BLOODSTREAM & INTRAVASCULAR CATHETER-RELATED INFECTIONS

Dr. Leonard Mermel
Professor of Medicine
Warren Alpert Medical School of Brown University
Medical Director
Department of Epidemiology & Infection Control
Rhode Island Hospital

Potential Conflicts of Interest

• Research funding: Theravance
• Consultant: 3M, CareFusion, Catheter Connections, Fresenius Medical, Marvao Medical

Bloodstream Infections and Blood Cultures

Guidelines for Blood Cultures

• Cumitech IC, Blood Cultures IV, EJ Baron, ed, ASM Press, 2005

Interpreting Positive Blood Cultures

• Isolation of coag-negative staph in blood often (> 80%) represents contaminant or not clinically significant
• Isolation of Corynebacteria, Bacillus, or Propionibacteria usually (>90%) contaminants
• Half of viridans group strep in non-neutropenic pt’s blood cultures are of no clinical significance or contaminants
• Candida, Staph aureus, GNRs, AFB in blood cultures always consider true pathogens

Weinstein et al, CID 1998; Pien et al, AJM 2010

Types of Bloodstream Infection

• 1° BSI - no clear source based on physical exam or available cultures (often CABS)
• 2° BSI - source identified based on physical exam or available cultures (e.g. UTI, VAP, SSI)
Detecting Bacteremia & Fungemia

- Blood culture volume - most important determinant of yield in adults & children
- Single set blood cultures – unable to determine if false-positive if grows potential skin contaminant; thus obtain 2 blood culture sets from different sites
- Collect 20-30 ml in adults from 2 separate sites; weight-based volume in children
- If blood culture is catheter-drawn, then obtain other culture from peripheral vein to avoid false-positive culture from contaminated catheter hub/connector

Mermel & Maki, Ann Intern Med 1993; Mermel et al, CID 2009

Intravascular Catheter-Related Infections

Compendium & Guidelines for Prevention of Intravascular Catheter-Related Infections


Defining Intravascular Catheter-Related Infection

Incidence vs Incidence Density

<table>
<thead>
<tr>
<th></th>
<th>Unit A</th>
<th>Unit B</th>
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<tbody>
<tr>
<td>Incidence</td>
<td>1/100 caths</td>
<td>5/100 caths</td>
</tr>
<tr>
<td></td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Duration of cath</td>
<td>5 d</td>
<td>20 d</td>
</tr>
<tr>
<td>Incidence</td>
<td>1/500 cath d</td>
<td>5/2000 cath d</td>
</tr>
<tr>
<td>Density</td>
<td>2.0/1000 cath d</td>
<td>2.5/1000 cath d</td>
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</tbody>
</table>

Clinical Definitions

clinical definitions (CRBSI) vastly different from surveillance definitions (CLABSI / CABSI)
Localized Catheter Infection*

- Exit / insertion site infection - purulent exudate at catheter exit / insertion site
- Tunnel infection - cellulitis along subcutaneous tract of a tunneled catheter
- Catheter colonization - significant growth from a catheter component (eg tip) by quantitative or semiquantitative methods

*localized infection may lead to systemic (ie bloodstream) infection

Catheter-Related Bloodstream Infection

- Concordant growth between catheter tip or hub, or exit site exudate, or infusate and percutaneously-drawn blood cultures
- Concordant growth between catheter-drawn & percutaneously-drawn quantitative blood cultures and \([C_{bc}]:[P_{bc}] > 3:1\)
- Concordant growth between catheter-drawn & percutaneously-drawn blood cultures and time from blood draw to detection by automated blood culture system is at least 2 hours earlier for catheter-drawn culture

Pathogens Involved

- Coagulase-negative Staph are most common causes of CRBSI, but...
- Majority of complications from CRBSI due to Staph aureus or Candida

Pathogen-Specific Outcome of Catheter-Related Bloodstream Infection

Preventative Strategies Should be Based on Understanding Pathogenesis
You are asked to see a 52 y/o patient who is a used car salesman. He unknowingly sold a vastly overpriced car with engine trouble to a member of La Cosa Nostra (the mob). He was later found with multiple gunshot wounds to the abdomen, leading to hospitalization, bowel resection, short-gut syndrome, prolonged TPN and recurrent catheter infections. He now has limited IV access.

Which of the following would you recommend regarding the site of CVC placement?

