Safe Critical Care: Testing Improvement Strategies

Prevention of Catheter-Related Bloodstream Infections

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Overview

• Discuss the burden of CVC-BSI
• Review recommended guidelines for preventing CVC-BSI
• Review Vanderbilt experience with CVC insertion tool
• Review the IHI CVC Bundle
Introduction

- Central venous catheters (CVCs) are a commonly used modality especially in intensive care units, serving a vital role in the management of critically ill patients.
- Typical sites include the internal jugular, subclavian, and femoral veins.
- Various CVC devices are available, including introducers, multi-lumen catheters, PICC lines, and hemodialysis catheters.

Introduction

- Due to their size and location, CVCs confer a much greater risk for bloodstream infection (BSI) than simple peripheral intravenous lines.
- Episodes of catheter-related bacteremia cannot be traced back to one specific cause.
- Result from the cumulative exposure to a series of known potential risk factors.
- These risk factors can be categorized according to the two phases of catheter care: insertion and daily management.
Introduction

- This webcast is intended for nurses and physicians working in our ICUs.
- The topics outlined in this tutorial are universal and apply to most critical care settings.
- The recommendations in this tutorial are supported whenever possible by expert guidelines in the published literature.
- Providers will ultimately need to make treatment decisions based on their own clinical judgment and individual patient characteristics.

Central Venous Catheter-Related Bloodstream Infection (CVC-BSI)

- Increasing use of CVCs in ICUs
- Approximately 48% of all ICU patients have CVCs at some point during their hospital stay
- Over 15 million CVC-days per year in US ICUs
- CVCs disrupt the integrity of the skin, leading to a portal for pathogen entry and subsequent CVC-related BSI
Burden of CVC-BSI

- Approximately 90% of catheter-related BSIs occur with CVCs
- Mortality attributable to CVC-related BSI is between 4% and 20%
- An estimated 500-4,000 U.S. patients die annually due to BSI
- Attributable cost per infection = $34,508–$56,000
- Annual cost of CVC-related BSIs ranges from $296 million to $2.3 billion.

Epidemiology of CVC-BSI

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>37%</td>
</tr>
<tr>
<td>Gram-negative rods</td>
<td>14%</td>
</tr>
<tr>
<td>Enterobacter species</td>
<td>5%</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>4%</td>
</tr>
<tr>
<td><em>Klebsiella pneumoniae</em></td>
<td>3%</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>2%</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>13%</td>
</tr>
<tr>
<td><em>Enterococcus</em></td>
<td>13%</td>
</tr>
<tr>
<td>Candida species</td>
<td>8%</td>
</tr>
</tbody>
</table>
Indications for CVC Placement

- Rapid delivery of pharmcotherapeutic drugs or compounds
- Volume resuscitation
- Hemodynamic instability/need for monitoring
- Lack of sustainable peripheral access
- Dialysis therapy
- Long-term parenteral nutrition

Placement of a central venous catheter solely for ease of phlebotomy in a patient with adequate peripheral veins is strongly discouraged.
Rationale

• Many CVC-BSI may be prevented if recommended guidelines are uniformly followed.

• Using the IHI 100,000 Lives Campaign and our experience with a standardized intervention aimed at CVC insertion practices, we have developed a BSI prevention toolkit.

Process of CVC Care

INPUT

# CVC Inserted

Insertion

Maintenance

BSI Rate

OUTPUT
Risk Factors for BSI During the Process of CVC Care

**Insertion**
- Provider knowledge of risk factors
- Consider safest insertion site
- Patient positioned & sedated
- Trainee experience
- Pager(s) handed off
- Hand hygiene
- Skin antisepsis
- Maximal sterile barriers
- Number of needle sticks
- Hubs attached
- Line anchored
- Antibiotic-impregnated catheter

**Maintenance**
- Provider knowledge of risk factors
- Minimize CVC manipulation
- Consolidate blood draws
- Daily site inspection (visual & palpation)
- Dressing change protocol
- Hand hygiene prior to accessing hubs
- Hub antisepsis prior to accessing
- Tubing replaced after blood product infusions
- Hubs replaced after any opening
- Nurse-to-patient ratio
- Specialized line teams
- Protocol for CVC removal

