Catheter Related Blood Stream Infections

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Conflicts of Interest

-Only internal

Introduction

- Separating the important from the minutia
- Considerable degree of complexity in management for a variety of reasons
- Evolving area of understanding
- Current practice often haphazard
- Likely to remaining a significant issue even/especially with changing face of healthcare
Outline

- Introduction
- Epidemiology
- Definitions
- Central line mechanics
- Pathophysiology
- Prevention
  - Central Line Bundle
  - Other prevention
  - Unanswered questions in prevention
- Diagnosis
- Treatment/Management
  - Removal
  - Exchange
  - Retention
- Algorithms
- New Directions
- Conclusion

Epidemiology of CRBSI

- 11% of all healthcare associated infections
- 256,000 cases occurring each year in the United States
- 87% of bloodstream infections are associated with an intravascular device
- 64 percent of the nosocomial BSIs reported were primary BSIs, most are associated with intravascular catheters.
- 60 cases per 10,000 hospital admissions. Approximately 15 percent of cases occurred in children.
- 51 percent of cases occurred in the intensive care unit (ICU).
- Central venous catheter was in place in 72 percent, peripheral intravenous catheter in 35 percent, and an arterial catheter in 16 percent.
- The crude mortality rate was 27 percent.
- In 2008 in the United States, an estimated 37,000 CR-BSI occurred among patients receiving outpatient hemodialysis.
- Increased LOS 10-20 days
- Estimated the average cost of care for each patient with CRBSI is $45,000 with an estimated $2.3 billion annual cost to the U.S. healthcare system.

Epidemiology of CRBSI: CVCs

- Estimated 5 million CVCs placed per year
- Approximately 90 percent of all catheter-related bloodstream infections in the United States occur with CVCs
- Estimated in the U.S. CVCs caused approximately 50,000-100,000 CRBSIs and 28,000 deaths in ICU patients.
- 23,000 central line-associated BSIs occurred among patients in inpatient wards in the United States in 2009.
- CR-BSI associated with central lines among patients hospitalized in intensive care units (ICUs) in the United States decreased from 3.64 to 1.65 infections per 1000 central line days between 2001 and 2009.
- Reported pooled incidence of central line-associated BSI across 422 ICUs in 36 countries in Latin America, Asia, Africa, and Europe from 2004 to 2009 was substantially higher, 6.8 events per 1000 central line days.
Definitions

- CRBSI: catheter related blood stream infection, technically ANY type of catheter
- CLABSI: central line associated blood stream infection, used as a proxy for CRBSI
- LCBI: laboratory confirmed blood stream infection
- CSEP: clinical sepsis
- PICC: peripheral intravenous catheter
- Midline: peripheral intravenous catheter inserted 3-8 inches but without tip in a central vein
- CVC: central venous catheter
- Tunneled: a CVC that extends some distance through subcutaneous space
- Cuffed: a CVC with a polymer annulus that allows body to grow into
- Insertion site: the entrance site of a catheter into the blood vessel
- Exit site: the site where the catheter exits from the subcutaneous space to the outside
- Port: a surgically implanted CVC with no external apparatus, accessed percutaneously

Central Line Placement

-Seldinger Technique

1. CVC
   - triple lumen

Central Venous Catheters

1. CVC
   - triple lumen
2. "Groshong" - refers to slit valve - may be any type of catheter
3. "Hickman" - tunneled catheter - "Brooke" similar but narrower, often single lumen
4. Port, "Port-A-Cath" - no external component - percutaneous access at point of use

Images from:
1. Image from: http://www.wikiskripta.eu/index.php/Seldingerova_technika
3. Image from: http://www.cixip.com/index.php/page/content/id/1863
5. Image from: http://www.mercyangiography.co.nz/Procedures/Oncology/Port-A-Cath.html
CVC Locations

Femoral Internal Jugular and Subclavian

Biased, Artificial Graphs

Non-infectious Risks to Patient

Provider Ease of Placement

Risk

Ease

FV UI SCV Type of Line

FV UI SCV Type of Line

Non-infectious Risks: arterial puncture, bleeding, pneumothorax
Criteria for “Ease of Placement”: patient position, vessel uniformity, clarity of landmarks