1. Recommend femoral vein insertion, this site appears to have a lower risk of infection and thrombosis compared with other sites.
2. Recommend subclavian vein insertion, this site appears to have a lower risk of infection compared with other sites.
3. Recommend internal jugular vein insertion, this site appears to have a lower risk of infection compared with other sites.

Placement of CVCs

- Minimize femoral catheter placement in adults
While observing CVC insertion in another patient, you’re distressed by your colleagues’ poor aseptic technique. The patient was a malpractice attorney. He went on to develop S. aureus CRBSI and endocarditis. Septic emboli to frontal lobes of the brain changed his malevolent, bellicose personality to a docile one, but with significant intellectual impairment. The hospital is successfully sued by his law partner. The patient, unable to continue as an effective well-paid malpractice attorney, went into politics and has a successful career in the Tea Party.

Which of the following evidence-based recommendations would serve as the basis for a future educational program re: CVC insertion?

1. Clean insertion site w/ alcoholic chlorhexidine. Use minimal barrier precautions (mask, gown, gloves and small drape).
2. Clean insertion site w/ alcoholic chlorhexidine. Use maximal barrier precautions (mask, eye protection, gown, gloves, hat, and large sheet drape).
3. Clean insertion site w/ alcoholic chlorhexidine. Use maximal barrier precautions (mask, eye protection, gown, gloves, hat, and large sheet drape). Use a chlorhexidine-containing dressing at the insertion site.
4. Clean insertion site w/ alcoholic chlorhexidine. Use maximal barrier precautions (mask, eye protection, gown, gloves, hat, and large sheet drape). Use a chlorhexidine-containing dressing at the insertion site. Bathe patient daily with chlorhexidine-based antiseptic.

Barrier Precautions

- Use maximum barrier precautions for central venous catheter insertion

Efficacy of Barrier Precautions During CVC Insertion

<table>
<thead>
<tr>
<th></th>
<th>Minimal</th>
<th>Maximal</th>
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<tbody>
<tr>
<td>Cath colonization</td>
<td>7.2%</td>
<td>2.3%*</td>
</tr>
<tr>
<td>Cath sepsis</td>
<td>3.6%</td>
<td>0.6%*</td>
</tr>
</tbody>
</table>

* p<0.05

Raad et al, ICHE 1994

Cutaneous Antisepsis

- Use alcoholic chlorhexidine to clean the skin prior to catheter insertion
Meta-Analysis: Prospective, Randomized Studies of Alcoholic Chlorhexidine vs Povidone-Iodine Cutaneous Antisepsis

**Cath colonization**

<table>
<thead>
<tr>
<th>Study</th>
<th>Cath colonization</th>
<th>CRBSI</th>
<th>Weight</th>
<th>Odd's Ratio</th>
<th>95% CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Bathing of Patients with CVCs</td>
<td></td>
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<tr>
<td>- Bathe patients daily with chlorhexidine-based product rather than soap and water</td>
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<tr>
<td><strong>Chlorhexidine-Containing Dressings</strong></td>
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<tr>
<td>- Use chlorhexidine-containing dressings at catheter insertion sites (also for pediatric patients &gt; 2,000 gms)</td>
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<tr>
<td><strong>Chlorhexidine-Impregnated Sponge (Biopatch) Dressing for CLABSI Prevention: Prospective, Randomized Multi-Center Study</strong></td>
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<tr>
<td>CHG Sponge</td>
<td>Control</td>
<td>Cath colonization</td>
<td>6.5%</td>
<td>16.8%</td>
<td></td>
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<tr>
<td>CRBSI</td>
<td></td>
<td></td>
<td>0.4%</td>
<td>1.3%*</td>
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<tr>
<td>*3532 CVCs &amp; arterial caths</td>
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<tr>
<td>1HR 0.34 (0.27-0.47) 1HR 0.24 (0.09-0.64)</td>
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<tr>
<td>Biopatch contact dermatitis = 5.3/1000 cath d</td>
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<tr>
<td><strong>Chlorhexidine Dressing (Tegaderm CHG) for CLABSI Prevention: Prospective, Randomized Study</strong></td>
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<tr>
<td>CHG dressing</td>
<td>Control</td>
<td>Cath colonization</td>
<td>4.3</td>
<td>10.9</td>
<td></td>
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<tr>
<td>1000 cath days</td>
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<tr>
<td>CRBSI/1000 cath days</td>
<td></td>
<td></td>
<td>0.5</td>
<td>1.3</td>
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<tr>
<td>*4163 CVCs and arterial caths</td>
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<tr>
<td><strong>Standard or highly adhesive dressing</strong></td>
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<tr>
<td>1HR 0.41 (0.31-0.56) 1HR 0.40 (0.20-0.90)</td>
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<tr>
<td>Contact dermatitis = CHG dressing (2.3%), standard dressing (1%) p&lt;0.001</td>
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</tbody>
</table>

