Strategies to prevent indwelling catheter associated blood stream infections

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Ignaz Semmelweis 1818- 1865

• ‘Father of infection control’
• Hungarian physician
• 1847 worked as an obstetrician in Vienna General Hospital where he made some startling observations...
Case control analysis: Difference in Maternal mortality between 2 clinics

1st Clinic – doctor/medical student led
2nd Clinic – midwife led
Post-partum infections associated with physicians handling corpses prior to delivery
An agent of change

Puerperal fever
Monthly mortality rates 1841-1849

Percent of patients

Chlorine handwash
But as an agent of change?

- “You, Herr Professor, have been a partner in this massacre.”
- “Should you, Herr Hofrath, without having disproved my doctrine, continue to train your pupils [against it], I declare before God and the world that you are a murderer and the ‘History of Childbed Fever’ would not be unjust to you if it memorialized you as a medical Nero.”
Hero or Martyr
– ‘The Saviour of Mothers’

Issued in Austria in 1965 – 100\textsuperscript{th} year anniversary of his death
Why is preventing catheter associated infections important?

• Blood stream infections are a major cause of health-care associated morbidity and mortality
  - 12- 25% attributable mortality
  - excess length of hospital stay up to 12- 24 days
• Problem first recognized in late 1970s – 25,000 patients developed device-related bacteraemia in US each year
• CDC estimates approximately 41,000 central line associated blood stream infections occur in US hospitals each year
• Increasing rates as an expanding array of vascular devices being used in an ageing population with multiple co-morbidities
• 90% of catheter related blood stream infections are associated with central venous catheters
• The attributable cost: up to $20,000-$56,000 per episode in USA
FAQs
(frequently asked questions)

“Catheter-Associated Bloodstream Infections”
(also known as “Central Line-Associated Bloodstream Infections”)

What is a catheter-associated bloodstream infection?
A “central line” or “central catheter” is a tube that is placed into a
patient’s large vein, usually in the neck, chest, arm, or groin. The
catheter is often used to draw blood, or give fluids or medications.
It may be left in place for several weeks. A bloodstream infection
can occur when bacteria or other germs travel down a “central line”
and enter the blood. If you develop a catheter-associated blood-
stream infection you may become ill with fevers and chills or the
skin around the catheter may become red and sore.

Can a catheter-related bloodstream infection be treated?
A catheter-associated bloodstream infection is serious, but often
can be successfully treated with antibiotics. The catheter might
need to be removed if you develop an infection.

What are some of the things that hospitals are doing to prevent

catheter-associated bloodstream infections?
To prevent catheter-associated bloodstream infections doctors and
nurses will:
• Choose a vein where the catheter can be safely inserted and
where the risk for infection is small.
• Clean their hands with soap and water or an alcohol-based hand
rub before putting in the catheter.
• Wear a mask, cap, sterile gown, and sterile gloves when putting
in the catheter to keep it sterile. The patient will be covered with
a sterile sheet.
• Clean the patient’s skin with an antiseptic cleanser before putting
in the catheter.
• Clean their hands, wear gloves, and clean the catheter opening
with an antiseptic solution before using the catheter to draw
blood or give medications. Healthcare providers also clean their
hands and wear gloves when changing the bandage that covers
the area where the catheter enters the skin.
• Decide every day if the patient still needs to have the catheter.
The catheter will be removed as soon as it is no longer needed.
• Carefully handle medications and fluids that are given through
the catheter.

What can I do to help prevent a catheter-associated bloodstream
infection?
• Ask your doctors and nurses to explain why you need the cath-
eter and how long you will have it.
• Ask your doctors and nurses if they will be using all of the pre-
vention methods discussed above.
• Make sure that all doctors and nurses caring for you clean their
hands with soap and water or an alcohol-based hand rub before
and after caring for you.
• If you do not see your providers clean their hands,
please ask them to do so.
• If the bandage comes off or becomes wet or dirty, tell your nurse
or doctor immediately.
• Inform your nurse or doctor if the area around your catheter is
sore or red.
• Do not let family and friends who visit touch the catheter or the
tubing.
• Make sure family and friends clean their hands with soap and
water or an alcohol-based hand rub before and after visiting you.

