Technologic Innovations to Prevent Catheter-Related Bloodstream Infection

Mark E. Rupp, MD
Professor & Chief, Infectious Diseases
Director, Infection Control & Epidemiology
University of Nebraska Medical Center

Hosted by Bruce Gamage
Provincial Infection Control Network of British Columbia

www.webbertraining.com

April 6, 2017

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

Clinical Significance of CLA-BSI

- 78,000 central line-associated bloodstream infections (CLA-BSI) are estimated to occur yearly in United States hospitals and dialysis units.
- 2013 NHSN report from 4,567 US facilities, mean CLA-BSI rate in critical care units ranged from 0.0 – 3.0/1000 CVC d.
- CLA-BSI are associated with an estimated mortality rate of 12.3% and excess healthcare costs between $7,288 and $29,156 per episode.

Rosenthal VD, et al. AJIC 2014


Countries Represented: Argentina, Bolivia, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Cyprus, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, Honduras, India, Iran, Saudi Arabia, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Puerto Rico, Romania, Russia, Serbia, Slovakia, Sudan, Thailand, Tunisia, turkey, United Arab Emirates, Uruguay, Venezuela, Vietnam

Comparisons of device-associated health care-associated infection rates per 1,000 device-days in the INICC (2007-2012) and the US NHSN (2012):

- Medical and surgical sites
  - CAUTI
  - SSI
  - VAP

- Pediatric ICU
  - CAUTI
  - SSI
  - VAP

- Neonatal ICU
  - CAUTI
  - SSI
  - VAP

- Medical and surgical ICU
  - CAUTI
  - SSI
  - VAP

- OR
  - CAUTI
  - SSI
  - VAP

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

Relative frequency of CR-BSI as a total of all HAIs by country (ECDC PPS 2011-2012)

Pathogenesis of CVC-Associated BSI

Potential Sources for Bacterial Contamination of Intravascular Catheters

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Pathogenesis of CVC-Associated BSI

Mature biofilm-associated infection with diverse population of cells including “persister cells” is very difficult to eradicate with catheter in place.
Practice Associated Interventions

- Education & Training
- Staffing Levels
- Insertion Procedures
  - Full Sterile Barriers & Checklist
- Post Insertion Care
  - Dressing Integrity
  - Aseptic Access Technique (scrub the hub)
  - Discontinuing unneeded catheters

Intervention in 108 ICUs:
- Daily Goals Sheet
- Hand Hygiene
- Full Sterile Barrier Precautions
- Chlorhexidine Antiseptic
- Avoidance of the Femoral Site
- Removal of CVCs asap

Mean BSI/1000 CVC d

Baseline 18 mo
(P<0.002)
What if Practice Measures Aren’t Working??????

Prevention of CR-BSI Technologic Innovations

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Behavioral Change vs. Technology

“If you can choose between education and influencing human behavior or introduction of a gizmo, choose the gizmo everytime.”

Bob Weinstein
Do antimicrobial-coated catheters prevent BSI?

<table>
<thead>
<tr>
<th>Coating Type</th>
<th>Study Authors</th>
<th>Study Year</th>
<th>Patient Count</th>
<th>BSI Rate</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymeric sulfobetaine (polySB)</td>
<td>Casey et al.</td>
<td>2008</td>
<td>20</td>
<td>5.9%</td>
<td>0.023</td>
</tr>
<tr>
<td>Heated CVCs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-Fluorouracil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rifampin-Miconazole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver Nanoparticles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorhexidine/Minocycline/Rifampin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gentian violet/Chlorhexidine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Pattern (Sharklet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Novel Antimicrobial Coatings & CVCs

- 5-Fluorouracil
- Rifampin-Miconazole
- Silver Nanoparticles
- Chlorhexidine/Minocycline/Rifampin
- Gentian violet/Chlorhexidine
- Surface Pattern (Sharklet)
- Polymeric sulfobetaine (polySB)
- Heated CVCs

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass

Preservation of Dressing Integrity

- **Dressing disruption is a major risk factor for catheter-related infections**

<table>
<thead>
<tr>
<th>Table 5. Association between dressing disruption and catheter colonization or infection (unadjusted and adjusted Cox models)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catheter Colonization: cCFU</strong></td>
</tr>
<tr>
<td><strong>HR (95% CI)</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Unadjusted</td>
</tr>
<tr>
<td>Final Disruption</td>
</tr>
<tr>
<td>Final Disruption</td>
</tr>
<tr>
<td>Final Disruption</td>
</tr>
<tr>
<td>Final Disruption</td>
</tr>
</tbody>
</table>