Maiwald & Chan PLOS ONE 2012

D'Orio et al, IOCE 2012

Timsit et al, JAMA 2009

Timsit et al, AJRCCM 2012
You approach some administrators and recommend an educational campaign for physicians who insert catheters and implementation of prevention bundles to reduce patient risk. They object saying there’s no evidence that such costly interventions will make any difference in outcomes.

Which of the following is correct?

1. Infection control education & implementation of prevention bundles re: cath insertion and maintenance cannot reduce the incidence of CRIs.

2. Infection control education & implementation of prevention bundles re: cath insertion and maintenance can reduce the incidence of CRIs. However, CLABSIs do not independently lead to increased length of hospital stay so such a program is unwarranted.

3. Infection control education & implementation of prevention bundles re: cath insertion and maintenance can reduce the incidence of CLABSIs. Since intravascular cath-related BSIs do independently lead to increased length of stay, such a program is warranted.

Prevention ‘Bundles’ of Best Practice to Reduce CLABSI

- Use evidence-based prevention bundles for insertion and management of CVCs

CLABSI Prevention Program

- Educate physicians & nurses about proper insertion & maintenance of catheters
- Use central line cart or kit that contains everything needed to insert CVCs with strict aseptic technique
- Use a prevention bundle
• Use a checklist to assure insertion bundle is followed during catheter insertion
  – Hand hygiene before gloving
  – Maximum barrier precautions (gowns, gloves, mask & eye shield, hair cover, large sheet drape)
  – Alcoholic chlorhexidine antiseptic for cleaning insertion site
  – Avoid femoral line insertion in adults
• Nurse or physician observer present during insertion is empowered to stop insertion procedure if checklist not followed (ie, breach in aseptic technique observed)

• On daily rounds, ask if catheters can be removed; document response in medical record
• Measure CLABSI/1000 cath day; report rate to all ICUs compared to CDC NHSN data stratified by ICU type

Catheter Hubs and Connectors

• Clean catheter hubs and connectors before accessing them
• Consider alcohol-impregnated port protector

Reducing PICC CLABSI and PICC Lumen Colonization: Quasi-Experimental, Mult-Center Study
Alcohol wipe cath connector Alcohol-impregnated connector protector +/- wipe
CLABSI/
1000 PICC d 1.4 0.7
Lumen contam 12.7% 5.5% **
*p=0.04; **p=0.002

Pronovost et al, BMJ 2010
RI Adult ICU Collaborative
Statewide CLABSI Aggregate, Q1, 2006 - Q1, 2012
(at RIH also included CHG sponge dressing)

RIH Catheter-related bloodstream infection rate quarterly with 95% confidence intervals (at Rhode Island Hospital)

Reducing PICC CLABSI and PICC Lumen Colonization: Quasi-Experimental, Mult-Center Study
Alcohol wipe cath connector Alcohol-impregnated connector protector +/- wipe
CLABSI/
1000 PICC d 1.4 0.7
Lumen contam 12.7% 5.5% **
*p=0.04; **p=0.002

Wright et al, AJIC 2012
Reducing CVC CLABSI in an Adult Trauma & Neurosurgery ICUs: Quasi-Experimental Study

Alcohol wipe  Alcohol-impregnated cath connector  Alcohol-impregnated connector protector  +/- alcohol wipe

CLABSI/1000 CVC d’  4.3  1.1

*3763 total CVC days

Paridis, Uustis, Jefferson, Mermel 2013 (unpublished)

Despite vast improvements in infection control surrounding catheter care, there is still a high incidence of catheter-related BSI in one remaining ICU. Your stress level is really high, so your loving spouse suggests a relaxing vacation at your in-laws where you can play bridge with their friends in the nursing home, sing baritone in the local boy’s choir, and help cook lunch and clean up at the 200 person family picnic where someone’s bound to find out you’re an ID doc and ask you about their sick goldfish, Uncle Fred’s infected bunions, or Aunt Tilly’s friend who’s sister has a dog with Lyme disease. You exert your strong will and determination and instead of going to the in-laws, you go back to the hospital and make the following recs:

