World Health Organization | Patient Safety | SAVE LIVES Clean Your Hands

Inaugural infection control webinar series

16 March 2010, 3 pm (CET*)

# Epidemiology and prevention of bloodstream infections

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**The slides as well as a recorded version will be available at:**

www.webbertraining.com

www.who.int/gpsc/5may/news/webinars

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1. Pathogenesis
2. Definition
3. Epidemiology
4. Risk factors
5. Procedural Interventions
6. Technical Interventions
7. Summary



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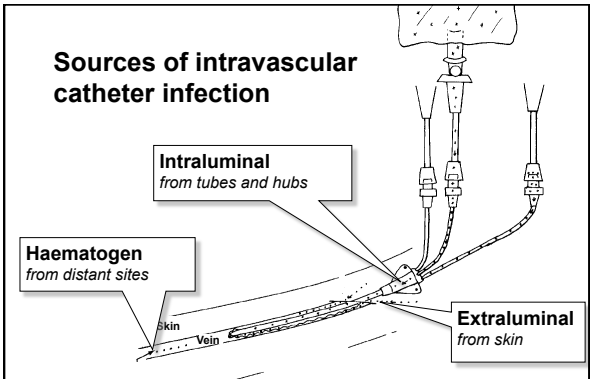
## Sources of intravascular catheter infection



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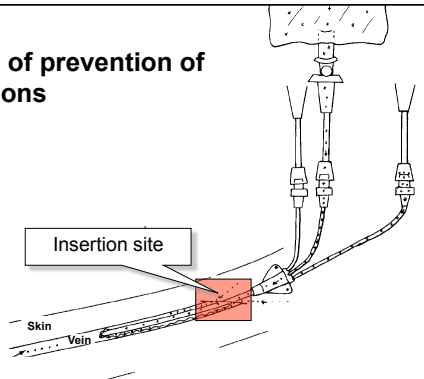
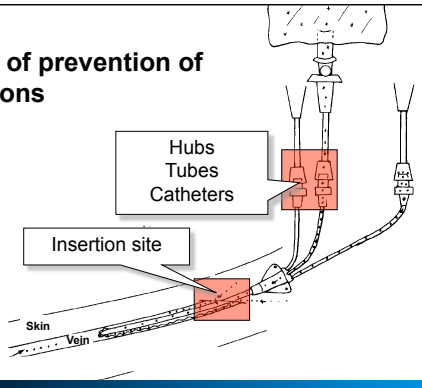
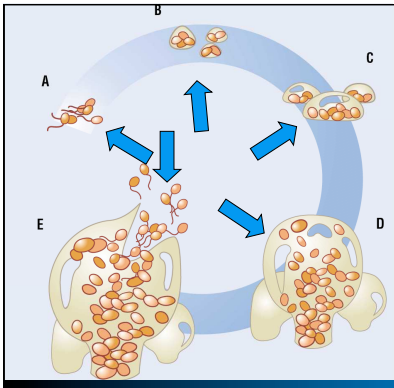
## Focus of prevention of infections



## Focus of prevention of infections




A. Attachment

B. Irreversible attachment, aggregation and formation of extracellular matrix

C. Maturation

D. Maximal thickness

E. Detachment of planktonic bacteria

Schachter. *Nature Biotechnology* 2005;21:361

## Biofilm Formation

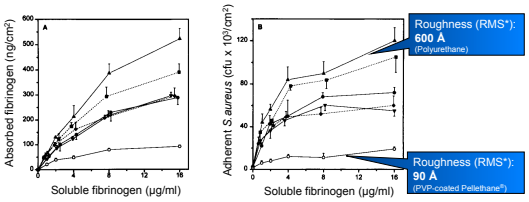
**Co-factors:**
- Fibrinogen[1], Fibronectin[2]
- Calcium[3], Magnesium[3], Iron[3,4]
- Production of extracellular matrix[5,6]
- DNA[7]
- Stress[8*]

*subinhibitory concentrations of aminoglycoside on *P.aeruginosa* & *E. coli*


1. Mehall. *Crit Care Med* 2002;30:908
2. Vaudaux. *J Infect Dis* 1993;167:633
3. Banin. *Appl Environ Microbiol* 2006;72:2064
4. Rhodes. *J Med Microbiol* 2007;56:119
5. Falcieri. *J Infect Dis* 1987;155:524
6. Sheth. *Lancet* 1985; 2:1266
7. Qin. *Microbiology* 2007:153:2083
8. Hoffman. *Nature* 2005;436:1171


**The formation of protein layers occurs within seconds of blood contact with a foreign surface.[1]**

**Fibrinogen and *S.aureus* adherence is reduced on polyurethane catheters with reduced surface roughness and hydrophilic properties.[2]**





1. Brash. *Ann NY Acad Sci* 1987
2. Francois. *Biomaterials 1996*;17:667

* RMS: root mean square

**Biofim on a catheter surface**


Penetration of antibiotics limited due to viscous matrix

→ Resistance in lower/inner sheets of biofilm due to sub-inhibitory concentrations

*Epidemiology and Prevention of Bloodstream Infections*

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**BSI-LCBI:**
**laboratory-confirmed bloodstream infection**

1 Patient 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

Horan. *Am J Infect Control* 2008;36:309



**BSI-LCBI:**
**laboratory-confirmed bloodstream infection**

2 Patient has at least 1 of the following signs or symptoms: fever (>38°C), chills, or hypotension

**and**
signs and symptoms and positive laboratory results are not related to an infection at another site

**and**
common skin contaminant is cultured from 2 or more blood cultures drawn on separate occasions

Horan. *Am J Infect Control* 2008;36:309

In criteria 2 and 3, the phrase "2 or more blood cultures drawn on separate occasions" means (1) that blood from at least 2 blood draws were collected within 2 days of each other (eg, blood draws on Monday and Tuesday or Monday and Wednesday would be acceptable for blood cultures drawn on separate occasions, but blood draws on Monday and Thursday would be too far apart in time to meet this criterion) and (2) that at least 1 bottle from each blood draw is reported by the laboratory as having grown the same common skin contaminant organism (ie, is a positive blood culture).



