Catheter-related blood stream infection: Incidence and pathophysiology
Introduction

• Intravascular devices are indispensible in modern clinical practice
• Central venous catheters (CVCs) are commonly inserted in critically ill patients
• Approx 90% of the CRBSI occur with CVCs

Central line - Definition

• A catheter whose tip terminates in a great vessel - the aorta, PA, SVC, Inferior VC, brachiocephalic veins, IJV, subclavian veins, external iliac veins, and common femoral veins.
• Femoral lines
• Peripherally inserted central catheter (PICC) lines

the National Healthcare Safety Network (NHSN)
CRBSI - Incidence

Based on the North American data compiled from the NNIS from October 1986 to December 1990

- 2.1 per 1000 catheter days for respiratory ICUs
- 5.1 for medical-surgical ICUs
- 5.8 for trauma ICUs
- 30.2 for burn units

More recent data from NNIS from January 1992 through June 2004:

- the median rate of CRBSI in ICUs of all types ranged from 1.8 to 5.2 per 1000 catheter-days

CRBSI - Incidence

From 1 May 2000 to 30 April 2003:

- CR-BSI rate of 2.79 per 1000 catheter days

• 48% of ICU patients have CVCs, accounting for about 15 million central-venous-catheter-days per year in ICUs

• If 5.3 CRBSI occur per 1,000 catheter days, the attributable mortality is approx 18%

• Probably about 14,000 deaths occur annually due to central line infections. Some estimates put this figure as high as 28,000 deaths per year

• In addition, CRBSI prolong hospitalization by a mean of 7 days. Estimates of attributable cost per bloodstream infection are estimated to be between $3,700 and $29,000.

CRBSI - Incidence

Data from NAICU 2007:
• 66.2% of ICU patients have CVCs

Data from HSA JB 2005:
• 9.43 per 1000 catheter-in-situ days
CRBSI - Pathogenesis

• 4 major sources:
  a. colonization from skin
  b. intraluminal or hub contamination
  c. secondary seeding from a bloodstream infection
  d. rarely contamination of the infusate
Colonization from skin

- Colonization of the intracutaneous and intravascular portions of the catheter by micro-organisms
- Micro-organisms from patient’s skin and occasionally hands of health care workers
- Micro-organisms on the skin can migrate along the s/c tract created by indwelling catheter
Colonization from skin

• The deposition of biofilm on external and internal surface of vascular catheters → the colonization process

• Biofilms are protected colonies where micro-organisms exist
Biofilm formation

• takes place in 2 stages:
  a. attachment of microbes to the object
  b. production of an extracellular matrix (called a glycocalyx or slime) that surrounds the microbes and protects them from adverse environmental conditions

O,Toole G et al. Biofilm formation as microbial development.
Annu Rev microbiol 2000;54:49-79
Biofilms on vascular catheters

• Can shield the encased microbes from circulating antibiotics
• Antibiotic concentrations must be 100 to 1000 times greater to eradicate bacteria in biofilms than to kill free-flowing bacteria
• Microbes can gain access to the internal lumen of vascular catheters through break points in the infusion system such as stopcocks and catheter hubs

• A prominent route of infection for CVCs in place > 2 weeks or in patients with a surgically implanted device


Secondary seeding from a bloodstream infection

- Microbes in circulating blood can attach directly to indwelling vascular catheters or can become trapped in the fibrin meshwork that surrounds indwelling catheters
- More likely to occur in long-term catheters

Raad II et al. Diagnosis of catheter-related infections: The role of surveillance and targeted quantitative skin cultures. Clin Infect Dis 1995; 20:593

Contamination of the infusate

• Infusate or additives such as heparin flush may become contaminated
• A rare source of CRBSI
• Causes epidemic infections


Infusion fluid
Intrinsic contamination - during manufacture or preparation
In use contamination - via ports, stopcocks, changing bags, etc
Risk factors

• Femoral or internal jugular more than subclavian


Risk factors

- Repeated catheterization
- Presence of septic focus elsewhere


Risk factors

• Catheter insertion using submaximal barrier precautions


Maki, DG. Yes, Virginia, aseptic technique is very important: Maximal barrier precautions during insertion reduce the risk of central venous catheter-related bacteremia. Infect Control Hosp Epidemiol 1994; 15:227.
Risk factors

• Nontunneled more than tunneled

Risk factors

• Tunneled more than totally implantable device


Risk factors

• Lower risk with silver-chelated collagen cuff


Peripheral intravascular catheters

- Lower extremities > upper extremities
- Wrist > hands
- Placement > 3-4 days
- PVC and polyethylene > teflon
PAC

- Catheterization >3-5 days
- Colonization at insertion site
- Int jug > subclavian
- Catheter insertion using submaximal barrier precautions
- Regular protective plastic sleeves > shield sleeves
CVC

- Int jug > subclavian
- repeated catheterization
- Presence of septic focus elsewhere
- Nontunneled > tunneled
- Tunneled > totally implanted device
- Catheter insertion using submaximal barrier precautions
- Lower risk with silver-chelated collagen cuff
- Lower risk with antibiotic or antiseptic impregnated short term catheters
Catheter-care factors

• Emergent > elective
• Skill of inserter
• Skin under dressing – moist > dry
• Cutaneous antiseptic – 70% alcohol and 10% povidone iodine more
• Antibiotic-lock solutions – lower risk in neutopenic patients with long term catheters
• Microbiology
• A number of studies also reported coagulase-negative staphylococci as the most common organism

Sadoyama G, Gontijo Filho PP. Comparison between the jugular and subclavian vein as insertion site for central venous catheters: microbiological aspects and risk factors for colonization and infection. Braz J Infect Dis 2003 Apr; 7(2):142-8
A survey of 112 medical ICUs in the United States:

- CoNS, mostly *Staph epidermidis* (36%)
- Enterococci (16%)
- Gram-negative aerobic bacilli (16%)
  
  *Pseudomonas aeruginosa, Klebsiella pneumoniae, E coli*, etc
- *Staph aureus* (13%)
- *Candida species* (11%)
- Other organisms (8%)

• A study in HSA ICU 2005:

80.6% Gram –ve bacteria: K. pneumoniae (38.9%)
P. aeruginosa (19.4%)
A. baumanii (13.9%)
Enterobacter spp (8.3%)

19.4% Gram +ve bacteria: MRSA (13.9%)
MSSA (2.8%)
CoNS (2.8%)