What do I need to do when I go home from the hospital?
Some patients are sent home from the hospital with a catheter in
order to continue their treatment. If you go home with a catheter,
your doctors and nurses will explain everything you need to know
about taking care of your catheter.
• Make sure you understand how to care for the catheter before
leaving the hospital. For example, ask for instructions on shower-
ing or bathing with the catheter and how to change the catheter
dressing.
• Make sure you know who to contact if you have questions or
problems after you get home.
• Make sure you wash your hands with soap and water or an
alcohol-based hand rub before handling your catheter.
• Watch for the signs and symptoms of catheter-associated blood-
stream infection, such as soreness or redness at the catheter site
or fever, and call your healthcare provider immediately if any
occur.

If you have additional questions, please ask your doctor or nurse.

Co-sponsored by:
How can they be prevented?

• Large body of evidence suggesting that blood steam infections (BSI) associated with catheters are modifiable
• Michigan-Keystone project:
  - 103 ICUs in the USA
  - Major reduction in CVC-BSIs from 7.7 to 1.4 CVC-BSIs per 1000 CVC-patient days
• Used a complex intervention targeting specific technical practices
• Combined support for cultural, behavioral and systemic change
• 3 year follow-up study reported sustained improvement and accelerated the trend in a reduction in mortality rates

Technical interventions

• Hand hygiene, gown, gloves, hat, mask. Eye protection when indicated
• Skin antisepsis: 2% chlorhexidine gluconate in 70% isopropyl alcohol
• Maximal sterile precautions including full barrier drapes
• Site of insertion: avoid the femoral route
• CVC maintenance: aseptic access technique, daily site review and remove CVCs at earliest opportunity
Non-technical interventions – promotion of safety culture

• Science of safety
  – Guidance and teaching resources
  – Clinical stories and safety incidents
  – Training sessions

• Identifying and learning from incidents
  – Root cause analysis
  – Staff safety assessment

• Teamwork and communication
  – Establishing a unit safety team
  – Safety climate and team working
  – Safety culture survey
  – Daily goals checklist
‘Matching Michigan’

• National Patient Safety Agency ran an initiative to tackle CVC BSIs 2009-2011

• Aimed to reduce the mean level to 1.4 per 1000 CVC-patient days

• 3 components – technical, non-technical (cultural and systems) and a standardised national reporting system

The context: national infection control initiatives in England

2001 Mandatory reporting to the HPA of MRSA bacteraemia.


2004 Mandatory reporting of *Clostridium difficile* infection

2004 Hospital in Europe Link for Infection Control through Surveillance of Nosocomial Infections in ICU

2004 to 2008 Health Foundations Safer Patients Initiative (24 hospitals)
• 2005 DoH Saving Lives programme – NHS High Impact Interventions modeled on Institute of Healthcare Improvement bundles
• 2006 Health Act DoH Scope of Practice gives new powers of inspection to Healthcare Commission
• 2008 Health and Social Care Act 2008: required registration with CQC: duty to protect patients against HCAIs. New code of practice
• 2008 Patient Safety First – includes interventions to reduce CVC-BSIs
• 2008 High Quality Care for All: Next Stage Review – NPSA to tackle catheter related bloodstream infections
• 2009-2001 Matching Michigan project
• 2011 Mandatory reporting of MSSA and E. Coli bacteraemias
‘Matching Michigan’ Design

• Prospective, interventional, non-randomised, stepped, four-cluster 2-year quality improvement project
• Continuous feedback of results to participating ICU’s
• Each cluster was invited to attend 2 training days including technical and non-technical interventions adapted from Michigan-Keystone project
Results

• 223 ICUs, 79% general adult, 9% paediatric and 11.6% subspecialty
• Infection data submitted on 2479 ICU-months of a maximum 2787 (reliability rate 0.89)
• Of 1092 CVC-BSIs reported - 81% were ICU acquired
Central venous catheter (CVC)-blood stream infection (BSI) rates.

