Zero tolerance for catheter related infections: is it a dream for developing countries?

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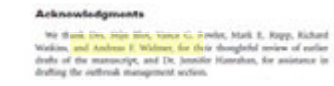
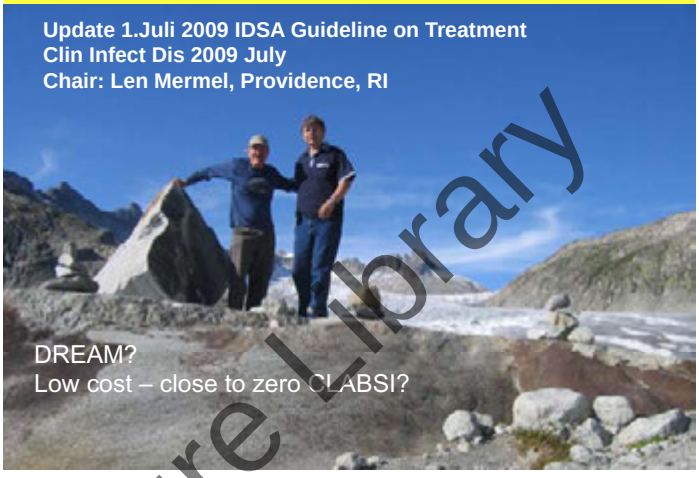
Clinical Practice Guidelines for the Diagnosis and Management of Intravascular Catheter-Related Infection: 2009 Update by the Infectious Diseases Society of America

CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011



Mermel LA et al, IDSA Guidelines. Clin Infect Dis 2009

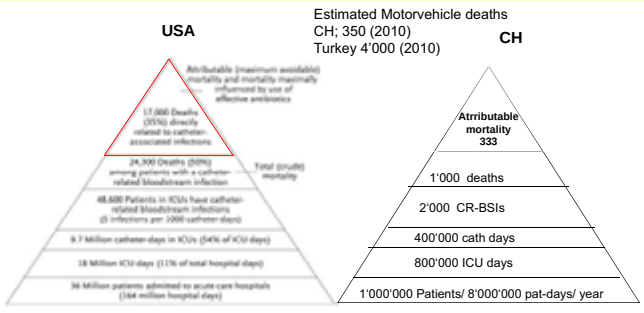


Magnitude of the Problem

- 15 Mio CVC days per year in the US
- 5.3 CA-BSIs / 1000 catheter days
- 250,000 Episodes of CA-BSIs in ICUs/year
- Estimated 9'600-20'000 deaths/year due to CA-BSIs
- Attributable mortality: 12-25%
- Attributable cost per episode: 3'700-29'000 US $

CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011
CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections. MMWR 2002;51:# RR-10

Annual Patient Stays in the 6`000 Acute Care Hospitals and Associated ICUs in the United States



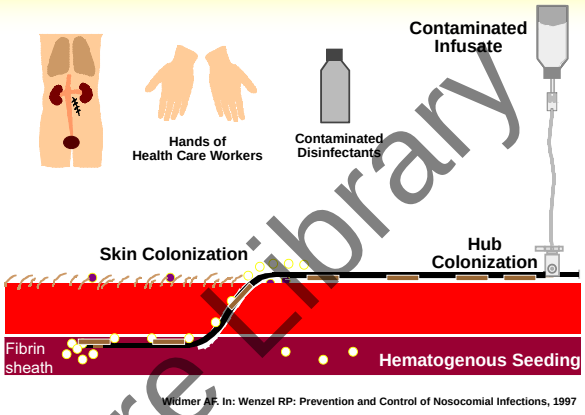
Wenzel R and Edmond M. N Engl J Med 2006;355:2781-2783