**infection**

**Table 2.** Examples of "sameness" by organism speciation

| Culture | Companion Culture | Report as.. |
|---|---|---|
| *S epidermidis* | *Coagulase-negative staphylococci* | *S epidermidis* |
| *Bacillus* spp (not *anthracis*) | *B cereus* | *B cereus* |
| *S salivarius* | *Strep viridans* | *S salivarius* |

**Table 3.** Examples of "sameness" by organism antibiogram

| Organism Name | Isolate A | Isolate B | Interpret as.. |
|---|---|---|---|
| *S epidermidis* | All drugs **S** | All drugs **S** | Same |
| *S epidermidis* | OX **R**<br>CEFAZ **R** | OX **S**<br>CEFAZ **S** | Different |
| *Corynebacterium* spp | PENG **R**<br>CIPRO **S** | PENG **S**<br>CIPRO **R** | Different |
| *Strep viridans* | All drugs **S** | All drugs **S** except ERYTH **R** | Same |

**S**, sensitive; **R**, resistant.

**and**
signs and symptoms and positive la
to an infection at another site

**and**
common skin contaminant is cultur
drawn on separate occasions

Horan. *Am J Infect Control* 2008;36:309



**BSI-CSEP: Clinical Sepsis**

**→ CDC: CSEP may be used only to report primary BSI in neonates and infants. It is not used to report BSI in adults and children!**

Patient <1 year of age has at least 1 of the following clinical signs or symptoms with no other recognized cause: fever (>38°C rectal), hypothermia (<37°C rectal), apnoea, or bradycardia
**and**
blood culture not done or no organisms detected in blood
**and**
no apparent infection at another site
**and**
physician institutes treatment for sepsis.







## Intensive Care Units

## National Healthcare Safety Network (NHSN) Report: ICU

| Type of location | No. of locations* | Pooled mean |
|---|---|---|
| Critical care units | | |
| Burn | 35 | 5.5 |
| Medical cardiac | 228 (221) | 2.0 |
| Medical major teaching | 125 | 2.6 |
| Medical all others | 153 (147) | 1.9 |
| Medical/surgical major teaching | 182 (181) | 2.1 |
| Medical/surgical all others ≤15 beds | 718 (650) | 1.5 |
| Medical/surgical all others >15 beds | 280 (277) | 1.5 |
| Neurologic | 24 (23) | 1.4 |
| Neurosurgical | 72 | 2.5 |
| Pediatric cardiothoracic | 18 | 3.3 |
| Pediatric medical | 16 (15) | 1.3 |
| Pediatric medical/surgical | 129 (123) | 3.0 |
| Respiratory | 8 | 1.7 |
| Surgical | 208 (207) | 2.3 |
| Surgical cardiothoracic | 203 (202) | 1.4 |
| Trauma | 62 | 3.6 |

Per 1'000 catheter-days

Edwards. *Am J Infect Control* 2009;37:783

## International Nosocomial Infection Control Consortium report, data summary for 2003-2008: ICU

| Type of ICU | No. of ICUs | No. of patients | Pooled mean CLAB rate |
|---|---|---|---|
| Coronary | 9 | 8845 | 8.5 |
| Surgical-cardiothoracic | 4 | 1683 | 3.6 |
| Medical | 12 | 11,410 | 9.0 |
| Medical-surgical | 83 | 85,989 | 7.4 |
| Neurosurgical | 5 | 2996 | 17.7 |
| Pediatric | 22 | 23,047 | 7.8 |
| Surgical | 13 | 7925 | 8.4 |
| Trauma | 3 | 2237 | 3.1 |
| Burn | 1 | 191 | 0.0 |
| Overall | 152 | 144,323 | 7.6 |

173 ICUs from: Latin America, Asia, Africa, and Europe

Rosenthal. *Am J Infect Control* 2010;38:95

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| | NHSN n/1'000 CVC-days | INICC[1] n/1'000 CVC-days |
|---|---|---|
| Coronary ICU | 2.8 | 9.9 |
| Surgical cardiothoracic ICU | 1.6 | 1.6 |
| Medical ICU | 2.9 | 10.6 |
| Medical/surgical ICU | 2.4 | 8.9 |
| Neurosurgical ICU | 3.5 | 13.1 |
| Surgical ICU | 2.7 | 17.1 |
| Trauma ICU | 4.6 | 10.6 |

[1]79 ICUs from: Argentina, Brazil, Colombia, Costa Rica, Cuba, India, Kosova, Lebanon, Macedonia, Mexico, Morocco, Nigeria, Peru, Philippines, Turkey, Uruguay

Rosenthal. *Am J Infect Control* 2008;36:627

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**Europe**

| | |
|---|---|
| United Kingdom | 2.8-5.4 per 1000 patients at risk (84 hospitals; hospital-wide) |
| Germany | 2.1 per 1000 catheter-days (309 ICUs) |

Coello. *J Hosp Infect* 2003;53:46
Gastmeier. *J Hosp Infect* 2006;64:16

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# Non - Intensive Care Units

