td>None</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

* Products containing antiseptic ingredients such as triclosan, hexachlorophene, chlorhexidine gluconate
Chlorhexidine Gluconate vs Povidone Iodine

<table>
<thead>
<tr>
<th>Study (Reference), Year</th>
<th>Risk Ratio (95% CI)</th>
<th>Catheters, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maki et al. (7), 1991</td>
<td>0.18 (0.02–1.46)</td>
<td>441</td>
</tr>
<tr>
<td>Sheehan et al. (9), 1993</td>
<td>1.05 (0.07–16.61)</td>
<td>346</td>
</tr>
<tr>
<td>Meffre et al. (10), 1995</td>
<td>0.97 (0.20–4.77)</td>
<td>1117</td>
</tr>
<tr>
<td>Mimoz et al. (11), 1996</td>
<td>0.64 (0.15–2.81)</td>
<td>315</td>
</tr>
<tr>
<td>Legras et al. (12), 1997</td>
<td>0.13 (0.01–2.45)</td>
<td>457</td>
</tr>
<tr>
<td>Humar et al. (14), 2000</td>
<td>0.75 (0.20–2.75)</td>
<td>374</td>
</tr>
<tr>
<td>Knasinski and Maki, 2000*</td>
<td>0.36 (0.14–0.95)</td>
<td>849</td>
</tr>
<tr>
<td>Overall (95% CI)</td>
<td>0.49 (0.28–0.88)</td>
<td>3899</td>
</tr>
</tbody>
</table>
Maximal Barrier Precautions

For the Provider:

- Hand hygiene
- Non-sterile cap and mask
  - All hair should be under cap
  - Mask should cover nose and mouth tightly
- Sterile gown and gloves

For the Patient:

- Cover patient’s head and body with a large sterile drape
# Catheter Site Selection

## RCT- Jugular vs Subclavian Approach

<table>
<thead>
<tr>
<th>Study</th>
<th>Jugular n/N</th>
<th>Subclavian n/N</th>
<th>RR (95%CI Random)</th>
<th>Weight %</th>
<th>RR (95%CI Random)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lehr</td>
<td>11 / 152</td>
<td>13 / 272</td>
<td>1.51 [0.70, 3.30]</td>
<td>46.1</td>
<td>1.51 [0.70, 3.30]</td>
</tr>
<tr>
<td>Poisson</td>
<td>10 / 75</td>
<td>1 / 107</td>
<td>23.2 [1.84, 107.58]</td>
<td>23.2</td>
<td>23.2 [1.84, 107.58]</td>
</tr>
<tr>
<td>Schillinger</td>
<td>3 / 50</td>
<td>3 / 50</td>
<td>1.00 [0.21, 4.72]</td>
<td>30.7</td>
<td>1.00 [0.21, 4.72]</td>
</tr>
<tr>
<td><strong>Total (95%CI)</strong></td>
<td>24 / 278</td>
<td>17 / 428</td>
<td>2.24 [0.62, 8.09]</td>
<td>100.0</td>
<td>2.24 [0.62, 8.09]</td>
</tr>
</tbody>
</table>

Chi-square 5.06 (df=2) P= 0.08  Z=1.23 P= <0.00001

- Favor jugular
- Favor subclavian

Ruesch S: Complications of CVC; Crit Care Med 2002
Michigan ICUs: Keystone Project

- Cohort Study in 103 ICUs
  - 1625 (85%) ICU beds
  - 375,757 Catheter days

- CLABSI rates decreased from 2.7 per 1000 catheter days (baseline) to 0 in 18 month follow-up (p<0.002)

- Total savings in the 18 month span were:
  - Patient Lives Saved - > 1,700
  - Hospital Days Saved – 84,000
  - Hospital Care Dollars Saved - $188 million*
# Keystone Project - Rates of CLABSI