https://www.cia.gov/library/publications/the-world-factbook/geos/tu.html

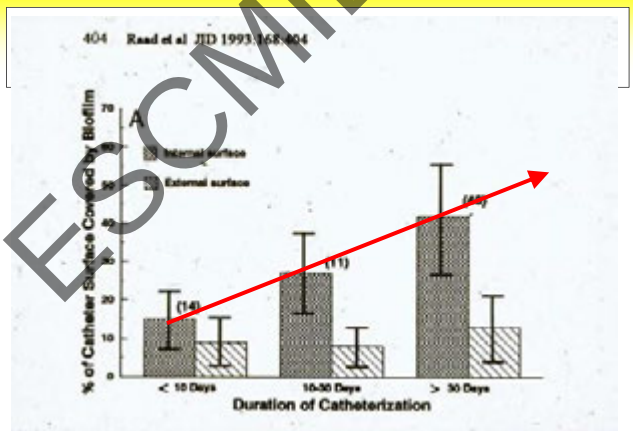
Catheter use: Expected Rate of CR-BSIs

Device	prospective studies	mean (CI_{95}) per 100 catheters		mean (CI_{95}) per 1000 cath days	
Peripheral venous catheter	13	0.2	(0.1–0.3)	0.6	(0.3–1.2)
Arterial catheter	6	1.5	(0.9–2.4)	2.9	(1.8–4.5)
Short-term, nonmedicated CVC	*61*	*3.3*	*(3.3–4.0)*	*2.3*	*(2.0–2.4)*
Pulmonary-artery catheter	12	1.9	(1.1–2.5)	5.5	(3.2–12.4)
Hemodialysis catheter					
Noncuffed	15	16.2	(13.5–18.3)	2.8	(2.3–3.1)
Cuffed	6	6.3	(4.2–9.2)	1.1	(0.7–1.6)
PICC	8	1.2	(0.5–2.2)	0.4	(0.2–0.7)
Long-term tunneled and cuffed CVC	18	20.9	(18.2–21.9)	1.2	(1.0–1.3)
Port a cath	13	5.1	(4.0–6.3)	0.2	(0.1–0.2)

Crnich CJ & Maki DG. CID 2002; 34:1232–42



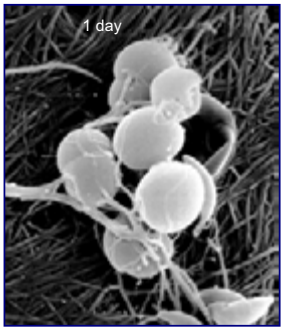
Widmer AF. In: Wenzel RP: Prevention and Control of Nosocomial Infections, 1997

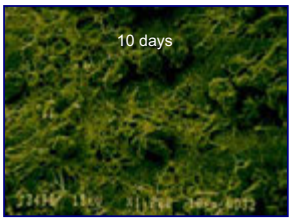


Susceptibility to Infection
Minimum Infectious Dose

	Implant	without Implant
Elek, 1957 S.aureus	10^2 cfu/mL	10^6 cfu/mL
Zimmerli, 1982 S.aureus	10^2 cfu/mL	10^6 cfu/mL
Widmer, 1989 S.epidermidis	10^3 cfu/mL	10^6 cfu/mL

Biofilm Formation on Catheters





Minimal Bactericidal Concentration (MBC)

Coagulase-negative staphylococci oxa R

Antibiotic	Phases of Bacterial Growth: Logarithmic	Stationary	Fold Increase
	MHB	PBS	
Vancomycin	4 µg/ml	50 µg/ml	12.5
Daptomycin	2 µg/ml	12.5 µg/ml	6
Teicoplanin	4 µg/ml	12.5 µg/ml	3
Ciprofloxacin	0.5 µg/ml	100 µg/ml	200
Rifampin	0.06 µg/ml	0.15 µg/ml	2.5
Netilmicin	8 µg/ml	400 µg/ml	50

Widmer AF. J Infect Dis 1990;162:96-100

Definitions and Epidemiology

Surveillance Definition CA-BSI

Catheter-associated bloodstream infec -BSI):
Defined by the following:
A CLABSI is a primary BSI in a pa a central line within the 48-hour period bef lopment of the BSI and is not bloodstream infection at another site. Bloodstream infe dered to be associated with a central line as in use during the 48-hour period elopment of the bloodstream infection“ and oth rces have been ruled out

Surveillance Definition

CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections. MMWR 2002;51:# RR-10

Clinical Definition CR-BSI

Catheter-related bloodstream infection (CR-BSI):

isolation of the same organism (i.e., identical species, antibiogram) from a semiquantitative or quantitative culture of a catheter segment and from the blood (preferably drawn from a peripheral vein) of a patient with accompanying clinical symptoms of BSI and no other apparent source of infection. In the absence of laboratory confirmation, defervescence after removal of an implicated catheter from a patient with BSI may be considered indirect evidence of CR-BSI.