A: Total Adult & Paediatric CVC-BSI Infection Rate (---) and CVC Utilisation ratio % (-----) by Quarter

B: Ratio of ICU-Acquired to (non-ICU + ICU-Acquired) CVC-BSIs

C: Adult CVC-BSI Infection Rate (---) and CVC Utilisation ratio % (-----) by Quarter

D: Adult ICU CVC-BSI rates by Cluster

E: Paediatric CVC-BSI Infection Rate (---) and CVC Utilisation ratio % (-----) by Quarter

F: Paediatric CVC-BSI rates by Cluster


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Discussion

• Programme demonstrated a 60% reduction in reported CVC-BSIs in adult ICU’s in England
• The interventional package delivered seemed to contribute to a reduction in BSIs from CVCs
• However pre-ICU infections diminished in line with ICU-acquired infections indicating the secular trend was not limited to ICU
5 point evidence based bundle

• Good hand hygiene
• Use of maximal barrier precautions for insertion
• Use of Chlorhexidine/alcohol to prepare the skin
• Optimal catheter site selection (avoidance of femoral vein for central venous access)
• Daily review of line necessity and removal of unnecessary lines
Old news - Ultrasound guided versus anatomical landmark

• Meta-analysis of 18 RCTs
  – Failed placement ↓ RR 86%
  – Complications ↓ RR 57%
  – First attempt failure ↓ RR 41%
  – Attempts ↓ 1.4
  – Time ↓ 69.3 sec

BMJ 2003; 327: 361-7
Pathogenesis – catheter associated biofilms

- Attachment of free-floating (planktonic) microorganisms to a surface/catheter
- Sessile organisms divide to form micro-colonies and secrete extracellular polysaccharide matrix
- Complex structure through which organisms receive nutrients and waste diffuses away
- Cell-cell communication or quorum sensing
- ‘Invisible’ to the immune system – down regulated surface receptors
- If unfavorable circumstances (exhaustion of nutrients or overcrowding) sessile organisms detach and become planktonic
- Presence of planktonic organisms in bloodstream or urine results in symptomatic host infection
Biofilms
Significance of biofilms

• Decrease susceptibility to antimicrobial agents
  – Physical impairment of diffusion
  – Reduced bacterial growth
  – Local alterations of environment that might impair activity

• Microbiology of planktonic organisms might not reflect those of sessile organisms

• Close proximity of organisms allowing plasmid transfer and enhancing antimicrobial resistance
I just can't go with the flow anymore. I've been thinking about joining a biofilm.

This Slime Smile created by Jamie Pennington
Sites of contamination

Skin organisms
- Endogenous
- Skin flora
- Extrinsic
- HCW hands
- Contaminated disinfectant

Contaminated catheter hub
- Endogenous
- Skin flora
- Extrinsic
- HCW hands

Contaminated infusate
- Extrinsic
- Fluid
- Medication
- Intrinsic
- Manufacturer

Fibrin sheath, thrombus

Skin

Vein

Hematogenous
from distant infection
(1) Skin at the device insertion site

- Endogenous flora from the patient
- Exogenous flora from health care workers
- Characteristic organisms: coagulase negative staphylococci and *staph aureus*
(2) Catheter hub and lumen

- Hub contamination heavily weighted risk factor
- Estimated that hub, lumen or both contributed to 2 thirds of microorganisms that infected long-term catheters and a quarter from skin
- Outbreaks linked with contaminated medications (direct or piggybacked)
- Clusters of infection linked to flushing catheter with fluids from a contaminated source
(3) Infusate

Examples:
- *Bacillus cereus* in TPN: 23 cases – July 2014
- Sterile water – *Burkholderia cepacia*
- Heparin catheter-lock – *Stenotrophomonas maltophilia*
- Lipid emulsions – lipid dependent yeast *Malassezia furfur*
- Magnesium sulphate solution – *Serratia marcescens*
Epidemiology of device related infections