<table>
<thead>
<tr>
<th>Study Period</th>
<th>No. of ICUs</th>
<th>Overall</th>
<th>Teaching Hospital</th>
<th>Non-Teaching Hospital</th>
<th>&lt; 200 Beds</th>
<th>&gt; 200 Beds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>55</td>
<td>2.7 (0.6-4.8)</td>
<td>2.7 (1.3-4.7)</td>
<td>2.6 (0-4.9)</td>
<td>2.1 (0-3.0)</td>
<td>2.7 (1.3-4.8)</td>
</tr>
<tr>
<td><strong>During Implementation</strong></td>
<td>96</td>
<td>1.6 (0-4.4)</td>
<td>1.7 (0-4.5)</td>
<td>0 (0-3.5)</td>
<td>0 (0-5.8)</td>
<td>1.7 (0-4.3)</td>
</tr>
<tr>
<td><strong>After Implementation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-3 months</td>
<td>96</td>
<td>0 (0-3.0)</td>
<td>1.3 (0-3.1)</td>
<td>0 (0-1.6)</td>
<td>0 (0-2.7)</td>
<td>1.1 (0-3.1)</td>
</tr>
<tr>
<td>4-6 months</td>
<td>96</td>
<td>0 (0-2.7)</td>
<td>1.1 (0-3.6)</td>
<td>0 (0-0)</td>
<td>0 (0-0)</td>
<td>0 (0-3.2)</td>
</tr>
<tr>
<td>7-9 months</td>
<td>95</td>
<td>0 (0-2.1)</td>
<td>0.8 (0-2.4)</td>
<td>0 (0-0)</td>
<td>0 (0-0)</td>
<td>0 (0-2.2)</td>
</tr>
<tr>
<td>10-12 months</td>
<td>90</td>
<td>0 (0-1.9)</td>
<td>0 (0-2.3)</td>
<td>0 (0-1.5)</td>
<td>0 (0-0)</td>
<td>0.2 (0-2.3)</td>
</tr>
<tr>
<td>13-15 months</td>
<td>85</td>
<td>0 (0-1.6)</td>
<td>0 (0-2.2)</td>
<td>0 (0-0)</td>
<td>0 (0-0)</td>
<td>0 (0-2.0)</td>
</tr>
<tr>
<td>16-18 months</td>
<td>70</td>
<td>0 (0-2.4)</td>
<td>0 (0-2.7)</td>
<td>0 (0-1.2)</td>
<td>0 (0-0)</td>
<td>0 (0-2.6)</td>
</tr>
</tbody>
</table>

No. of Bloodstream Infections per 1000 Catheter-Days

Pronovst PJ: NEJM 2006
Ventilator Associated Pneumonia (VAP)
Ventilator Associated Pneumonia (VAP)

- Occurs in 10-20% of pts on a ventilator > 48 hours
- Rates from 1-4 cases/1,000 vent days
- Mortality attributable to VAP may exceed 10%

Pts with VAP require:
- Prolonged mechanical ventilation
- Extended hospitalizations
- Excess use of antimicrobials
- Increased direct medical costs

### Gram-Negative Infections Are Associated With Poor Outcomes in VAP

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Prevalence n (%)</th>
<th>Mortality a n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. aeruginosa</em></td>
<td>57 (14.3)</td>
<td>16 (28.6)</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>13 (3.3)</td>
<td>3 (23.1)</td>
</tr>
<tr>
<td><em>Enterobacter</em> spp</td>
<td>13 (3.3)</td>
<td>1 (7.7)</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>12 (3.0)</td>
<td>3 (25.0)</td>
</tr>
<tr>
<td><em>Acinetobacter</em> spp</td>
<td>8 (2.0)</td>
<td>4 (50.0)</td>
</tr>
</tbody>
</table>

VAP is often associated with gram-negative pathogens and high mortality\(^1\)-\(^3\)

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Diagnostic Criteria for VAP

- Presence of a new or progressive infiltrate on CXR and 2 of the 3 following:
  - Temperature > 38^0C (100.4^0F)
  - Leukocytosis or leukopenia
  - Purulent respiratory secretions

- Positive respiratory culture

- For quantitative cultures, a bacterial density of at least:
  - $10^6$ CFU/ml for an endotracheal aspirate
  - $10^4$ CFU/ml for a BAL specimen
  - $10^4$ CFU/ml for a protected-specimen brush

### Potential Pathogens in HAP, VAP, HCAP

<table>
<thead>
<tr>
<th>Potential Pathogens with No Risk Factors for MDR Pathogens, Early Onset (&lt;5 days), and Any Disease Severity</th>
<th>Potential Pathogens with Late Onset (≥5 days) or Risk Factors for MDR Pathogens</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Streptococcus pneumoniae</em></td>
<td>Pathogens with early onset disease plus</td>
</tr>
<tr>
<td><em>Haemophilus influenzae</em></td>
<td>MDR pathogens</td>
</tr>
<tr>
<td>Methicillin-sensitive <em>S. aureus</em></td>
<td>• <em>P. aeruginosa</em></td>
</tr>
<tr>
<td>Antibiotic-sensitive enteric gram-negative bacilli</td>
<td>• <em>K. pneumoniae</em> (ESBL)</td>
</tr>
<tr>
<td>• <em>E. coli</em></td>
<td>• <em>Acinetobacter</em> species</td>
</tr>
<tr>
<td>• <em>K. pneumoniae</em></td>
<td>MRSA</td>
</tr>
<tr>
<td>• <em>Enterobacter</em> species</td>
<td><em>Legionella pneumophila</em></td>
</tr>
<tr>
<td>• <em>Proteus</em> species</td>
<td></td>
</tr>
<tr>
<td>• <em>Serratia marcescens</em></td>
<td></td>
</tr>
</tbody>
</table>

