Prevention of Nosocomial Infection in the ICU

Robert McIntyre, Jr., MD
The national U.S. rates of which of the following healthcare associated infections have increased during the past decade?

1. Central vascular catheter-associated bloodstream infections
2. Ventilator-associated pneumonias
3. Catheter-associated urinary tract infections
4. Surgical site infections
5. *Clostridium difficile* infections
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## Infection Control Over the Past Decade

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Then</th>
<th>Now</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRBSIs</td>
<td>5.0/1000 catheter days</td>
<td>1.7/1000 catheter days</td>
<td>a,b</td>
</tr>
<tr>
<td>VAP</td>
<td>9.5/1000 ventilator days</td>
<td>2.0/1000 ventilator days</td>
<td>a,b</td>
</tr>
<tr>
<td>CAUTIs</td>
<td>5.4/1000 catheter days</td>
<td>3.1/1000 catheter days</td>
<td>a,b</td>
</tr>
<tr>
<td>C. difficile infection</td>
<td>5.5 cases/10,000 discharges</td>
<td>11.2 cases/10,000 discharges</td>
<td>c,d</td>
</tr>
</tbody>
</table>

Abbreviations: CRBSIs, catheter-related bloodstream infections; VAP, ventilator-associated pneumonia; CAUTIs, catheter-associated urinary tract infections.

- b Am J Infect Control 2009; 37:783–805
- d [http://hcupnet.ahrq.gov](http://hcupnet.ahrq.gov)

Adapted from Patterson et al, Crit Care Med 2010; 38(8):265-8.
In-patient Infections – “National” Surveillance

<table>
<thead>
<tr>
<th>Rank</th>
<th>Overall</th>
<th>CLABSI</th>
<th>CAUTI</th>
<th>VAP</th>
<th>SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CoNS</td>
<td>CoNS</td>
<td>E coli</td>
<td>S aureus</td>
<td>S aureus</td>
</tr>
<tr>
<td>2</td>
<td>S aureus</td>
<td>Enterococcus spp</td>
<td>Candida spp</td>
<td>P aeruginosa</td>
<td>CoNS</td>
</tr>
<tr>
<td>3</td>
<td>Enterococcus spp</td>
<td>Candida spp</td>
<td>Enterococcus spp</td>
<td>Enterobacter spp, and A baumanii</td>
<td>Enterococcus spp</td>
</tr>
<tr>
<td>4</td>
<td>Candida spp</td>
<td>S aureus</td>
<td>P aeruginosa</td>
<td>--</td>
<td>E coli</td>
</tr>
</tbody>
</table>

Note. Of the 28,502 cases of HAIs reported, 4,671 (16.4%) were polymicrobial. CLABSI, central-line associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; VAP, ventilator-associated pneumonia, SSI, surgical site infection; CoNS, coagulase-negative Staphylococci.

Control & Prevention Keyed to Modes of Transmission of Infectious Agents

- **Contact**
  - Direct (body-to-body)
  - Indirect (e.g., fomites/environment, HCWs’ hands)
- **Large Droplet** (>5 μm; travel 3-6 feet)
- **Small Droplet** (droplet nuclei ≤5 μm; remain airborne)
- **Endogenous** (auto-inoculation & device-related)
- **Common source**
- **Vectorborne**
The most appropriate hospital room placement for a patient with seasonal influenza is:

1. A private room with negative pressure
2. A private room with negative pressure and 100% exhaust (i.e., no recirculation of air)
3. Any private room; personnel must mask and gown to enter room
4. Any private room; personnel must mask for patient contact (within 3-6 feet of patient)
5. Any room (and no special precautions) once anti-viral therapy initiated
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Isolation Categories are Based on Modes of Transmission

<table>
<thead>
<tr>
<th></th>
<th>Hand Hygiene</th>
<th>Private Room</th>
<th>Gloves</th>
<th>Gown</th>
<th>Mask</th>
<th>Eye Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Yes</td>
<td>PRN</td>
<td>PRN</td>
<td>PRN</td>
<td>PRN</td>
<td>PRN</td>
</tr>
<tr>
<td>Droplet</td>
<td>Yes</td>
<td>Yes*</td>
<td>PRN</td>
<td>PRN</td>
<td>W/in 3 ft</td>
<td>PRN</td>
</tr>
<tr>
<td>Contact</td>
<td>Yes</td>
<td>Yes*</td>
<td>Yes</td>
<td>Yes</td>
<td>PRN</td>
<td>PRN</td>
</tr>
<tr>
<td>Airborne</td>
<td>Yes</td>
<td>All</td>
<td>PRN</td>
<td>PRN</td>
<td>N95</td>
<td>PRN</td>
</tr>
</tbody>
</table>