- In the UK: 2.8-5.4 per 1000 patients at risk (84 hospitals, hospital-wide)
- Influenced by parameters related to:
  - Patient (immunosuppression, skin integrity, age, underlying illness, other infection at another site, alteration in micro flora, excess blood loss)
  - Catheter – composition, size, number of lumens, location, duration
  - Hospital - nurse-to-patient ratio, insertion by less experienced personnel
Incidence density – Events per 1000 device days

• Central venous catheter (CVC)
  - 2.7/1000 catheter-days

• Peripherally inserted central cannula (PICC)
  - 2.1/1000 catheter-days

• Tunneled CVCs
  - 1.6/1000 catheter-days

• Peripheral venous catheters
  - 0.5/1000 catheter-days

• Implantable port systems
  - 0.1/1000 catheter-days
Prevention of Device associated bacteraemia (1) Before insertion

- Education of health care personnel
- Educational interventions reduce health care associated infections particularly in general hospital wards rather than ICUs
- Catheter insertion checklists
- Standard catheter insertion kits containing all necessary items (bundle)
(2) At insertion – measures shown to work

• Hand hygiene
• Maximal sterile barrier precautions (mask, cap, sterile gown and gloves)
• 2% chlorhexidine* (2% chlorhexidine in 70% isopropyl alcohol better at reducing number of peripheral venous catheters that were colonized or contaminated than 70% isopropyl alone)

* Small et al. Infect Control Hosp Epidemiol. 2008; (29) 963-965
(3) After insertion

- Daily assessment
- Non-essential catheters removed
- Disinfection of hubs, connectors, ports to reduce microbial burden
- Polyurethane dressings
Catheter associated Urinary Tract Infections (CAUTI)

• 70-80% of infections due to an indwelling catheter
• 12-16% of adult inpatients will have a urinary catheter at some time
• Daily risk of bacteriuria varies from 3-7% with an indwelling catheter
• Risk factors: duration, female, older age, not maintaining a closed circuit
• Associated with increase in morbidity, mortality, length of stay and hospital cost
What is "catheter-associated urinary tract infection"?
A urinary tract infection (also called "UTI") is an infection in the urinary system, which includes the bladder (which stores the urine) and the kidneys (which filter the blood to make urine). Germs (for example, bacteria or yeasts) do not normally live in these areas; but if germs are introduced, an infection can occur.

If you have a urinary catheter, germs can travel along the catheter and cause an infection in your bladder or your kidney. In that case it is called a catheter-associated urinary tract infection (or "CA-UTI").

What is a urinary catheter?
A urinary catheter is a thin tube placed in the bladder to drain urine. Urine drains through the tube into a bag that collects the urine. A urinary catheter may be used:
- If you are not able to urinate on your own
- To measure the amount of urine that you make, for example, during intensive care
- During and after some types of surgery
- During some tests of the kidneys and bladder

People with urinary catheters have a much higher chance of getting a urinary tract infection than people who don’t have a catheter.

How do I get a catheter-associated urinary tract infection (CA-UTI)?
If germs enter the urinary tract, they may cause an infection. Many of the germs that cause a catheter-associated urinary tract infection are common germs found in your intestines that do not usually cause an infection there. Germs can enter the urinary tract when the catheter is being put in or while the catheter remains in the bladder.

What are the symptoms of a urinary tract infection?
Some of the common symptoms of a urinary tract infection are:
- Burning or pain in the lower abdomen (that is, below the stomach)
- Fever
- Bloody urine may be a sign of infection, but is also caused by other problems
- Burning during urination or an increase in the frequency of urination after the catheter is removed.

Sometimes people with catheter-associated urinary tract infections do not have these symptoms of infection.

Can catheter-associated urinary tract infections be treated?
Yes, most catheter-associated urinary tract infections can be treated with antibiotics and removal or change of the catheter. Your doctor will determine which antibiotic is best for you.

What are some of the things that hospitals are doing to prevent catheter-associated urinary tract infections?
To prevent urinary tract infections, doctors and nurses take the following actions.