**University of Geneva Hospitals**

**Table III** Catheter-related bloodstream infections, days at risk, utilisation rate, transfer details and reasons for placement stratified by medical departments

| | ICU | Internal medicine | Non-abdominal surgery | Abdominal surgery |
|---|---|---|---|---|
| CRBSI, ID (95% CI) | 4.91 (2.0–10.1) | 1.88 (0.2–6.8) | 2.38 (0.1–13.2) | 7.65 (2.5–17.8) |
| CVC-days | 1427 | 1066 | 420 | 654 |
| CVC utilisation rate | 30% | 4% | 2% | 5% |
| Transfer at any time | 318 (75%) | 76 (18%) | 55 (13%) | 40 (9%) |
| Location at insertion | 304 (71%) | 59 (14%) | 34 (8%) | 29 (7%) |
| Transfers to other departments | 267 (73.0%) | 50 (13.7%) | 27 (7.4%) | 22 (6.0%) |
| Reasons for CVC insertion[a] | | | | |
| Antibiotic treatment | 53/316 (17%) | 31/91 (34%) | 19/55 (35%) | 9/43 (21%) |
| Parenteral nutrition | 24/316 (8%) | 10/91 (11%) | 3/55 (6%) | 28/43 (65%) |
| Bad vein condition | 34/316 (11%) | 31/91 (34%) | 13/55 (24%) | 5/43 (12%) |
| Volume monitoring | 273/316 (86%) | 51/91 (56%) | 36/55 (66%) | 20/43 (47%) |
| Chemotherapy | 8/316 (3%) | 10/91 (11%) | 1/55 (2%) | 0 |

ICU, intensive care unit; CRBSI, catheter-related bloodstream infection; CVC, central venous catheter; ID, incidence density = episodes per 1000 CVC-days at risk; CI, confidence interval.
[a] More than one reason for insertion could apply.

Zingg. *J Hosp Infect* 2009;73:41

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Central Venous Catheter (CVC) Utilization and Catheter-Associated Bloodstream Infection (CA-BSI) Rates for 4 **General Medicine** Wards at a Teaching Hospital in St. Louis, **Missouri**

| Variable | Ward A | Ward B | Ward C | Ward D | Total |
|---|---|---|---|---|---|
| No. of CVC-days | 1,704 | 1,989 | 1,610 | 2,034 | 7,337 |
| No. of patient-days | 7,978 | 8,112 | 8,618 | 8,466 | 33,174 |
| Catheter utilization ratio[a] | 0.21 | 0.25 | 0.19 | 0.24 | 0.22 |
| CA-BSI rate[b] | 5.3 | 8.0 | 4.3 | 4.9 | 5.7 |

[a] Defined as the number of CVC-days divided by the number of patient-days.
[b] Defined as the number of CA-BSIs per 1,000 catheter-days.

Marschall. *Infect Control Hosp Epidemiol* 2007;28:905

**National Healthcare Safety Network (NHSN) Report: non-ICU**

| | No. of locations* | No. of CLABSI | Central line-days | Pooled mean |
|---|---|---|---|---|
| Medical/surgical | 617 (575) | 733 | 618,196 | 1.2 |
| Neurologic | 12 (10) | 8 | 10,723 | 0.7 |
| Neurosurgical | 15 (14) | 12 | 13,866 | 0.9 |
| Orthopedic | 56 (47) | 32 | 40,425 | 0.8 |
| Pediatric medical | 12 | 18 | 10,232 | 1.8 |
| Pediatric medical/surgical | 61 (31) | 102 | 32,581 | 3.1 |
| Postpartum | 36 (3) | 0 | 943 | 0.0 |
| Rehabilitation | 121 (106) | 39 | 47,052 | 0.8 |
| Surgical | 93 (87) | 189 | 132,336 | 1.4 |
| Vascular surgery | 8 | 13 | 11,345 | 1.1 |

Edwards. *Am J Infect Control* 2009;37:783

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## Catheter Types

## Incidence density

Events per 1000 device-days

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

PICCs
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

**Risk for CLABSI**

Maki. *Mayo Clin Proc* 2006;81:1159

## Incidence density

**CVC (2.7‰) >> Port system (0.1‰)**

…However, in proportions:

**CVC (4.4%) ≈ Port system (3.6%)**

Maki. *Mayo Clin Proc* 2006;81:1159

## Incidence density

**CVC (2.7‰) >> Peripheral lines (0.5‰)**

…However, in absolute numbers:

**CVC ≈ Peripheral lines**

Zingg. *Int J Antimicrob Agents* 2009;34:S38
Pujol. *J Hosp Infect* 2007;67:22

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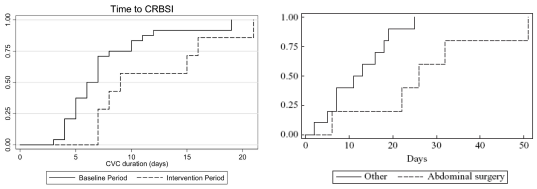
## Time to infection: CVC

**ICU** **Non-ICU**




Zingg. *Crit Care Med* 2009;37:2167
Zingg. *J Hosp Infect* 2009;73:41

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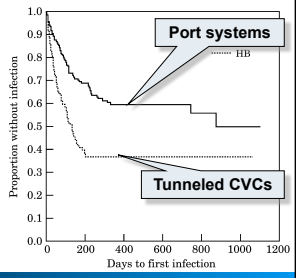
## Time to infection: port systems

→ Adults:
median of 80 days
→ Children:
mean of 100 days




Chang. *Am J Infect Control* 2003;31:34
Adler. *J Hosp Infect* 2006;62:358

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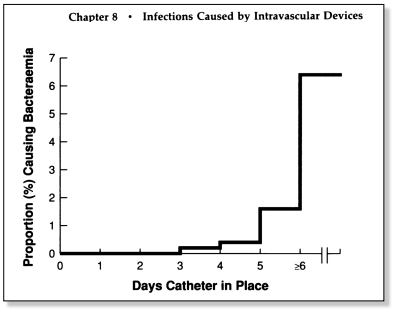
## Dwell-time

Dwell-time > 7 days → RR: 1.0-8.7

Safdar. *Medicine* 2002;81:466
Ena. *Infect Control Hosp Epidemiol* 1992;13:15
Moro. *Infect Control Hosp Epidemiol* 1994;15:253




Waldvogel: Infections Associated with Indwelling Medical Devices, 3rd Ed.