* When possible; cohort if not possible. Avoid rooming with immunosuppressed or high risk patients. All = Airborne Infection Isolation: negative pressure with no air recirculation (unless HEPA-filtered); 6-12 ACH.
You admit a patient with sepsis and a history of decubitus ulcer infection by methicillin resistant S. aureus, vancomycin-resistant Enterococci, and carbapenem-resistant K. pneumoniae. The appropriate patient care order is:

1. Standard precautions
2. Droplet precautions
3. Contact precautions
4. Airborne precautions
5. Contact and airborne precautions
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Isolation Precautions — Examples of Indications

• Standard – All patients
• Droplet – Bacterial meningitis, pertussis, mumps, seasonal influenza
• Contact – Multidrug resistant (MDR) bacteria, infectious diarrhea, chickenpox
• Airborne – Tuberculosis, chickenpox, measles
ABCDs of Preventing Device Infection

• A – Asepsis for care
• B – Bundles for insertion
• C – Coatings / Checklists
• D – Discontinue devices
Prevent Device Infections

CLABSI
VAP
CAUTI
SSI
MRSA
C. difficile
Dangerous Devices

- 400,000 CLABSI occur per year in the U.S.
- CLABSI is associated with:
  - Increased morbidity
  - Mortality rates of 10% to 20%, or 11 deaths each day in U.S. hospitals
  - Prolonged hospitalization (mean of 7 days) and increase in medical costs >$28,000 per infection
Risk Factors for CLABSI

- Site of insertion – Internal Jugular & Femoral Veins poses more risk than Subclavian Vein
- Multiple lumen catheters - more manipulation and contamination of multiple ports
- Increased tissue trauma during insertion - cutdowns increase risk
- TPN and/or Lipids
- Higher patient to nurse ratios
- Infection elsewhere – e.g. UTI or Wound

Merer et al. JAMA. 2001;286:700-7
Risk Factors for CLABSI, continued

- Colonization of catheter with organisms
- IV catheterization longer than 72 hours
- Inexperience/knowledge of personnel inserting the line
- Use of stopcocks
- Poor technique using needleless access

Cookson St *Infection Control Hosp Epidemiology* 1998; 19:23-7; Do AN *Journal of Infect Dis* 1999; 179: 442-41; McDonald LC *Infect Control Hosp Epidemiology* 1998; 19: 77-
Many Opportunities for Error: Sources of CLABSI

http://www.phppo.cdc.gov/cdcrecommends/figures/ivfigure1.gif
Evidence-based Practices to Prevent CLABSI

• Clean hands with a waterless alcohol based hand sanitizer or wash hands with soap and water before inserting or handling a line

• Select best insertion site (subclavian lowest infection risk, avoid femoral) and least lumens possible

• Use proper skin preparation (chlorhexidine)

• Use the BioPatch® for additional skin antisepsis – releases chlorhexidine over 7 days

• Remove catheter as soon as possible and avoid unnecessary use
Specific Indications for Hand Hygiene

**Before:**
- Patient contact
- Donning gloves when inserting a central line
- Inserting urinary catheters, peripheral vascular catheters, or other invasive devices

**After:**
- Patient contact
- Contact with body fluids or excretions, non-intact skin, wound dressings
- Removing gloves

Site Selection

- To reduce infection risk, the SUBCLAVIAN site is preferred unless medically contraindicated
  - For patients on (or anticipated to need) hemodialysis, National Kidney Foundation 2000 guidelines recommended against the use of the subclavian vein due to the risk of stenosis

- If the IJ vein is chosen, use the right side to reduce risk of non-infectious complications
Line Selection

• Use a single lumen catheter, unless multiple lumens are absolutely necessary
  – Multiple lumens = more hubs to get colonized = greater risk for infection

• Consider a tunneled or implanted line for patients requiring long-term access (>30 days)

• Get dialysis patients evaluated for fistula access

Dezfulian, Crit Care Med. 2003 Sep;31(9):2385-90
Get the Catheters Out

• Catheters and other invasive devices are the #1 exogenous cause of hospital-onset infections

• Evaluate **daily** the need for the line and remove immediately when not needed

Figure. Scanning electron micrograph of biofilm on an intravenous catheter connector 24 hours after insertion.
Cutaneous Antisepsis: Goals

- Remove transient organisms and soil from the skin
- Reduce number of resident microbial flora and inhibit their rebound growth
- Create a sterile working surface that acts as a barrier between the insertion site and any possible source of contamination
Evidence Supporting Use of Chlorhexidine Skin Prep: a Meta Analysis

Chaiyakunapruk N, Ann Intern Med. 2002;136:792-801

The diamond indicates the summary risk ratio and 95% confidence intervals. THE USE OF CHLORHEXIDINE SKIN PREP WAS PROTECTIVE AGAINST CLABSI.
How to Use Chloraprep
(2% chlorhexidine in 70% alcohol)

• Pinch wings on the “Chloraprep” applicator to pop the ampule.