1. Use chlorhexidine-silver sulfadiazine coated CVCs in this ICU, they’re assoc with reduced CRI risk and proven not to be assoc with chlorhexidine, silver sulfadiazine, or antibiotic resistance.
2. Use minocycline-rifampin coated CVCs in this ICU, they’re assoc with reduced CRI risk and proven not to be assoc with minocycline or rifampin resistance.
3. Use either of these CVCs; however, resistance of infecting microbes should be monitored as development of resistance has not been ruled-out.
4. Use either of these CVCs; however, resistance of infecting microbes should be monitored as development of resistance has not been ruled-out. Additionally, consideration could be made for use of antimicrobial lock solution.

Antiseptic & Antibiotic Impregnated Catheters

• Consider use in individual patients or patient populations with a high incidence of CLABSI despite compliance with basic infection control practices

Meta-Analysis of CRBSI in Prospective, Randomized Clinical Trials

Meta-Analysis of CRBSI in Prospective, Randomized Clinical Trials

<table>
<thead>
<tr>
<th>Study</th>
<th>Control</th>
<th>Intervention</th>
<th>MD (95% CI)</th>
<th>Test for heterogeneity</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wright et al. 2005</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Mermel et al. 2005</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>Wright et al. 2006</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>Mermel et al. 2006</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>Total (n=5)</td>
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<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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</tbody>
</table>


Antimicrobial Lock Solution

- Use in individual patients or patient populations with a high incidence of CLABSIs despite compliance with basic infection control practices.

Prospective, Randomized Studies of Antibiotic Catheter Lock Solution to Prevent Hemodialysis CRBSI (CRBSI/cath day)

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment</th>
<th>Control</th>
<th>MD (95% CI)</th>
<th>Test for overall effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abraham et al. 2006</td>
<td>0.0000</td>
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<tr>
<td>Mehl et al. 2006</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>Gross et al. 2006</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>Total (n=3)</td>
<td>0.0000</td>
<td>0.0000</td>
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Yahav, et al, CID 2008

Ethanol Catheter Lock Solutions

Your colleague at another hospital has instituted prevention bundles with a chlorhexidine-based cutaneous antiseptic to prep CVC insertion sites, maximal barrier precautions, and even use of antiseptic-coated catheters; however, he still has a high incidence of CLABSIs compared with national benchmark data.

You are perplexed and find no obvious reason despite reading his Tarot cards and checking his weekly astrology forecast.

Which of the following should you do?
1. Tell your friend to call his personal financial manager, see if he has enough money tucked away to take an early retirement and move into a beachfront home in the Caribbean.

2. Check to see if the type of needleless hubs used on CVCs at his hospital has recently changed.

3. Recommend that he start using antibiotic prophylaxis during CVC insertion.

4. Tell him to find someone else to blame, immediately followed by a long vacation to a place without internet access.

Increased CABSI using Needleless Connectors

<table>
<thead>
<tr>
<th>Needleless system used</th>
<th>Split septum</th>
<th>Mechanical valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3/1000 cath d</td>
<td>8.5/1000 cath d <em>(p=0.02)</em></td>
<td></td>
</tr>
<tr>
<td>2.6/1000 cath d</td>
<td>5.8/1000 cath d <em>(p=0.03)</em></td>
<td></td>
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<tr>
<td>1.8/1000 cath d</td>
<td>6.0/1000 cath d <em>(p&lt;0.001)</em></td>
<td></td>
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<tr>
<td>3.9/1000 cath d</td>
<td>10.6/1000 cath d <em>(p&lt;0.001)</em></td>
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</table>


Recommendations

- Line cart or kit with all components needed for aseptic catheter insertion
- Checklist for catheter insertion to assess prevention bundle compliance
- Catheter insertion & maintenance using a hospital-wide approach to infection prevention by ‘bundling’ multiple evidence-based strategies
- Maximal barrier precautions for CVC insertion
- Minimize femoral line placement in adults
Recommendations

- If hospital unit or pt population has CRBSI rate above institutional goal after full implementation of above-noted interventions, or individual pts have limited venous access & history of recurrent CRBSI, then consider use of:
  - Chlorhexidine-silver sulfadiazine impregnated catheter or minocycline-rifampin impregnated catheter
  - Antimicrobial lock solution