- positive semiquantitative culture ≥15 CFU) (tip OR sc segment CFU/catheter segment culture (Sonication)
- 2 simulataneous quantitative blood cultures with a ≥ 5:1 Ratio
- Differential time period to positivity of CVC culture vs peripheral blood culture (automated BC system) > 2 hrs

CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections. MMWR 2002;51:# RR-10

Signs and Symptoms of CR- BSIs

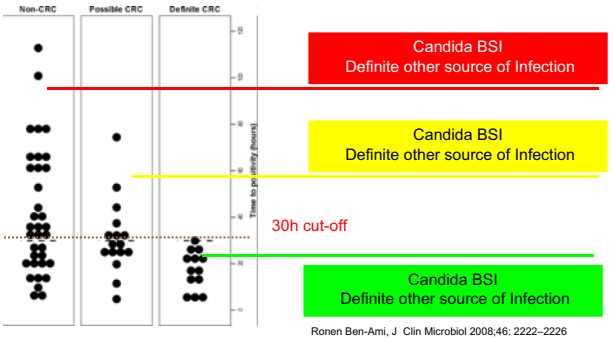
Parameters	No. (%) of CVCs n=1263		Noncolonized and CVC-related BSI, n = 35	Colonized CVCs, n = 333	Uninfected CVCs, n = 894
Pain	**(0, 1)**	**25 (2%)**	**0.0**	**0.2 ±0.4**	**0.2 ±0.4**
Erythema	**(0–2)**	**25 (2%)**	**0.0**	**0.1 ±0.3**	**0.1 ±0.2**
Swelling	**(0, 1)**	**126 (10%)**	**0.2 ±0.4**	**0.1 ±0.4**	**0.1 ±0.4**
Purulence	**(0, 1)**	**10 (0.8%)**	**0**	**0.0 ±0.1**	**0**
Overall	**(0–5)**	**126 (10.0%)**	**0.2 ±0.4**	**0.1 ±0.1**	**0.1 ±0.1**

Safdar N & Maki D. Crit Care Med 2002; 30:2632–2635

Accuracy of Diagnosis of Catheter-associated Infection by „Differential Time to Positivity“: ▲ 2hrs

	Cath-type	Sensitivity	Specifity	PPV	NPV
Blot et al J.Clin Microbiol 1998;36:105-109,	---	96%	100%	100%	93%
Blot et al 1999	LT/ST	94%	91%	94%	91%
Seifert H. 2003	ST	82%	88%	75%	92%
Raad II Ann Intern Med 2004	ST LT	81% 93%	92% 75%	94% 86%	84% 87%
Bouza E. 2007	ST	96%	90%	61%	99%

Differential Time to Positivity (DTP) among Patients with Suspected Catheter-Related Candidemia.



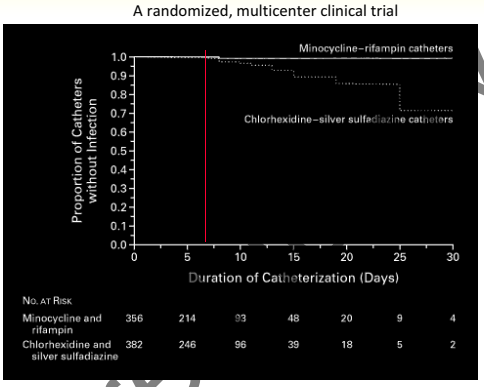
Ronen Ben-Ami, J Clin Microbiol 2008;46: 2222–2226

Infection Control Activity

Coating of Catheters

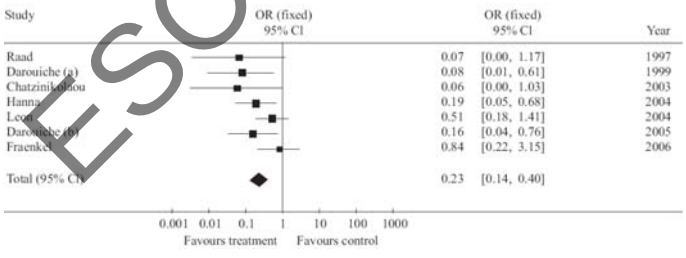
CVCs impregnated with minocycline and rifampin vs chlorhexidene gluconate and silver sulfadiazine

A randomized, multicenter clinical trial



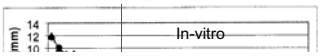
Darouiche and Raad II. NEJM 1999;340:1-8.)