Prevention of CVC-BSI
Teamwork & Quality Improvement

• Efforts to reduce CVC-related BSI require coordination between all providers on a patient's care team
• Physician must inform the patient’s nurse at the earliest opportunity whenever CVC insertion is anticipated
• Allows the nursing staff to arrange proper coverage

Teamwork & Quality Improvement

• Patient care is improved on several levels:
  ➢ Nurse functions as an assistant to the proceduralist who is otherwise unable to touch any object outside the sterile field
  ➢ Team approach enhances patient safety – allows for a time out
Experience of Proceduralist

- CVCs inserted by inexperienced providers have higher rates of infectious and mechanical complications.
- If a proceduralist has placed less than 5 central lines, a more experienced provider must properly supervise the procedure.

Hand Hygiene

- Healthcare workers (HCW) = vehicle for transmission of pathogens
- HCW hand washing adherence usually poor:
  - Frequencies range from 4-81% (mean 40%)
- Improved adherence associated with:
  - Reduced infection rates
  - Elimination of resistant pathogens
Hand Hygiene: 
Break the Chain of Transmission

- Even if providers wear gloves, studies have consistently shown that hand washing immediately prior to the handling of a line reduces the incidence of infections.
- Use of a waterless, alcohol-based gel is at least as effective as traditional soap and water.
Hand Hygiene

• When caring for central lines, appropriate times for hand hygiene include:
  – Before and after palpating catheter insertion sites
  – Before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter
  – When hands are obviously soiled or if contamination is suspected
  – Before and after invasive procedures
  – Between patients
  – Before donning and after removing gloves
  – After using the bathroom

Fingernails

• Fingernails often harbor microorganisms after thorough hand cleansing.
• Lengthy or artificial fingernails increase this tendency for pathogenic organisms to remain on the hands.
• In general, avoid wearing artificial nails at work and should keep their nails trimmed.
Catheter Insertion Site

Risk of infection:
- Central vein >>> Peripheral vein
- Femoral >>> IJ > Subclavian
Subclavian = preferred

Table 3  Catheter-Related Infections: Internal Jugular vs. Subclavian Approach

<table>
<thead>
<tr>
<th>Colonization</th>
<th>Bloodstream infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>IJ (%)</td>
<td>SC (%)</td>
</tr>
<tr>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>37$^A$</td>
</tr>
<tr>
<td>21</td>
<td>10$^A$</td>
</tr>
<tr>
<td>28</td>
<td>15$^A$</td>
</tr>
<tr>
<td>22</td>
<td>10$^A$</td>
</tr>
<tr>
<td>35</td>
<td>14$^A$</td>
</tr>
<tr>
<td>27</td>
<td>4$^A$</td>
</tr>
<tr>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Abbreviations: IJ = internal jugular vein; SC = subclavian vein.

$^a p < 0.05$  

Mermel L, 2000
Patient Positioning

• Occasionally overlooked
• Insure patient is both comfortable and lying flat (or in slight Trendelenberg).
• Consider sedation and analgesia issues before starting the procedure.
• Several other steps can also optimize a provider’s performance: adjusting the bed height, turning on all the lights, and handing off pagers.

Hair Removal

• If hair must be removed prior to line insertion, clipping is recommended.
• Shaving is not appropriate because razors cause local skin abrasions that subsequently increase the risk for infection.
Skin Prep: Chlorhexidine

- Used as an antiseptic
- Provides better skin antisepsis than other agents (e.g. povidone-iodine)
- Use during CVC insertion
- Must allow time for solution to dry
- In neonates under 30 days old, a lower concentration of chlorhexidine (0.5% as compared with 1-2%) should be used

Maximal Barrier Precautions

- CV Cs should always be placed using maximal barrier precautions
- Maximal barrier precautions are also recommended for any guidewire exchanges.
- Want to avoid contamination of the procedure field and procedure tools (e.g. guidewire) during CVC insertion
- Without barrier precautions, BSI rates 2-6 times higher
Maximal Barrier Precautions

• For the operator placing the central line and for those assisting in the procedure:
  – **Strict** compliance with hand hygiene
  – Wearing **cap, mask, sterile gown, and gloves**.
  – Cap should cover all hair.
  – Mask should cover the nose and mouth tightly. These precautions are the same as for any other surgical procedure that carries a risk of infection.