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## Insertion Site

| | RR |
|---|---|
| Internal jugular access | 1.0-3.3 |
| ***Subclavian access*** | 0.4-1.0 |
| Femoral access | 3.3-4.8 |

**However:** no difference of catheter colonization (40.8 vs. 35.7 per 1000 catheter-days) and CLABSI (2.3 vs. 1.5 per 1000 catheter-days) hemodialysis catheters

Parienti. *JAMA* 2008;299:2413

Goetz. *Infect Control Hosp Epidemiol* 1998;19:842
Merrer. *JAMA* 2001:286:700
Ruesch. *Crit Care Med* 2002;30:454

## Lumen

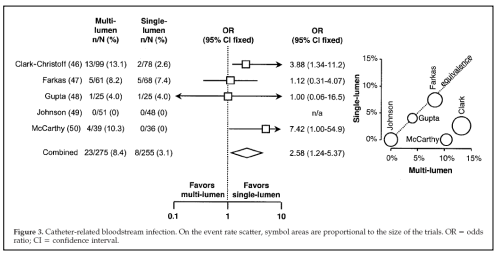



Figure 3. Catheter-related bloodstream infection. On the event rate scatter, symbol areas are proportional to the size of the trials. OR = odds ratio; CI = confidence interval.

Zürcher. *Anesth and Analg* 2004;99:177





## Contaminated intravenous products

There is evidence in the literature about smaller and larger epidemics with contaminated intravenous products

Mackel. *J Clin Microbiol* 1975;2:486
Maki. *Am J Med* 1976;60:471
Matsaniotis. *Infect Control* 1984;5:471





## Insertion without using appropriate (maximal) sterile barrier precautions (MSB)

Sterile gloves, sterile body gown, face mask, head cap, full-size sterile drape around the insertion site

- Insertion without MSB[1]:
  → Risk CRBSI ↑ (RR 2.1)
- Insertion with MSB[2]:
  → Risk CRBSI ↓ (RR 0.2)

[1]Mermel. *Am J Med* 1991;91:S197 (Swan Ganz catheters)
[2]Raad II. *Infect Control Hosp Epidemiol* 1994;15:231

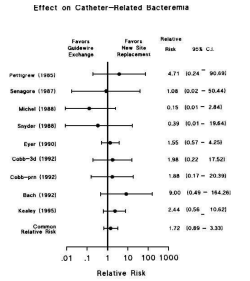




## Guidewire exchange

The use of a guidewire for CVC replacement may be a risk factor

RR: 1.0-3.3




Cobb. *New Engl J Med* 1992;327:1062
Safdar. *Medicine* 2002;81:466
Cook. *Crit Care Med* 1997;25:1417





## Parenteral nutrition

Parenteral nutrition and especially the lipids are associated with the risk for catheter-associated bloodstream infection: RR 1.04–4.79

Safdar. *Medicine* 2002;81:466
Robert. *Infect Control Hosp Epidemiol* 2000;21:12
Opilla. *JPEN J Parenter Enteral Nutr* 2007;31:302





## Catheter-related thrombosis

Catheter-related central vein thrombosis is a “frequent” complication of central venous catheterization in ICU patients and is closely associated with catheter-related sepsis: RR 2.62

Timsit. *Chest* 1998;114:207

**Composition of nursing staff and workload**

Lower regular-nurse-to-patient and higher pool nurse-to-patient ratios (OR 3.4) are risk factors for CRBSI.

Robert. *Infect Control Hosp Epidemiol* 2000;21:12
Hugonnet. *Crit Care Med* 2007;35:76



**Povidone iodine vs. Chlorhexidine**

The use of chlorhexidine (2% aqueous or 0.25-0.5 alcohol-based), rather than 10% povidone-iodine for cutaneous disinfection before insertion of an intravascular device and for post-insertion site care can substantially reduce the incidence of device related infection.

Maki. *Lancet* 1991;338:339
Mimoz. *Crit Care Med* 1996;24:1818



**Hand hygiene**

Hand hygiene promotion, guided by health care workers' perceptions, identification of the dynamics of bacterial contamination of health care workers' hands, and performance feedback, is effective in sustaining compliance improvement and is independently associated with infection risk reduction.

Pessoa-Silva. *Pediatrics* 2007;120:e382
Zingg. *Crit Care Med* 2009;37:2167







- Hand hygiene
- Maximal sterile barrier precautions
- Chlorhexidine rather than povidone-iodine for skin antisepsis
- Avoiding femoral access
- Single lumen if possible
- Remove catheter as soon as possible
- Good work organization
- No guidewire exchange
- No routine catheter change



**Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care**

*Philippe Eggimann, Stephan Harbarth, Marie-Noëlle Constantin, Sylvie Touveneau, Jean-Claude Chevrolet, Didier Pittet*

**Multimodal Intervention:**

- Education
- Standardized Processes
- MSB
- Chlorhexidine
- Hand hygiene
- CVC care

Eggimann. *Lancet* 2000;355:1864

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- 2 Intensive care units
- 2‘104 patients at baseline
- 1‘050 patients at intervention
- 13‘200 patient days