CR-BSIs: Meta-analysis rifampicin and minocycline-CVCs versus uncoated CVCs



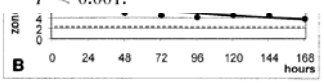
Falagas ME. Journal of Antimicrobial Chemotherapy (2007) 59, 359–369

In Vivo Anti-infective Efficacy of the New Coated CHX/SDD Catheter



Catheter type	Total no. of catheters	Log_{10} CFU *S. aureus* removed (mean ± SD)	% of catheters with purulence at insertion site
CS1	44	4.3 ± 2.8^b	64^b
CS2	45	0.3 ± 0.9^b	0^b

[a] The inoculation occurred 2 days after catheter implantation.
[b] $P < 0.001$.



Bassetti S. AAC 2001;45:1535–1538

Second Generation C/SS-Coated vs. Uncoated Short-Term Central Venous Catheters

3x higher concentration of chlorhexidine on external surface, and chlorhexidine incorporated onto luminal surface of catheter, hub, and extension lines

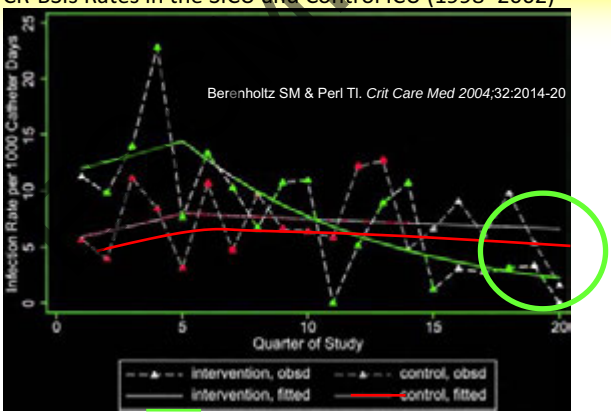
Outcome	Coated	Control	*P*
Catheter Colonization	32/345 (9%)	59/362 (16%)	<0.01
Catheter-related BSI	1/345 (0.3%)	3/362 (0.8%)	NS
BSI/1000 catheter-days	0.42	1.24	NS

Rupp M. et al. Ann Intern Med 2006;143:570-80

Infection Control Activity

Teaching

CR-BSIs Rates in the SICU and Control ICU (1998–2002)



The Intervention: Michigan Intervention ICU study

1. **Hand washing**
2. full-barrier precautions during the insertion of CVCs
3. cleaning the skin with chlorhexidine
4. avoiding the femoral site, if possible,
5. removing unnecessary catheters

Pronovost P et al. N Engl J Med 2006;355:2725-2732

Characteristics of 103 Participating ICUs, According to the Period of Implementation of the Intervention to Reduce the Rate of Catheter-Related Bloodstream Infections

Table 1. Characteristics of 103 Participating ICUs, According to the Period of Implementation of the Intervention to Reduce the Rate of Catheter-Related Bloodstream Infections.

Period	No. of ICUs	No. of Catheter-Days per Month (median (interquartile range))	Teaching Hospital (%)	No. of Beds (median (interquartile range))
March to May 2004*	40	154 (94–258)	83	404 (268–609)
June to August 2004	35	146 (72–228)	57	336 (218–610)
September to November 2004	17	181 (80–275)	59	299 (190–393)
After November 2004	11	172 (48–279)	73	288 (181–917)

* Baseline data were not collected by ICUs implementing the study intervention during the baseline (preimplementation) period.

Study sample: >25'000 catheter days

Pronovost P et al. N Engl J Med 2006;355:2725-2732

The Intervention

USA	Europe
1. Hand washing	1. Hand hygiene with alcoholic compound
2. full-barrier precautions during the insertion of CVCs	2. full-barrier precautions during the insertion of CVCs
3. cleaning the skin with chlorhexidine	3. cleaning the skin with chlorhexidine, (alternative: octenidin, polihexanide
4. avoiding the femoral site, if possible,	4. avoiding the femoral site, if possible,
5. removing unnecessary catheters	5. removing unnecessary catheters

Pronovost P et al. N Engl J Med 2006;355:2725-2732

Widmer AF.
Surgical Hand Hygiene in:
WHO Guideline for Hand Hygiene 2009
Widmer AF. Infect Control Hosp Epidemiol 2004
Widmer AF. Infect Control Hosp Epidemiol 2007
Widmer AF. J Hosp Infect 2009
Tschudin & Widmer. Crit Care Med 2010
Widmer AF. Manuel of Clinical Microbiology 2011