• For the patient:
  – Cover the patient with a **large sterile drape**, with a small opening for the site of insertion.

• These precautions are the same as for any other surgical procedure that carries a risk of infection.

Impact of Maximal Barrier Precautions

<table>
<thead>
<tr>
<th>Author/date</th>
<th>Design</th>
<th>Catheter</th>
<th>Odds Ratio for Infection w/o MBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mermel 1991</td>
<td>Prospective Cross-sectional</td>
<td>Swan Ganz</td>
<td>2.2 (p&lt;0.03)</td>
</tr>
<tr>
<td>Raad 1994</td>
<td>Prospective Randomized</td>
<td>Central</td>
<td>6.3 (p&lt;0.03)</td>
</tr>
</tbody>
</table>

Raad, Infect Control Hosp Epidemiol. Apr 1994;15(4 Pt 1):231-238
Prophylactic Antibiotics

- Prophylactic treatment prior to CVC insertion is not recommended.
- Prophylaxis with intravenous vancomycin or teicoplanin during CVC insertion did not reduce the incidence of CVC-related infections.
- May select for the acquisition of resistant organisms.

Topical Antibiotics/Antiseptics

- Prophylactic povidone-iodine ointment reduced hemodialysis catheter infections in randomized study.
- Prophylactic mupirocin may prevent overall infections
  - Ointment ultimately induces mupirocin resistance
  - May damage the integrity of polyurethane catheters.
- Rates of catheter colonization with Candida spp also ↑
- Study results conflicting
- Use of antimicrobial ointments not recommended
Antibiotic/Antiseptic-Impregnated Catheters

- Antiseptic/antibiotic impregnated CVCs can significantly reduce BSIs, at least in catheters remaining in place up to 30 days.
- Several types are available:
  - Rifampin-minocycline
  - Chlorhexidine-silver sulfadiazine
  - Silver, carbon and platinum
- $$$ (~3x as much as regular catheter)
- Concern for induction of resistance
- Experts recommend using antibiotic impregnated catheters ONLY if the infection rate remains high despite adherence to other proven strategies

Multiple Attempts at Placement

- Risk of infection or mechanical complications increases with each needle stick.
- If multiple attempts do not result in successful canalization, ask for assistance from a more experienced colleague.
- Remain particularly attuned to the patient's level of comfort and anxiety.
- Ultrasound guidance to localize the vein prior to insertion may reduce the number of attempts
Minimize Distractions

- In order to limit potential break in the sterile field, the insertion team should work to minimize distractions
- Hand off pagers

Anchoring Lines

- Catheters must be properly anchored after insertion.
- A loosely-anchored catheter slides back and forth, increasing the risk for contamination of the insertion tract.
- Likewise, the contamination shield should always be used on pulmonary artery catheters.
Catheter Site Dressing

- Transparent dressings = ordinary sterile gauze.
- Both dressing types have similar rates of CVC-related BSI
- However, if blood is oozing from the catheter insertion site, absorbent gauze dressing is preferred.
- Change gauze every 2 days
- Change transparent dressing every 7 days
- Dressing should **always** be changed if it becomes damp, loosened, or soiled.