Eggimann. *Lancet* 2000;355:1864

| Guidelines | Control period* |
|---|---|
| **Material preparation** | Based on physicians' individual preferences. |
| **Positioning of patient** | According to nursing habits acquired elsewhere—eg, nursing school, hospital wards. |
| **Line insertion** | General institutional recommendations. |
| Skin preparation | Hair-shaving. |
| Skin antisepsis | Povidone iodine 10% or alcohol-based (70%) solution of chlorhexidine gluconate (0-5%). |
| Barrier precautions | Sterile gloves, small fenestrated sheets, paper mask. |
| Insertion technique | Various techniques; no specific training of ICU physicians. |
| **Dressing** | Several types according to individual non-standardised criteria. Transparent occlusive dressings or preprepared devices for peripheral lines. |
| **Replacement** | Every 24 h for all dressings, administration sets, and devices. |
| **General handling** | Universal precautions. |
| **Device removal** | Peripheral line: after 3–5 days. Central line: no specific recommendations. |
| **Hand hygiene during insertion and care** | Handwashing with surgical soap in sink before and after each patient care, or hand disinfection. |

| Guidelines | Intervention period† |
|---|---|
| **Material preparation** | Material prepared according to detailed list to avoid interruption during insertion (cards available in preparation room). |
| **Positioning of patient** | Recommendations for placing of patients and devices to permit optimum access to insertion site. Presence of nurse to assist physician mandatory. |
| **Line insertion** | Detailed written guidelines. |
| Skin preparation | Hair-cutting instead of shaving. Skin cleansing with surgical swab. |
| Skin antisepsis | Alcohol-based (70%) solution of chlorhexidine gluconate (0-5%), with 2-min drying time before insertion. |
| Barrier precautions | Sterile gown and gloves, large sheets, cap, surgical mask (except for peripheral lines). |
| Insertion technique | Specific training of ICU physicians;‡ promotion of subclavian (CVC) and wrist vein (short lines) sites. |
| **Dressing** | Occlusive devices not allowed. Written guidelines for dressing. Replaced every 72 h except for the first dressing after catheter insertion. Dry gauze-based dressing occluded with porous adhesive band obligatory. |
| **Replacement** | Every 72 h for administration sets and devices; every 24 h for lipid emulsion lines. Lines for blood product infusions immediately removed after use. |
| **General handling** | Opening of hub: on antiseptic-impregnated pads after hand disinfection. General measure: new caps after any opening of hubs. |
| **Device removal** | Peripheral line: after 72 h systematically. Central line: as clinically indicated, no routine replacement. Any access: prompt removal if not absolutely necessary. Clinical sepsis: guidewire exchange if unexplained. |
| **Hand hygiene during insertion and care** | Hand disinfection: strongly emphasised before and after any care. Handwashing: for soiled hands, followed by hand disinfection. |

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| Nosocomial infections | Control period | | Intervention period | | p |
|---|---|---|---|---|---|
| | | Incidence density | | Incidence density | |
| **Bloodstream** | | 11·3 | | 3·8 | 0·75 |
| Microbiologically documented | | 3·1 | | 1·2 | <0·0001 |
| Clinical sepsis | | 8·2 | | 2·6 | 0·04 |
| **Exit-site catheter** | | 9·2 | | 3·3 | <0·0001 |
| Skin or mucous membranes | 102 | 11·4 | 30 | 7·0 | 0·62 (0·41–0·93) | 0·02 |
| Miscellaneous* | 15 | 1·7 | 9 | 2·1 | 1·26 (0·55–2·87) | 0·66 |
| Total | 468 | 52·4 | 145 | 34·0 | 0·65 (0·54–0·78) | <0·0001 |

*Including secondary bloodstream infections occurring during the control period (one *Candida albicans* urinary-tract infection) and the intervention period (one each of *Enterobacter cloacae* skin and urinary-tract infections; one *C albicans* urinary-tract infection).

Eggimann. *Lancet* 2000;355:1864

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An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU

Peter Pronovost, M.D., Ph.D., Dale Needham, M.D., Ph.D., Sean Berenholtz, M.D., David Sinopoli, M.P.H., M.B.A., Haitao Chu, M.D., Ph.D., Sara Cosgrove, M.D., Bryan Sexton, Ph.D., Robert Hyzy, M.D., Robert Welsh, M.D., Gary Roth, M.D., Joseph Bander, M.D., John Kepros, M.D., and Christine Goeschel, R.N., M.P.A.

**Bundle:**

- Hand hygiene
- MSB
- Skin antisepsis with chlorhexidine
- Avoiding femoral access
- Remove of needless CVC

Pronovost. *New Engl J Med* 2006;355:2725

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- 103 Intensive care units in Michigan
- 18 Months follow-up
- 1‘981 Months cumulated
- 375’757 CVC days

Pronovost. *New Engl J Med* 2006;355:2725

median/1'000 CVC days

Table 3. Rates of Catheter-Related Bloodstream Infec… …seline (before Implementation of the Study Intervention) to 18 Months of Follow-up.*

| Study Period | No. of ICUs | No. of Bloodstream Infections per 1000 Catheter-Days | | | | |
|---|---|---|---|---|---|---|
| | | Overall | Teaching Hospital | Nonteaching Hospital | <200 Beds | ≥200 Beds |
| | | median (interquartile range) | | | | |
| Baseline | 55 | 2.7 (0.6–4.8) | 2.7 (1.3–4.7) | 2.6 (0–4.9) | 2.1 (0–3.0) | 2.7 (1.3–4.8) |
| During implementation | 96 | 1.6 (0–4.4)† | 1.7 (0–4.5) | 0 (0–3.5) | 0 (0–5.8) | 1.7 (0–4.3)† |
| After implementation | | | | | | |
| 0– 3 mo | 96 | 0 (0–3.0)‡ | 1.3 (0–3.1)† | 0 (0–1.6)† | 0 (0–2.7) | 1.1 (0–3.1)‡ |
| 4–6 mo | 96 | 0 (0–2.7)‡ | 1.1 (0–3.6)† | 0 (0–0)‡ | 0 (0–0)† | 0 (0–3.2)‡ |
| 7–9 mo | 95 | 0 (0–2.1)‡ | 0.8 (0–2.4)‡ | 0 (0–0)‡ | 0 (0–0)† | 0 (0–2.2)‡ |
| 10–12 mo | 90 | 0 (0–1.9)‡ | 0 (0–2.3)‡ | 0 (0–1.5)‡ | 0 (0–0)† | 0.2 (0–2.3)‡ |
| 13–15 mo | 85 | 0 (0–1.6)‡ | 0 (0–2.2)‡ | 0 (0–0)‡ | 0 (0–0)† | 0 (0–2.0)‡ |
| 16–18 mo | 70 | 0 (0–2.4)‡ | 0 (0–2.7)‡ | 0 (0–1.2)† | 0 (0–0)† | 0 (0–2.6)‡ |