Less Biased, Artificial Graph

Infectious Risk to Patient

Risk

FV UI SCV Type of Line
Sources of CRBSI

- Contamination in Placement
  - Catheter is being inserted through colonized surface
  - Inadequate sterilization
  - Inadequate barrier precautions
- Contamination in Maintenance
  - Inadequate hub care prior to access
  - Inadequate dressing care
- Contamination in Use
  - Inadequate infusate sterility
- Contamination Internally
  - Hematogenous seeding from other sites of infection

The Core of the Matter: Biofilm

“An ounce of prevention is worth a pound of cure.”
-Benjamin Franklin
The Central Line Bundle

- Developed by Peter Pronovost.
- Implemented in 103 ICUs in MI, 375,000 catheter days
- 5 interventions for central line placement adhered to rigidly by means of a checklist
  1. Handwashing, 2. full barrier precautions, 3. site selection, 4. chlorhexidine antisepsis, 5. daily evaluation of need and prompt removal
- CLABSI decreased from 7.7/1000 catheter days to 1.4/1000 catheter days at 16 and 18 months.

Subsequent Bundle Components

- Timeout
- Ultrasound guidance
- Chlorhexidine impregnated sponge
- Catheter hub preparation
- Post-procedure CXR

Other Potential Preventions

- Antibiotic/antiseptic impregnated catheter
- Heparin impregnated catheter
- Prophylactic antibiotic lock
- Chlorhexidine bathing
- Sutureless fasteners
- Gauze dressing rather than transparent dressings
- Insertion site topical antibiotic
- Routine exchange of administration sets
Catheter Selection Risk 9

- Peripherally inserted midline catheters – 0.2 (95% CI 0.0-0.5)
- Peripheral intravenous catheters – 0.5 (95% CI 0.2-0.7)
- Peripherally inserted central catheters – 1.1 (95% CI 0.9-1.3)
- Cuffed and tunneled central venous catheters – 1.6 (95% CI 1.5-1.7)
- Arterial catheters for hemodynamic monitoring – 1.7 (95% CI 1.2-2.3)
- Noncuffed central venous catheters
  - Nonmedicated and tunneled – 1.7 (95% CI 1.2-2.3)
  - Nonmedicated and nontunneled – 2.7 (95% CI 2.6-2.9)
- Pulmonary artery catheters – 3.7 (95% CI 2.4-5.0)

Diagnostic Criteria (LCBI) 14

- LCBI must meet at least one of the following criteria:
  - Patient has a recognized pathogen cultured from one or more blood cultures and the pathogen is not related to an infection at another site.
  - Patient has fever, chills, and/or hypotension as well as positive laboratory cultures from two or more blood samples drawn on separate occasions which are not related to infection at another site and do not reflect contamination.
  - Patient <1 year of age has at least one of the following signs or symptoms: fever, hypothermia, apnea, or bradycardia (in addition to above criteria).
  - Criteria must prove a) there is blood stream infection and b) that BSI is from the catheter

Meeting Criteria 15

- Culture of same organism from culture tip and at least 1 peripheral blood culture
- Culture of same organism from two blood cultures (1 from catheter and 1 peripheral, 2 separate lumens of catheter(s) that meet quantitative criteria or DTP criteria
  - High false positive catheter culture. Important to get periph Cx
  - High negative predictive value of negative catheter Cxs however
- Quantitative blood cultures (not typically available): catheter sample cfu ≥3x peripheral cfu
  - Catheter Cx: ≥105 cfu from broth culture
- Semiquantitative: ≥15 cfu of same org in peripheral blood, hub site, insertion site
  - Catheter Cx: rolling. Any piece of cath tip on plate after catheter in place ≥7-10 days
- Subcutaneous port: qualitative culture of port fluid
- DTP (differential time to positivity): catheter culture returns positive ≥2 hours prior to peripheral culture
  - High sensitivity and specificity (85 and 91%)
Pathogens