• Hold the applicator down to allow the solution to saturate the pad.

• Press sponge against skin, apply chlorhexidine solution using a back and forth friction scrub for at least 30 seconds. DO NOT WIPE or BLOT

• Allow antiseptic solution time to dry COMPLETELY before puncturing the skin (may take 2 minutes).
Maximal Barrier Precautions: Dress for Success

- Use face mask, cap and sterile gloves
- Wear a sterile gown with wrap-around ties properly secured
- Instruct anyone assisting you to wear the same barriers
- Drape the patient with a LARGE sterile drape that covers the entire body
Use of Procedure Checklist at Denver Health

- Goal is to improve teamwork and focus efforts on infection prevention practices
- This checklist should be completed by 2\textsuperscript{nd} observer while the physician is performing a central line insertion.

FOR CENTRAL LINE INSERTION

1. \(\square\) Patient supine, Trendelenberg greater than or equal to 15\(^\circ\) unless contraindicated. Consider rolled towel or 1 L IV bag behind scapula with head turned away from insertion site, unless contraindicated.
2. \(\square\) RN Prepare 3X sterile saline flush syringes if not in kit. Consider mask/drape over patient’s mouth and nose, if ETT/trach consider cap over patient’s hair

OBSERVER monitor for sterility breaks and call "STOP"

3. \(\square\) Full body fenestrated drape; MAY NEED TO REGLOVE
4. \(\square\) Local Anesthesia (Lidocaine 1\%) MUST be instilled.
5. \(\square\) Estimate position of distal tip by surface-landmark guidance. Safe insertion (adults): L or R IJ/Subclav - 16 cm; PA cath = 45-50 cm. (Varies by insertion site and body position; See pkg insert.)
6. \(\square\) Locate vessel with ultrasound guidance – NO MORE THAN 3 PASSES WITH FINDER NEEDLE; CONSIDER CXR IF VESSEL NOT LOCATED BY 3\textsuperscript{rd} PASS
7. \(\square\) Observer notes that guidewire passes easily and monitors for PVC/VT
   DO NOT PERFORM INTRODUCTOR-TO-CATHETER EXCHANGE until venous access confirmed
   Arterial cannulation \(\square\) Yes \(\square\) No;
   Describe corrective action
   \(\square\) Needle exchanged for dilator/s then exchanged for catheter
   \(\square\) Remove white obturator from coated catheter lumen
   \(\square\) Aspirate blood then saline flush; clamp and cap ports.
8. \(\square\) Occlusive Central Line Dressing per P&P.
9. \(\square\) Order portable chest XRay; Confirm position
   Position of catheter tip appropriate \(\square\) Yes \(\square\) No
   PTX \(\square\) Yes \(\square\) No Other Complications
   Describe corrective action/s

Call \textsuperscript{STOP} if the physician fails to complete a step and jeopardizes a sterile field. Have the team regroup and start over.

This is everyone’s responsibility!!
Post-Insertion Line Care

- Apply a sterile dressing to the insertion site **before** the sterile barriers are removed.

- Semi-permeable transparent dressings are preferred to allow visualization of the site.

- If the insertion site is oozing, apply a gauze dressing instead of a transparent one.

Follow routine dressing changes per protocol. Replace dressings when the dressing becomes damp, loosened, soiled or after lifting to inspect the site.

- **Transparent Dressings** = 1x/week and PRN.
- **Gauze Dressings** = Every Monday, Wednesday, Friday and PRN.

O’Grady NP, et al. MMWR Recommendations and Reports . 51(RR10):1-26, August 9, 2002
Guidewire Exchange

• Routine guidewire exchange or site rotation does not benefit the patient and may be detrimental

• Guidewire exchange is acceptable for replacing a malfunctioning catheter or downsizing a catheter

• Guidewire exchange is not recommended for known CLABSI—line should be removed

• When changing out a catheter, switch to a new set of sterile gloves before handling the new catheter

The Extras....