Catheter insertion
- Catheters are put in only when necessary and they are removed as soon as possible.
- Only properly trained persons insert catheters using sterile ("clean") technique.
- The skin in the area where the catheter will be inserted is cleaned before inserting the catheter.
- Other methods to drain the urine are sometimes used, such as
  - External catheters in men (these look like condoms and are placed over the penis rather than into the penis)
  - Putting a temporary catheter in to drain the urine and removing it right away. This is called intermittent urethral catheterization.

Catheter care
- Healthcare providers clean their hands by washing them with soap and water or using an alcohol-based hand rub before and after touching your catheter.

  If you do not see your providers clean their hands, please ask them to do so.
- Avoid disconnecting the catheter and drain tube. This helps to prevent germs from getting into the catheter tube.
- The catheter is secured to the leg to prevent pulling on the catheter.
- Avoid twisting or kinking the catheter.
- Keep the bag lower than the bladder to prevent urine from backflowing to the bladder.
- Empty the bag regularly. The drainage spout should not touch anything while emptying the bag.

What can I do to help prevent catheter-associated urinary tract infections if I have a catheter?
- Always clean your hands before and after doing catheter care.
- Always keep your urine bag below the level of your bladder.
- Do not tug or pull on the tubing.
- Do not twist or kink the catheter tubing.
- Ask your healthcare provider each day if you still need the catheter.

What do I need to do when I go home from the hospital?
- If you will be going home with a catheter, your doctor or nurse should explain everything you need to know about taking care of the catheter. Make sure you understand how to care for it before you leave the hospital.
- If you develop any of the symptoms of a urinary tract infection, such as burning or pain in the lower abdomen, fever, or an increase in the frequency of urination, contact your doctor or nurse immediately.
- Before you go home, make sure you know who to contact if you have questions or problems after you get home.

If you have questions, please ask your doctor or nurse.
Core strategies to prevent catheter associated UTIs

• Insert catheters only for appropriate indications
• Leave catheters in place only as long as needed
• Ensure that only properly trained persons insert and maintain catheters
• Insert catheters using aseptic technique and sterile equipment (acute care setting)
• Following aseptic insertion, maintain a closed drainage system
• Maintain unobstructed urine flow
• Practice hand hygiene and standard (or appropriate isolation) precautions
Core Prevention strategies – appropriate indications

- Acute retention or bladder outflow obstruction
- Accurate fluid balance in critically ill
- Perioperative
  - Urological/genitourinary surgery
  - Prolonged surgery, large volume infusions/diuretics, urinary output
- Assist healing of sacral/perineal wounds in incontinent patients
- Comfort for end of life care if needed
Quality improvement programs

• System of alerts or reminders to remove unnecessary catheters
• Stop orders for urinary catheters
• Protocols for nurse-directed removal of unnecessary catheters
• Guidelines/algorithms for appropriate perioperative catheter management
Strategies to try if CAUTI not decreasing?

• Portable ultrasound - assess urine volume - reduces unnecessary catheterizations.

• Antiseptic or antimicrobial-impregnated catheters (silver-alloy coated).

• Electronic medical record systems:
  - Document indications and monitor dates/times of catheter insertions and removals
  - Electronic alerts prompting removal of unnecessary catheters.
Preventing infection:

(1) What works?

• Vascular catheters
  - maximal sterile barriers for insertion
  - Use 2% chlorhexidine for skin antisepsis
  - Avoid lower extremity insertion sites
  - Good hand hygiene
  - Catheter removal when no longer needed

• Urinary catheters
  - Closed drainage
  - Intermittent catheterization
  - Ensure dependent drainage
  - Catheter removal when no longer needed
(2) What probably works

- Vascular catheter
  - Antibiotic flushes
  - Prevention of thrombus formation

- Urinary catheters
  - Anti-microbial impregnated catheters
References

- http://www.cdc.gov/HAI/ca_uti/uti.html

- IDSA guidelines:
  - Clinical Practice Guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by Infectious Diseases Society of America
  - Diagnosis, Prevention, and Treatment of Catheter-Associated Urinary Tract Infection in Adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America