Pronovost. *New Engl J Med* 2006;355:2725

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Pronovost. *New Engl J Med* 2006;355:2725

**mean/1'000 CVC days: 7.7**

median/1'000 CVC days

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Pronovost. *New Engl J Med* 2006;355:2725

**mean/1'000 CVC days: 7.7**

**mean/1'000 CVC days: 1.4**

*Epidemiology and Prevention of Bloodstream Infections*

Impact of a prevention strategy targeting hand hygiene and catheter care on the incidence of catheter-related bloodstream infections*

Walter Zingg, MD; Alexander Imhof, MD; Marco Maggiorini, MD; Reto Stocker, MD; Emanuela Keller, MD; Christian Ruef, MD

**Interventions:**

- Hand hygiene
- Catheter care

Zingg. *Crit Care Med* 2009;37:2167

*Epidemiology and Prevention of Bloodstream Infections*

- 5 Intensive care units
- Cohort study
- Baseline and intervention
- 7279 CVC days

Zingg. *Crit Care Med* 2009;37:2167

| Module | Topic | Intervention | Details |
|---|---|---|---|
| I | Hand hygiene | Hand washing | When starting work<br>When finishing work<br>When hands are visibly soiled<br>After visiting the toilet |
| | | Hand rubbing | Before/after patient contact<br>Before/after invasive acts<br>Before/after manipulation of catheters or tubings<br>Before/after dressing changes<br>After direct contact with biological fluids<br>After glove removal |
| | | Hand rubbing technique | 20 sec with alcohol-based hand rub<br>Use enough disinfectant (>3 mL = pushing two times hand rub dispenser); redose if necessary<br>Six steps (European norm EN 1500:1997) |
| II | Catheter site dressing | Skin disinfection | Choice of:<br>Povidone iodine<br>Isopropyl alcohol<br>Octenidine |
| | | Material | Gauze: change after 48 hrs<br>Opsite IV 3000: change after 7 days* |
| | | Instant changing | Dressing does not cover entirely insertion site<br>Incomplete adherence of dressing<br>Secondary hemorrhage<br>Dressing is soggy<br>CVC is under pressure<br>Pain at insertion site |
| | | Technique | Hand rub before and after changing dressing<br>Prepare and check for completeness of the entire material before starting to change the dressing<br>Wear sterile gloves<br>Use a "non-touch-technique" during the whole procedure<br>Assessment of catheter insertion site<br>Use enough disinfectant at catheter insertion site<br>Use enough disinfectant<br>Respect incubation time of the disinfectant!<br>Avoid tension of the catheter |
| III | CVC manipulation | Technique | Strictly separate sterile and nonsterile material<br>"Non-touch-technique":<br>Always respect as much distance as possible to the system<br>Manipulate the catheter as little as possible<br>Replace administration sets no more frequently than at 72-hr intervals<br>Reduce components to a minimum<br>Disconnect tubing only when absolutely necessary<br>Reduce blood sampling through the catheter and use strict aseptic technique |
| IV | Preparation of infusates | Technique | Hand rub before preparation<br>Prepare a clean work place<br>Check for completeness of the entire material before preparing infusates<br>Use a "non-touch-technique" during the whole procedure<br>Always disinfect plugs |

Project adoption

↓

Education of head nurses and teaching nurses

↓

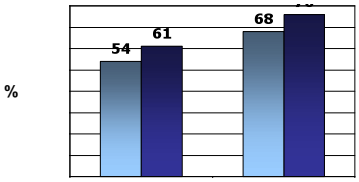
Ex-cathedra teaching

↓

Bedside teaching

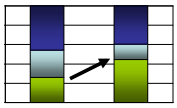
## Compliance with hand hygiene

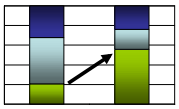
→ **improvement not impressive…**




**BUT…**

Zingg. *Crit Care Med* 2009;37:2167

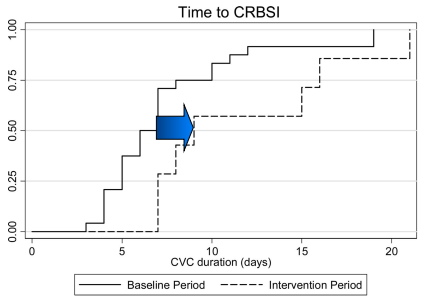




| | Baseline | Intervention |
|---|---|---|
| Incidence density (n/1'000 CVC Tage) | 3.9 | 1.0 |
| Time to infection (mean ±SD) | 6.52 ±3.48 | 9.3 ±6.63 |

Zingg. *Crit Care Med* 2009;37:2167

## Time-to-infection




Zingg. *Crit Care Med* 2009;37:2167

*Epidemiology and Prevention of Bloodstream Infections*

The effect of process control on the incidence of central venous catheter–associated bloodstream infections and mortality in intensive care units in Mexico*

Francisco Higuera, MD; Victor Daniel Rosenthal, MD, MSc, CIC; Pablo Duarte, MD; Javier Ruiz, MD; Guillermo Franco, MD; Nasia Safdar, MD

**Interventions:**

- CVC care
- Hand hygiene

Huguera. *Crit Care Med* 2005;33:2022

*Epidemiology and Prevention of Bloodstream Infections*

- 2 Intensive care units
- 12 Baseline and intervention
- 3,429 CVC days

Huguera. *Crit Care Med* 2005;33:2022

**46.3**/1'000 CVC days

**19.5**/1'000 CVC days

| Finding | Phase 1 | Phase 2 | RR | 95% CI | *p* |
|---|---|---|---|---|---|
| No. of BSIs | 28 | 55 | | | |
| IVD-days | 605 | 2824 | | | |
| BSI per 1000 IVD-days | 46.3 | 19.5 | 0.42 | 0.27–0.66 | .0001 |
| Total patients (n = 470) | 132 | 338 | | | |
| Total deaths (n = 175) | 64 | 111 | | | |
| Crude mortality rate (%) | 48.5 | 32.8 | 0.68 | 0.50–0.91 | .01 |

RR, relative risk; CI, confidence interval.