- Antimicrobial ointments risk line deterioration & do little to reduce CLABSI
- Chlorhexidine BIOPATCH dressing has been shown to reduce localized catheter insertion-site infection and CLABSI
- Antimicrobial coated catheters can decrease CLABSI when other basic infection control strategies also have been employed
- IV antimicrobial prophylaxis does not reduce CLABSI

**GOOD ASEPTIC TECHNIQUE IS MOST IMPORTANT!**

Remember These Simple Steps…

Foam Hand Gel . . 10 seconds

Maximum Sterile Barriers . . . . . . . . . . . . . . . . 50 seconds

Chloraprep. Apply . . 30 seconds
Dry . . . . . . 30 seconds

__________________________
2 minutes

2 Minutes to Save a Life. . . PRICELESS
Which of the following measures is least likely to reduce a patient’s risk of ventilator-associated pneumonia?

1. Spontaneous breathing trials
2. Elevation of the head of the bed to 45°
3. Change of ventilator circuit tubing q 3 days
4. Oral decontamination with chlorhexidine
5. Use of sub-glottic suctioning
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Ventilator Associated Pneumonia (VAP) – Key Points

• VAP is the 2nd most common nosocomial infection
  – Accounts for 15% of all hospital acquired infections
  – Incidence = 9% to 70% of patients on ventilators

• Associated with increased resource utilization
  – Increased ICU stay by several days
  – Increased avg. hospital stay 1 to 3 weeks
  – Added costs of $40,000 - $50,000 per stay

• Mortality = 13% to 55%

Centers for Disease Control and Prevention, 2003.
Diagnosing VAP

- VAP is a Hospital Acquired Nosocomial Pneumonia
- Diagnosis is imprecise and usually based on a Combination of Factors:
  - Positive cultures of blood / sputum / tracheal aspirate / pleural fluids
  - New or Changing Infiltrates
  - Clinical Factors: Temp >38 or <35; leukocytosis; Decrease in Oxygenation; Purulent Drainage
- Related entities are hospital and nursing home associated pneumonia
Bad Bugs: Early-Onset Pneumonia

- < 96 hours of intubation or ICU admission
  - Community-acquired & Antibiotic-sensitive
  - Pathogens:

  - *Streptococcus pneumoniae*
  - *Haemophilus influenzae*
  - *Staphylococcus aureus*
Bad Bugs: Late-Onset Pneumonia

- > 96 hours of intubation or ICU admission
- Hospital-acquired & Antibiotic-Resistant
- Pathogens:
  - Pseudomonas aeruginosa
  - Methicillin Resistant *Staphylococcus aureus* (MRSA)
  - Acinetobacter
  - Enterobacter

Risk Factors for Ventilator Associated Pneumonia - 1

• Major risk factor = mechanical intubation
• Factors that enhance colonization of the oropharynx &/or stomach:
  – Administration of antibiotics
  – Admission to ICU
  – Underlying chronic lung disease
  – Alkalinization of the stomach
Risk Factors for Ventilator Associated Pneumonia - 2

• Conditions favoring aspiration into the respiratory tract or reflux from GI tract:
  – Supine position
  – GERD
  – Nasogastric tube placement
  – Coma/Delirium
  – Intubation
  – Self-extubation
  – Immobilization
  – Surgery of head/neck/thorax/upper abdomen
Risk Factors for Ventilator Associated Pneumonia - 3

• Conditions requiring prolonged use of mechanical ventilatory support:
  – Potential exposure to contaminated respiratory devices
  – Contact with contaminated hands

• Host Factors:
  – Extremes of age
  – Malnutrition
  – Immunocompromised
  – Underlying condition/disease process

VAP Bundle: What YOU Can Do to Prevent VAP

- Comprised of multiple interventions required of all providers to prevent VAP
- All interventions must be instituted together for optimal VAP prevention
- Failure to perform one or more interventions may result in a diagnosis of VAP
Adult Ventilator Bundle:

W.H.A.P. O.U.T. VAP!

W = Wean patient from ventilator as soon as possible
H = Hand hygiene
A = Aspiration precautions
P = 1. Prevent Contamination of Respiratory Equipment
   2. DVT Prophylaxis
O = Oral Care
U = Peptic Ulcer Prophylaxis
T = Maintain Endotracheal Tube Cuff Pressure 25-30 cm H₂O and Ensure suction sideport of the supraglottic suction ETT (CASS Tube) is patent & on intermittent suction.
Sedation Vacation

Daily interruption of sedative medication is associated with decreased ventilator days and length of ICU stay.

**Surgical Patients**
- Reassess sedation goal every 4 hours.
- Attempt 50% decrease in drip once per shift.
- Coordinate trial with Respiratory Therapy.
- If drip reduction fails then rebolus and triate to SAS goal.