- The number of dressing disruptions was related to increased risk of colonization and bloodstream infection (P<0.001)


Hospital-wide assessment of compliance with central venous catheter dressing recommendations

Mark E. Rupp MD,*,**, Kyle Cassling BA,*, Hayley Faber BS,*, Elizabeth Lyden MS,*, Kate Tyner RN,*, Nedra Marion RN,*, Trevor Van Schooneveld MD,*,

- On any given day approximately 31% of dressings were suboptimal and in need of change
- Reasons: 69% blood under dressing, 25.4% edge lift, 5.4% moisture under dressing

N = 420 CVC

AJIC 2013

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Chlorhexidine Impregnated CVC Dressings

“Biopatch”

“Tegaderm CHG”

CR-BSI: 1.4/1000 CVC d vs 0.4/1000 CVC d (P<0.005)

No significant difference between 3d and 7d dressing changes

Full sterile barrier precautions used

Site prep with 4% povidone-iodine soln & PI/Ethol

Timsit, et al. JAMA, 2009

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Randomized Controlled Trial of Chlorhexidine Dressing and Highly Adhesive Dressing for Preventing Catheter-related Infections in Critically Ill Adults


- CR-BSI: 1.3/1000 CVC d vs 0.5/1000 CVC d (P= 0.02)
- Major-CRI: 2.1/1000 CVC d vs 0.7/1000 CVC d (P=0.0006)
- Highly adhesive dressings decreased dressing detachment rate (71.9% vs 64.3%; P<0.0001) but increased rate of colonization HR 1.65, 95%CI 1.21-2.26, P =0.0016)
Not All Mechanical Valves are Created Equal

Needless Connector Valves Linked to Increased CLA-BSI

- Maragakis: ICHE, 2006
- Rupp: Clin Infect Dis, 2007
- Salgado: ICHE, 2007
- Field: ICHE, 2007
- Toscano: AJIC, 2009
- Jarvis: Clin Infect Dis, 2009

(Figure from Jarvis, Infect Control Today, 2010)
Outbreak of Bloodstream Infection Temporally Associated with the Use of an Intravascular Needleless Valve

Mark E. Rupp, Lee A. Sholtz, Dawn R. Jourdan, Nedra D. Marion, Laura K. Tyner, Paul D. Fey, Peter C. Iwen and James R. Anderson

Clin Infect Dis 2007

A: Interlink IV Access System, Baxter
B: SmartSite Plus, Alaris Medical Systems

BSI Critical Care Units

8 critical care areas, 132 beds.
Baseline: 38,250 CVC days, rate 3.87/1000 CVC d
Outbreak: 10,340 CVC d, rate 10.64/1000 CVC d
(2.62 fold increase) (p < 0.0001)
Post removal: rate 5.59/1000 CVC d (p = 0.02)
Silver coated connector valves

- 2 silver coated IV connector valves on the market. Very little clinical data re: effect on colonization of catheters or Bloodstream infection.

Comparison of a Novel Silver-Coated Needleless Connector and a Standard Needleless Connector for the Prevention Of CLA-BSI
JT Jacob, et al. ICHE, 2015

CLA-BSI rate:
1.79/1000 CVC d vs 1.21/1000 CVC d
IR = 0.68 [95% CI 0.52-0.89] P = 0.005
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

Antiseptic Caps

Impact of universal disinfectant cap implementation on central line–associated bloodstream infections
Katreena Collette Merrill RN, PhD,*, Sharon Sumner RN, BS, Lorraine Linford RN, BS, CSNC, Carrie Taylor RN, MS, CIC, Christopher Macintosh RN, BS

CLA-BSI decreased from 1.5/1000 CVC d to 0.88/1000 CVC d, p = 0.004

AJIC, 2014

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Use of Disinfection Cap to Reduce Central-Line–Associated Bloodstream Infection and Blood Culture Contamination Among Hematology–Oncology Patients