Manipulating & Accessing Lines

- Excessive manipulation increases the risk for CVC-related BSI
- Limit the number of times a line is accessed
- Perform non-emergent blood draws at scheduled times
Manipulating & Accessing Lines

- Prior to accessing any line:
  - Hand hygiene
  - Wear gloves
  - Sterilize with an alcohol swab (friction is key)
- Pay keen attention to the potential for touch contamination when accessing a hub

Catheter Removal & Replacement

- Daily review of central line necessity:
  - Prevents unnecessary delays in removing lines that are no longer needed
  - Many times, lines remain in place simply because they provide reliable access and because personnel have not considered removing them.
- Risk of infection increases over time as the line remains in place
- Risk of infection decreases if the line is removed.
Catheter Removal & Replacement

• If a CVC is no longer required and peripheral access has been established, the CVC should be removed.
• Palpate the insertion site daily, with thorough inspection of the site if local tenderness or other signs of a possible infection are noted.
• If purulence is ever noticed at the insertion site, remove the catheter immediately and place a new catheter at a different site.
• Placement of a new catheter over a guidewire in the presence of bacteremia is unacceptable.

Catheter Removal & Replacement

• Replacing catheters at scheduled time intervals does not reduce rates of CVC-related bacteremia.
• Routine guidewire exchanges also fail to prevent infections.
• CVC removal exposes patients to risk of air embolus.
  – Patient should lie flat (or in slight Trendelenberg)
  – Instruct patients to take in a deep breath, and then pull the line when the patient exhales.
  – Apply firm pressure to the site for at least 10 minutes, longer if the patient has an underlying bleeding tendency.
Training and Education

- CVCs inserted by inexperienced providers have an increased risk for infection.
- CVCs maintained by inexperienced providers have an increased risk for infection.
- Frequent provider education decreases the risk for infection.
- Standardization of aseptic technique decreases the risk for infection.
- Specialized “Line Teams” decrease the risk for infection.

Outcome Definitions

- Key to measuring progress of any preventive strategy
- If standardized, allows comparison to national benchmarks
- CDC NNIS (now NHSN) definitions
Outcome Measure: CVC-BSI per 1000 CVC Days

- Central line catheter-related bloodstream infection rate per 1000 central line-days:
- Numerator: Number of CVC-related bloodstream infections x 1000
- Denominator: Number of CVC line-days (total number of days of exposure to central venous catheters by all patients in the selected population during the selected time period)

Surveillance for CVC-Related BSI

- Must use accurate identification of all infections using standardized definitions.
- Infection control and infectious diseases staff are usually responsible for collecting this data.
CDC NNIS Laboratory-Confirmed CVC-related BSI
(must meet at least 1 of the following criteria):

Criterion 1: Patient with CVC has a recognized pathogen cultured from 1 or more blood cultures and organism cultured from blood is not related to an infection at another site.

Criterion 2: Patient with CVC has at least one of the following signs or symptoms: fever, chills, or hypotension and at least one of the following:

a. Common skin contaminant (e.g., coagulase-negative staphylococci) is cultured from two or more blood cultures drawn on separate occasions

b. Common skin contaminant is cultured from at least 1 blood culture from a patient with CVC, and the physician institutes appropriate antimicrobial therapy

And signs and symptoms and positive laboratory results are not related to an infection at another site.
CDC NNIS Laboratory-Confirmed CVC-related BSI
(must meet at least 1 of the following criteria):

**Criterion 3:** Patient 1 year of age with CVC has at least one of the following signs or symptoms: fever, hypothermia, apnea, or bradycardia and at least one of the following:

a. Common skin contaminant is cultured from two or more blood cultures drawn on separate occasions

b. Common skin contaminant is cultured from at least one blood culture from a patient with an intravascular line, and physician institutes appropriate antimicrobial therapy

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**The Vanderbilt Experience**
Building a Collaboration

ICU Nurse Manager → ICU Director
Infection Control Practitioners → Hospital Epidemiologist
Nursing Staff → Critical Care Physicians
Center For Clinical Improvement → Patient Safety Officers

Intervention

- Toolkit
  - Educational tutorial
  - Examination
  - Checklist
- Administrative expectation
- Feedback of practices
- Change in culture
Central Venous Catheter Infections

Introduction
Central venous catheters (CVCs) are a commonly used modality in the medical intensive care unit (MICU), serving a vital role in the management of critically ill patients. By definition, these devices involve placement of a large-bore catheter into one of the body’s main central veins. Typical sites include the internal jugular, subclavian, and femoral veins. Although indications vary among critically ill patients, these catheters are usually placed for intravenous medication administration, volume infusion, hemodynamic monitoring, or hemodialysis catheters.