Decrease of CRBSI in a high prevalence setting by improving hand hygiene and catheter care.

Huguera. *Crit Care Med* 2005;33:2022

## CVC-bundle

1. Hand hygiene
2. Use of maximal sterile barrier precaution measures at catheter insertion
3. Skin antisepsis with chlorhexidine-containing products*
4. Subclavian access as the preferred insertion site for non-tunnelled catheters
5. Daily review of line necessity with prompt removal of unnecessary catheters

* e.g. 70% alcohol & 0.5% chlorhexidine-gluconate.





| Coating | Catheter colonization $n_{cvc}$ RR (95% CI) | CRBSI[1] $n_{cvc}$ RR (95% CI) |
|---|---|---|
| CHG/silver-sulfadiazine (external) | 2841 **0.59** (0.50-0.71) | 3016 **0.31** (0.06-1.54) |
| CHG/silver-sulfadiazine (external/internal) | 1070 **0.44** (0.23-0.85) | 1070 **0.70** (0.30-1.62) |
| Silver, platinum, carbon | 720 **0.76** (0.57-1.01) | 970 **0.54** (0.16-1.85) |
| Minocycline/rifampicin | 1063 **0.40** (0.23-0.67) | 840 **0.39** (0.17-0.92) |
| Chlorhexidine alone | 254 **1.11** (0.80-1.55) | 254 **2.37** (0.63-8.96) |
| Cefazolin | 518 **0.59** (0.04-7.72) | NA |
| Vancomycin | 176 **0.77** (0.63-0.93) | NA |

Ramritu. *Am J Infect Control* 2008;36:104



## Closed system using collapsible infusion bags

Rosenthal. *Am J Infect Control* 2004;32:135
Franzetti. Epidemiol Infect 2009;137:1041



4 level III ICUs in Buenos Aires, Argentina

608 open systems – 384 closed systems

| | Open system | Closed system | RR (95% CI) | *P* value |
|---|---|---|---|---|
| Catheter-days, No. | 4140 | 2117 | | |
| Catheter-associated bacteremias, No. | 27 | 5 | | |
| Incidence, per 1000 CVC-days | 6.52 | 2.36 | 0.36 (0.14-0.94) | .02 |

Rosenthal. *Am J Infect Control* 2004;32:135



**Meta-analysis: 4 identical interrupted time-series cohort trials**

Open fluid containers (glass or semi-rigid plastic) vs closed system (plastic fluid bags)

Methods: open system for 6-9 months followed by exclusive use of a closed system

## Pooled results:

| Patients | 2237 open system | 2,136 closed system | |
|---|---|---|---|
| CLABSI: | 10.1/1000 line-days | 3.3 per 1000 line-days | (p<0.001) |
| Mortality*: | 22.0/100 patients | 16.9/100 patients | (p<0.001) |

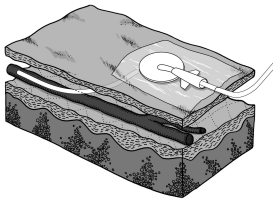
Maki, Rosenthal. *ICAAC* 2009;K-300
*All-cause mortality

## Chlorhexidine-impregnated sponge

| Control<br>n/1'000 CVC-days | Sponge<br>n/1'000 CVC-days |
|---|---|
| 7.2 | 3.8 |

p=0.02

Dwell-times: 15.8 (control), 16.6. (sponge)



Ruschulte. *Ann Hematol* 2008;88:267

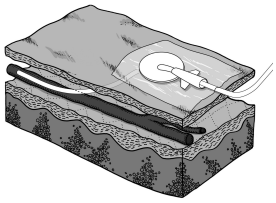


## Chlorhexidine-impregnated sponge

**Multicenter randomized controlled trial – ICUs in France**

| Control<br>n/1'000 CVC-days | Sponge<br>n/1'000 CVC-days |
|---|---|
| 1.3 | 0.4 |

p=0.004



Timsit. *JAMA* 2009;301:1231



## Lock solutions

- **Taurolidine-citrate**
- **Ethanol**
- **Chelators**
- **Methylene blue**



## Lock solutions

**Taurolidine**

→ In vitro studies: 6
→ In vivo studies: 11 (2 case reports; 7-70 included patients in cohort or randomized studies
→ 7/11 used taurolidine-***citrate*** 4%

Bradshaw. *J Pediatr Gastroenterol Nutr* 2008;47:179



## Lock solutions

| | Controls | TauroLock™ |
|---|---|---|
| Patients | 90 | 89 |
| Age (median) | 10.4 | 7.2 |
| Port-days | 3672 | 3989 |
| Tunneled CVC-days | 2414 | 2716 |

Simon. *BMC Infect Dis* 2008;8:102



## Lock solutions

| | Controls | TauroLock™ | |
|---|---|---|---|
| Bacteraemia | 30 | 25 | ns |
| Bacteraemia with CoNS* | 14 | 3 | 0.004 |
| ID all bacteraemia | 4.9 | 3.8 | ns |
| ID CoNS* | 2.3 | 0.5 | 0.004 |

More infections with Gram-positives et Gram-negatives!