Claudia A. Bush, MD,*,† Rachel Blaivas, MPH,‡ Nattalie Bell, RN,*,† Crystal Son, MPH,* Yu-Ting Huang, MPH,*,† Kent Sepkowitz, MD,*,†

Mary Dowling, MSN, RN,* Allison Lipps-Sneyerman, PhD,* Janet Fagans, RN, MPH, CIC* Kent Sepkowitz, MD,*,†

CLA-BSI in high-risk pts: Rate per 1000 CVC d: 4.93, 4.22, 4.47, 2.34 (P1-P4 respectively)

Blood culture contamination rate by CoNS

AJKD

Original Investigation

Dialysis Catheter-Related Bloodstream Infections: A Cluster-Randomized Trial of the ClearGuard HD Antimicrobial Barrier Cap

Jeffrey L. Hymes, MD,* Ann Mosney, MSN, RN, CNN,* Carly Van Zandt, MS,* Laurie Lynch, PhD,* Robert Ziebel, BS,* and Douglas Kikon, MBA*

- 12 month, prospective, cluster-randomized study in 40 HD units.
- 2470 pts; 350,000 CVC days
- 56% lower (+) Bld Cx rate (p=0.01)
- 40% decrease in hospital admissions for BSI (p=0.04); 31% less hospital days (p=NS)

Results for last 6 months of the study

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

UV light-emitting diode disinfection

- 285 nm UV LED effectively disinfected needleless connectors with 60s exposure at 0.5 cm.

Chlorhexidine Patient Bathing

Effectiveness of Chlorhexidine Bathing to Reduce Catheter-Associated Bloodstream Infections in Medical Intensive Care Unit Patients
Sauce C, Hombik, MD, William F. Truel, MD, H. G. Howes, MD, Jamil D. Lomas, MD, Mary K. Flaherty, MD, Robert A. Wesson, MD

- Daily CHG baths in ICU patients decreased BSI from 16.8 to 6.4/1000 CVC d.

Effect of Daily Chlorhexidine Bathing on Hospital-Acquired Infection

- 28% decrease in bloodstream infections (P = 0.007)

Targeted versus Universal Decolonization to Prevent ICU Infection

- HR for BSI (intervention vs baseline): 0.99 vs 0.78 vs 0.56 (P = <0.001)

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

Anti-Infective Catheter Lock Solutions

Conclusion: Anti-Infective Lock solutions are useful in certain circumstances. Additional study to assess optimal solution (antibiotics, alcohol, taurodilide, trisodium citrate, EDTA, nitroglycerin, etc) and populations

Zacharioudakis, et al. CID, 2015

Ethanol Locks to Prevent Catheter-Related Bloodstream Infections in Parenteral Nutrition: A Meta-Analysis


- Risk ratio for CR-BSI: 0.19 (95% CI 0.12-0.32)
- Risk ratio for catheter replacement: 0.28 (95% CI 0.06-1.23)
- Rare Toxicity: Etoh assoc with clotting, dizziness, CVC mechanical compromise, protein ppt, etc.

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

A novel antimicrobial and antithrombotic lock solution for hemodialysis catheters: A multi-center, controlled, randomized trial

Denis G. Maki, MD; Stephen R. Ash, MD; Roland K. Winger, BS, PE; Philip Lavin, PhD; for the AZEPTIC Trial Investigators
Crit Care Med 2011

- Prospective, Randomized, Multi-Ctr trial
- 25 HD units, 407 pts, 50K CVC days
- 7% citrate, 0.15% methylene blue, 0.15% methylparaben, 0.015% propylparaben (C-MB-P)
- 0.82 vs 0.24 CRBSI/1000 CVC d; RR 0.29 (0.12-0.7, p = 0.005)

Statewide Survey of Technologic CLA-BSI Prevention

- Nebraska statewide survey of hospitals (25 PPS/65 CAH)
- Response: 17 PPS (68%), 25 CAH (40%)

<table>
<thead>
<tr>
<th>Technology</th>
<th>PPS (%)</th>
<th>CAH (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHG Dressing</td>
<td>94</td>
<td>73</td>
</tr>
<tr>
<td>Antibiotic or Antiseptic CVC</td>
<td>47</td>
<td>31</td>
</tr>
<tr>
<td>Passive port disinfection</td>
<td>35</td>
<td>54</td>
</tr>
<tr>
<td>CHG bathing in ICU</td>
<td>65</td>
<td>8</td>
</tr>
<tr>
<td>CVC lock soln</td>
<td>17</td>
<td>12</td>
</tr>
</tbody>
</table>

Rupp et al. AJIC, 2016

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Technologic Innovations to Prevent Catheter-Related Bloodstream Infection
Prof. Mark E. Rupp, University of Nebraska
A Webber Training Teleclass

Scope of the Problem
What about Peripheral IVs???