Due to their size and location, CVCs confer a much greater risk for bacteremia than simple peripheral intravenous lines. When a bloodstream infection (BSI) occurs in a critically ill patient, the additional costs and the risk of death can be extraordinary.

In most cases, episodes of catheter-related bacteremia cannot be traced back to one specific cause. Rather, these infections are viewed as resulting from the cumulative exposure to a series of known potential risk factors. Three risk factors can be categorized according to the two phases of catheter care: insertion and daily management. This tutorial will discuss the most important of these risk factors, with a special emphasis on ways that providers can minimize the risks inherent to the insertion phase.

This website is intended for nurses and physicians working in the MICUs at both Vanderbilt & for Veterans Affairs Medical Center. Although individual facilities may differ, the topics outlined in this tutorial are universal and apply to most general critical care settings. Whenever possible, the guidelines in this tutorial are supported by expert recommendations in the published literature. Of course, providers will ultimately need to make treatment decisions based on their own clinical judgment and individual patient characteristics.

Abbreviations
BSI = bloodstream infection  
CVC = central venous catheter  
MICU = medical intensive care unit  
PVC = peripherally inserted central catheter

Days Between CVC-Related Bloodstream Infections
January 1999 - August 2003

Upper Control Limit = 109 days
Mean = 27 days
Days Between CVC-Related Bloodstream Infections
January 1999 - August 2003

At time of study conclusion = 240

UCL = 109 days

Mean = 27 days

Wall RJ et al Qual Saf Health Care 2005;14:295+
Project Aims

• Implement a campaign for Improving Critical Care (BSI and ventilator-associated pneumonia) as part of the IHI 100,000 Lives Campaign.
• Develop tool kits for reducing BSI and ventilator-associated pneumonia.
• Conduct a randomized controlled trial to compare the effectiveness of a Collaborative versus Campaign and Tool Kit strategy for implementing an improvement initiative.
• Examine the organizational and provider factors that contribute toward and enable successful performance improvement.

The Central Line Bundle

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

- A grouping of best practices with respect to a disease process that individually improve care, but when applied together result in substantially greater improvement.

- The science behind the bundle is so well established that it should be considered standard of care.

- Bundle elements are dichotomous and compliance can be measured: yes/no answers.

- Bundles eschew the piecemeal application of proven therapies in favor of an “all or none” approach.

Components of IHI CR-BSI Prevention Bundle

1) Hand hygiene
2) Maximal barrier precautions
3) Chlorhexidine skin prep
4) Optimal site selection
5) Daily review of line necessity
But, Does It Work?

Outcome and Cost Impact

- Rate of CR-BSIs fell from 11.3 to 0 per 1000 catheter days.
- Prevented annually (estimated):
  - 43 CVC-BSIs
  - 8 deaths
- Estimated savings to hospital: $1,945,922

• Some providers view CVC insertion as a “doctor phase” while daily CVC maintenance is seen as a “nursing phase.”
• This viewpoint challenges the notions of teamwork and shared responsibility that are essential for infection reduction.
• All providers have an impact on the many risk factors mentioned above.
• Knowledge alone is not sufficient for changing behavior—you must also take the necessary actions.
• If you have any questions about something in the ICU, ask someone.
• If you have suggestions to improve care in the ICU, speak up.
References


Complete details about the 100,000 Lives Campaign, including materials, contact information for experts, and web discussions, are available on the web at www.ihi.org.
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• ICU staff and physicians

Safe Critical Care Team

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• Frank Houser
• Jeanne James
• Susan Littleton
• Joel McKinsey
• Steve Mok
• Charles Posternack
• Joan Reischel
• Sheri Tejedor
• Mark Williams
Enrollment Deadline: 11/30/05

- E-mail to patient.safetymailbox@hcahealthcare.com
  - Provide your Hospital name
  - Provide name of your primary contact person, e-mail, telephone
- Visit Atlas site by using keyword Safe Critical Care
  - Go to the Sign Up box for e-mail link
  - Send contact information
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