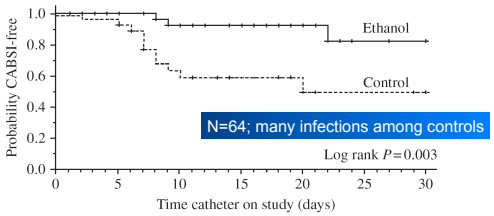
Results **encouraging** but not **conclusive!**

Simon. *BMC Infect Dis* 2008;8:102
*CoNS: coagulase negative Staphylococcus

*Epidemiology and Prevention of Bloodstream Infections*

## Lock solutions

### Ethanol




Sanders. *J Antimicrob Chemother* 2008;62:809

*Epidemiology and Prevention of Bloodstream Infections*

## Lock solutions

### Ethanol

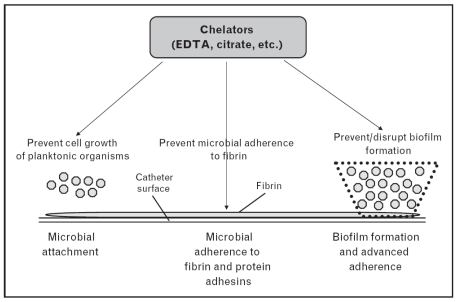
Ethanol 40-80% efficient in vitro…

**…but results were disappointing in a large randomized controlled trial (359 catheters*; 4 vs. 5 CLABSI)**

*PICCs (249), Hemodialysis catheters (63), Hickman catheters (47)

Crnich. 49th ICAAC 2009; San Francisco

## Lock solutions: Chelators




Raad II. *Curr Opin Infect Dis* 2008;21:385

## Lock solutions: Chelators

| Catheter lock solution | Catheter lock solution group | Control group | *P*-value |
|---|---|---|---|
| [1]M–EDTA | 1/11 | 9/14 | 0.01 |
| [1]M–EDTA | 0/14 | 10/48 | 0.05 |
| [1]M–EDTA | 1/7 | 47/7 | 0.0001 |
| [1]M–EDTA | 0/3 | 40/3[c] | <0.01 |
| Taurolidine–citrate | 0/37 | 4/39 | 0.047 |
| Taurolidine–citrate | 1/20 | 16/30 | <0.001 |
| Gentamicin–citrate | 0/53 | 7/55 | 0.002 |
| [2]TSC | 9/148 | 33/143 | <0.001 |

Small numbers!

[1]Minocycline-EDTA
[2]Trisodium citrate

Raad. *Curr Opin Infect Dis* 2008;21:385

*Epidemiology and Prevention of Bloodstream Infections*

## Lock solutions

### Citrate - Methylene blue – Paraben*

Sodium-citrate: 7%
Methylene blue: 0.05% + paraben

408 patients with 49,565 catheter-days
(207 controls [heparin]; 201 in C-MB-P group)

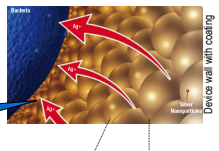
| C-MB-P* | Controls | |
|---|---|---|
| 0.24/1000 catheter-days | 0.82/1000 catheter-days | (p=0.005) |
| 0 patency failure | 4 patency failure | (p=0.120) |

Maki. *ICAAC* 2009;K-1235

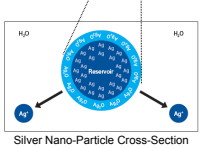
## Luer Activated Device (V-Link®)

The proprietary coating process results in a surface deposition consisting of tightly bound silver nano-particles that serve as reservoirs of silver ions.

Controlled silver-release




The V-Link device's VitalShield coating contains a nano-structure with a surface layer of $Ag_2O$ that controls the release of Ag+ when in contact with solution.




Silver Nano-Particle Cross-Section

Kindly provided by Baxter

1. Pathogenesis
2. Definition
3. Epidemiology
4. Risk factors
5. Procedural Interventions
6. Technical Interventions
7. **Summary**

## Zero Central Line Associated Bloodstream Infections: *…how to get there…*

- Multimodal intervention
- Bundle approach
- The "last mile" may require the use of some technical device (chlorhexidine patch, coated catheters, impregnated luer activated device, lock solutions…)



**The most important measures:**

**Standardized Processes** of insertion, catheter care and catheter removal – **Written Protocols**



**The most important measures:**

**Insertion**
- Maximal sterile precautions
- Hand hygiene
- Avoid femoral insertion site
- Checklist (stop CVC insertion procedures if guidelines are not followed)

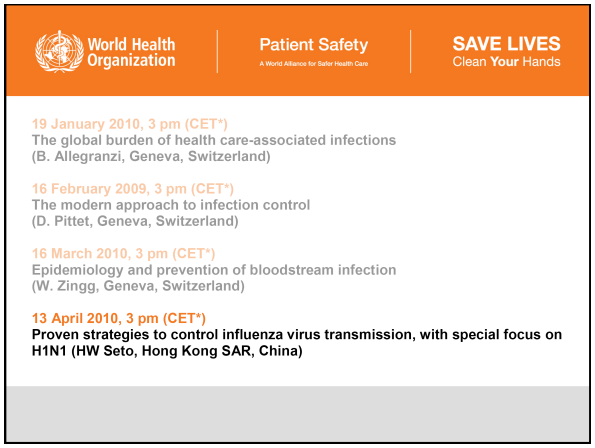


**The most important measures:**

Good **catheter care**
- Accurate dressings
- Daily evaluation of CVC and insertion site
- Accurate changing of tubes and hubs
- **Remove CVC**, as soon as possible



**Thank you**


World Health Organization
Patient Safety
A World Alliance for Safer Health Care
SAVE LIVES
Clean Your Hands
19 January 2010, 3 pm (CET*)
The global burden of health care-associated infections
(B. Allegranzi, Geneva, Switzerland)
16 February 2009, 3 pm (CET*)
The modern approach to infection control
(D. Pittet, Geneva, Switzerland)
16 March 2010, 3 pm (CET*)
Epidemiology and prevention of bloodstream infection
(W. Zingg, Geneva, Switzerland)
13 April 2010, 3 pm (CET*)
Proven strategies to control influenza virus transmission, with special focus on H1N1 (HW Seto, Hong Kong SAR, China)