- Of 24,179 nosocomial bloodstream infections (BSIs) occurring in 49 hospitals in the United States between 1995 and 2002
  - 31% Coagulase-negative staphylococci
  - 20% Staphylococcus aureus
  - 9% Enterococci
  - 9% Candida species
  - 6% Escherichia coli
  - 5% Klebsiella species
  - 4% Pseudomonas species
  - 4% Enterobacter species
  - 2% Serratia species
  - 1% Acinetobacter baumannii

Specific populations:

- Burn patients: P. aeruginosa most common Gram negative 16% of all BSI
- Malignancies: Gram negative organisms
- Hemodialysis: Gram positive organisms
- IV lipids/hyperalimentation: Malassezia furfur, Candida
- Infusate contamination: Gram negative rods, Klebsiella, Citrobacter, or non-aeruginosa Pseudomonas species, Enterobacteriaceae, and Candida
- Pocket/Tunnel infections: Staph aureus, P. Aeruginosa
- Needleless access devices: Pseudomonas, Klebsiella, Stenotrophomonas, Acinetobacter, and Serratia marcescens

Treatment/Management Options

- Catheter Removal
  - Complete extraction of catheter
  - Replacement of new catheter into new site
- Catheter Exchange
  - Change over a guidewire
  - When new access is limited
  - When clearcut indications for removal are lacking
- Catheter Retention/Salvage
  - Contaminated catheter is kept in situ
  - When access is limited, indications are lacking
  - Typically treated with antibiotic lock therapy (ALT)
Catheter Removal

- The most definitive management for CRBSI
- Best overall option
- Attempts at exchange and retention have high failure rates
- Clear indications for removal:
  - Infection with S. aureus, P. aeruginosa, fungemia, mycobacteria
  - Insertion site or pocket infection
  - Suppurative thrombophlebitis
  - Severe sepsis
  - Endocarditis
  - Persistent bacteremia after appropriate antibiotic therapy
  - Metastatic infection, septic emboli
  - True catheter colonization of Bacillus spp, Micrococcus spp, or Propionibacteria

Catheter Exchange

- Swapping existing catheter with biofilm out over a guidewire to place new catheter into same site
- Guidewire placed through contaminated site
- Indicated when:
  - Catheter removal is indicated
  - Risk for mechanical/bleeding complications is high
- Not indicated in sepsis

Catheter Retention/Salvage

- Poor success rates with S. aureus, P. aeruginosa, Candida
- Only appropriate for major contraindications to removal
- Not indicated in setting of:
  - Insertion site or pocket infection
  - Suppurative thrombophlebitis
  - Sepsis
  - Endocarditis
  - Persistent bacteremia
  - Metastatic infection.
- Typically made possible with antibiotic lock therapy
Antibiotic Lock Therapy

- Not indicated for
  - catheter infection for devices in place for <2 weeks; typically extraluminal infections
  - Extraluminal infections
  - S. aureus, Pseudomonas aeruginosa, resistant gram-negative bacilli, or Candida.
- Typically 100-1000x normal concentration of antibiotic
- Used in conjunction with systemic antibiotic Tx
- Dwell times less than 48h

Empiric CRBSI Antibiotic Tx

- Vancomycin (given high rate of Coag negative staph
- Daptomycin where vancomycin MICs (MIC) values >2 μg/mL
- Linezolid shown to be no better than placebo for empiric therapy
- Gram negative: 4th gen cephalosporin, carbapenem, beta lactam c inhibitor, aminoglycoside
- Pseudomonas: combination abx for neutropenic, septic, known risk factors
- Suspected candidemia: echinocandin (caspofungin) or azole if none in 3 months prior, and where Candida krusei or Candida glabrata infection is very low

Algorithm 1
New Directions

- **Lock therapy:**
  - Tetrasodium EDTA: Complete kill of biofilm bacteria and yeasts was observed within 24 hours
  - taurolidine, ethanol, hydrochloric acid and minocycline-EDTA (M-EDTA)
- Teflon and other polymer catheter surfaces that prevent adhesion
  - Heparin bonded CVC

Conclusions

- Prevention is far and away the most important measure
- Key to prevention is routine application of central line bundle
- Management of CRBSI is best accomplished with removal
- When complete removal is not possible exchange over a wire is a possibility
- If even exchange is contraindicated an option exists for catheter salvage with antibiotic lock therapy along with systemic antibiotics
References