MDR = multidrug-resistant.  
Adapted with permission from ATS/IDSA. *Am J Respir Crit Care Med.* 2005;171:388-416.  
Effect of Mechanical Ventilation (MV) and Prior Antimicrobial Use (ABT) on Development of Multi-resistant Pathogens

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Group 1 (n=22) MV &lt; 7 ABT = no</th>
<th>Group 2 (n=12) MV &lt; 7 ABT = yes</th>
<th>Group 3 (n=17) MV ≥ 7 ABT = no</th>
<th>Group 4 (n=84) MV ≥ 7 ABT = yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiresistant bacteria</td>
<td>0*</td>
<td>6 (30)</td>
<td>4 (12.5)†</td>
<td>89 (58.6)</td>
</tr>
<tr>
<td>*p &lt; 0.02 versus Groups 2, 3, or 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*p &lt; 0.0001 versus Group 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td>0</td>
<td>4 (20)</td>
<td>2 (6.3)</td>
<td>33 (21.7)</td>
</tr>
<tr>
<td><em>A. baumannii</em></td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3.1)</td>
<td>20 (13.2)</td>
</tr>
<tr>
<td><em>S. maltophilia</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6 (3.9)</td>
</tr>
<tr>
<td><em>MRSA</em></td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3.1)</td>
<td>30 (19.7)</td>
</tr>
<tr>
<td><em>Other bacteria</em></td>
<td>41 (100)</td>
<td>14 (70)</td>
<td>28 (87.5)</td>
<td>63 (41.4)</td>
</tr>
</tbody>
</table>

Selected recommendations from the guidelines:

- Collect cultures from all patients prior to initiating therapy; however, do NOT delay treatment of critically ill patients.
- Early, appropriate, broad-spectrum, empiric antibiotic therapy and adequate doses.
- Consider de-escalation once culture and susceptibility data are available.
- Consider duration of therapy.
Initial Empiric Therapy in HAP and VAP

- Directed at most virulent and prevalent pathogens
  - Gram negatives: *P. aeruginosa, Acinetobacter* spp.
  - Gram positives: *Staphylococcus aureus* (MSSA and MRSA)

- Combination therapy required
  - Carbapenems
  - Piperacillin/tazobactam
  - Cefepime

- Choice should not further promote development of resistance

Bowton DL. *Chest* 1999; 115: 28S-33S
Höffken G and Niederman MS. *Chest* 2002; 122: 2183-2196
Jones RN. *Chest* 2001; 119: 397S-404S
Antibiotic Therapy for Ventilator-associated Pneumonia: 8 vs 15 days

Chastre J et al. JAMA 2003; 290: 2588-2598
De-escalation in Practice

- Obtain culture specimens prior to initiating therapy
- Use updated, accurate institutional and unit-specific antibiograms
  - Awareness of the pathogens and their susceptibilities most likely to be associated with infection
- Include in empiric regimen treatment for potentially resistant pathogens associated with infection type
  - For example: *P aeruginosa*, *Acinetobacter* spp, *Klebsiella pneumoniae*, *Enterobacter* spp, and *Staphylococcus aureus*
- Modify therapy once culture and susceptibility results become available
  - Switch to narrower-spectrum agents as appropriate

Prevention of VAP

- Conduct active surveillance
- Adhere to hand hygiene guidelines
- Use non-invasive ventilation when possible
- Minimize duration of ventilation
  - Perform daily assessments and wean protocols
- Prevent aspiration
  - Maintain head of bed 30°-45°
  - Avoid gastric distention
  - Use a cuffed ET tube with in-line or subglottic suctioning

Prevention of VAP

- Reduce colonization of the aerodigestive tract
  - Avoid H1 blockers and PPIs in pts who are not high risk for stress ulcers or stress gastritis
  - Perform regular oral care with an antiseptic solution

- Minimize contamination of equipment

UCH ICU VAP Rates 2007-2010

**MICU**

- **2007 N=16**: 5.8
- **2008 N=12**: 4.5
- **2009 N=9**: 3.3
- **2010 N=7**: 2.9

**NeuroICU**

- **2007 N=3**: 2.7
- **2008 N=11**: 6.6
- **2009 N=5**: 3.6
- **2010 N=0**: 0.0

**SICU**

- **2007 N=14**: 6.41
- **2008 N=14**: 8.31
- **2009 N=7**: 3.25
- **2010 N=4**: 2.5

**BICU**

- **2007 N=5**: 4.5
- **2008 N=8**: 8.5
- **2009 N=4**: 4.3
- **2010 N=2**: 1.8
Questions?