**Medical Patients**
- Awakening Trial: STOP sedation once per shift.
- Coordinate trial with Respiratory Therapy.
- Allow patient to awaken & assess sedation requirement.
- If sedation required may rebolus & restart drip at 50% previous dose or may use IVP dosing.

Hand Hygiene

• **Before:**
  – Having contact with patients
  – Putting on gloves
  – Inserting any invasive device
  – Manipulating an invasive device

• **After:**
  – Having contact with a patient’s skin
  – Having contact with bodily fluids or excretions, non-intact skin, wound dressings, contaminated items
  – Having contact with inanimate objects near a patient
  – Removing gloves

Aspiration Precautions

• Elevate the head of bed 30-45 degrees by flexing bed or reverse Trendelenberg
  – Reduces chance of gastric reflux and aspiration of gastric contents
  – Even prone ventilated patients can have an elevated HOB.

• Proper position in bed
  – Minimize abdominal compression

Drakulovic MB. Lancet.1999;354:1851-1858
Patient Positioning: Contraindications to HOB Elevation

- Patient with hypovolemia – may lead to possible hypotension
- Patient with large femoral line in place (dialysis catheters)
- Spine precautions
  - May need “reverse” Trendelenberg

Drakulovic MB. *Lancet*. 1999;354:1851-1858
Do:

- Maintain HOB > 30 degrees unless contraindicated
- Continue Q 2 hour turning schedule

Don’t:

- Leave patient in supine position for prolonged periods
- Forget to turn tube feedings off prior to: placing patient in supine position AND prior to transporting patients.

http://www.tccd.edu/neutral/DivisionDepartmentPage.asp?pagekey=191&menu=1
Oral Care

• Failure to provide adequate oral care may lead to VAP

• When normal flora compromised, more susceptible to colonization by microorganisms (e.g., Gram-negative bacilli), not normally found in oropharyngeal secretions.

• Migration to lower airway can lead to VAP

Management of Oral and Tracheal Secretions

• Care of Equipment:
  – Maintain Endotracheal Tube Cuff Pressure at at 25-30cm
  – Ensure Suction Sideport of the Supraglottic suction ETT (CASS Tube) is patent and on intermittent suction
  – Use Closed Suctioning System, e.g. Ballard System.
Management of Oral and Tracheal Secretions (Cont.)

- Keep end of vent circuit, suction catheter or Yankauer tip, and patient’s manual ventilation bag **off the bed**. Hang them up or place them in a sterile container.

- Change the suction canister and mouth care kit every 24 hours.
Oral Care Protocol

- Oral cavity assessed every shift by RN.
- Assess baseline status of oral cavity: note absence of teeth, bleeding from the gums, color of teeth.

**GCS<10 and/or Intubated Patients:**

- *UPON INITIAL INTUBATION* the Respiratory Therapist brushes patient’s oral cavity with *Chlorhexidine*.
- Twice a day, the Registered Nurse provides oral care with *Chlorhexidine*.
- Provide these patients with oral care every 4 hours and PRN with mouthwash and soft swabs.
- Assess & determine need for removal of oropharyngeal secretions *AT LEAST* every 4 hours and PRN as well as prior to repositioning the tube or deflation of the cuff.
Surviving Sepsis Campaign Guidelines:

“Stress ulcer prophylaxis should be given to all patients with severe sepsis. H2 receptor inhibitors are more efficacious than sucralfate and are the preferred agents. Proton pump inhibitors have not been assessed in a direct comparison with H2 receptor antagonists and, therefore, their relative efficacy is unknown. They do demonstrate equivalency in ability to increase gastric pH.”

- Reduces acid production in stomach and the consequent risk of bleeding from gastric erosions and peptic ulcers.
- Some studies have shown increased rates of ventilator associated pneumonia in patients on prophylactic treatments, e.g. sucralfate.

DVT Prophylaxis

- DVT Prophylaxis in surgical, trauma, or medical ICU patients is associated with decreased VAP rates.

- Grade 1A Recommendation

Geerts WH. *Chest*. 2004; 126: 338S-400S.
Communicate Patient Daily Goals

- Prompts patient care priorities during rounds.
- Informs and aids in the identification all members of the health care team of the patient’s goals.
- Serves as a reminder of necessary VAP prevention interventions.
Routine ICU environmental cleaning with a detergent-disinfectant (a phenolic or quanternary ammonium product) is least likely to interrupt ICU transmission of:

1. Methicillin-resistant staphylococci
2. Vancomycin-resistant enterococci
3. Acinetobacter
4. Clostridium difficile
5. Norovirus
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