Yearly Use of Peripheral IVs

- Little systematic data regarding complications: infection, phlebitis, infiltration, extravasation

Review of 110 studies, 10,910 catheters
- 0.1 BSI/100 devices; 0.5 (95% CI 0.2–0.7)/1000 device days
- 9 studies that required microbial concordance between catheter and blood culture: 0.6 BSI/1000 device days
- 1 per 1000 devices x 330 Million/2.25 attempts per successful IV start = 146,000 episodes of BSI

The Risk of Bloodstream Infection in Adults With Different Intravascular Devices: A Systematic Review of 200 Published Prospective Studies
DENNIS G. MAEL, MD; DANIEL M. KLAGER, MD; AND CHRISTOPHER J. CRONCH, MD


Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia
A Webber Training Teleclass
Status of Vascular Access at the University of Nebraska Medical Center

- Series of point prevalence surveys in all units during summer 2015
- All units visited on at least 3 occasions
- 755 patients
  - 59 (8%) No vascular access
  - 414 (55%) peripheral IV only
  - 239 (32%) CVC only
  - 43 (6%) both CVC and PIV

Peripheral IVs

Problems with securement
Arterial Catheters & Dressings

Prevention of IV Catheter-Related Bloodstream Infection

Practice Measures
- Education and Training
- Appropriate staffing
- Insertion and Care Bundle
  - CHG skin prep
  - Sterile barrier precautions
  - Avoid femoral site
  - Scrub the hub
- Removal of CVCs

Technologic Innovations
- Antimicrobial-Coated CVC
- CHG impregnated dressings
- CHG patient bathing
- Catheter Flush/Lock soln
- Antimicrobial-Coated Connectors
- Antiseptic Caps
Prevention of IV Catheter-Related Bloodstream Infection and “Getting to Zero”

- Cost Effectiveness
- Point of Diminishing Returns

Questions & Comments
# Technologic Innovations to Prevent Catheter-Related Bloodstream Infection

Prof. Mark E. Rupp, University of Nebraska

A Webber Training Teleclass

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Speaker</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 12, 2017</td>
<td><strong>PRACTICAL STEPS TO DEVELOP AND SUSTAIN AN EFFECTIVE NATIONAL HAND HYGIENE PROGRAMME AND ITS IMPACT ON ANTIMICROBIAL RESISTANCE</strong></td>
<td>Professor Lindsay Grayson, World Health Organization, Melbourne, Australia</td>
<td>World Health Organization Infection Control Global Unit (<a href="http://www.who.int/gpsc/en">www.who.int/gpsc/en</a>)</td>
</tr>
<tr>
<td>April 25, 2017</td>
<td><strong>DO'S AND DONT'S FOR HOSPITAL CLEANING</strong></td>
<td>Dr. Stephanie Dancer, Health Protection Scotland</td>
<td></td>
</tr>
<tr>
<td>April 27, 2017</td>
<td><strong>COST ANALYSIS OF UNIVERSAL SCREENING VS. RISK FACTOR-BASED SCREENING FOR MRSA</strong></td>
<td>Dr. Virginia Roth, University of Ottawa</td>
<td></td>
</tr>
<tr>
<td>May 5, 2017</td>
<td><strong>SPECIAL LECTURE FOR 5 MAY</strong></td>
<td>Prof. Didier Pittet, World Health Organization, Geneva</td>
<td></td>
</tr>
</tbody>
</table>

Sponsored by the World Health Organization Infection Control Global Unit (www.who.int/gpsc/en)

---

## Thanks to Teleclass Education

**Patron Sponsors**

- [Sealed Air](www.sealedair.com)
- [VIROX](www.virox.com)
- [World Health Organization](www.who.int/gpsc/en)

Hosted by Bruce Gamage, Provincial Infection Control Network of British Columbia

A Webber Training Teleclass