The Intervention

1. **Hand washing**
2. full-barrier precautions during the insertion of CVCs
3. **cleaning the skin with chlorhexidine**
4. avoiding the femoral site, if possible,
5. removing unnecessary catheters

Pronovost P et al. N Engl J Med 2006;355:2725-2732

Maximal barrier precautions:
Raad II. *Infect Control Hosp Epidemiol* 1994;15:231

RANDOMIZED CONTROLLED TRIALS

Maximal Sterile Barrier Precautions Do Not Reduce Catheter-Related Bloodstream Infections in General Surgery Units

A Multi-Institutional Randomized Controlled Trial

Yoshinori Ishikawa, MD, Teruo Kiyama, MD,* Yoshio Haga, MD,† Masashi Ishikawa, MD,‡ Hitoshi Takeuchi, MD,§ Osamu Kimura, MD,¶ Yasuki Harihara, MD,‖ Kohki Sunouchi, MD,** Takumi Furuya, MD,†† and Masami Kimura, MD‡‡*

(*Ann Surg* 2010;251: 620–623)

Rate of CR-BSIs before Intervention

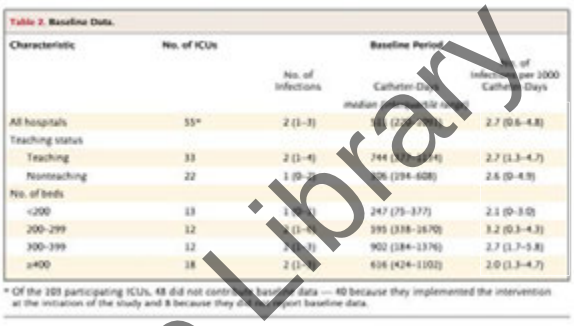


Table 2. Baseline Data.

Characteristic	No. of ICUs	Baseline Period	
		No. of Infections	Catheter-Days (median [interquartile range])	No. of Infections per 1000 Catheter-Days
All hospitals	55*	2 (1–3)	[illegible]	2.7 (0.6–4.8)
Teaching status				
Teaching	33	2 (1–4)	744 [illegible]	2.7 (1.3–4.7)
Nonteaching	22	1 (0–2)	426 (294–608)	2.6 (0–4.9)
No. of beds				
<200	13	[illegible]	247 (75–377)	2.1 (0–3.0)
200–299	12	[illegible]	595 (338–1670)	3.2 (0.3–4.3)
300–399	12	[illegible]	902 (384–1376)	2.7 (1.7–5.8)
≥400	18	2 (1–3)	636 (424–1102)	2.0 (1.3–4.7)

* Of the 103 participating ICUs, 48 did not contribute baseline data — 40 because they implemented the intervention at the initiation of the study and 8 because they did not report baseline data.

Pronovost P et al. N Engl J Med 2006;355:2725-2732

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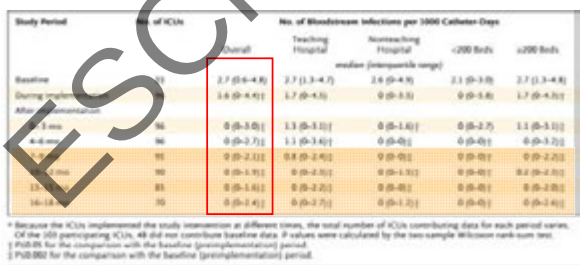
Rates of Catheter-Related Bloodstream Infection from Baseline (before Implementation of the Study Intervention) to 18 Months of Follow-up



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 (0–1.3)†	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)†

* Because the ICUs implemented the study intervention at different times, the total number of ICUs contributing data for each period varies. Of the 103 participating ICUs, 48 did not contribute baseline data. P values were calculated by the two-sample Wilcoxon rank-sum test.
† P<0.05 for the comparison with the baseline (preimplementation) period.
‡ P=0.082 for the comparison with the baseline (preimplementation) period.

An evidence-based intervention resulted in a large and sustained reduction (up to 66%) in rates of catheter-related bloodstream infection that was maintained throughout the 18-month study period

Pronovost P et al. N Engl J Med 2006;355:2725-2732

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Rates of Catheter-Related Bloodstream Infection from Baseline (before Implementation of the Study Intervention) to 18 Months of Follow-up

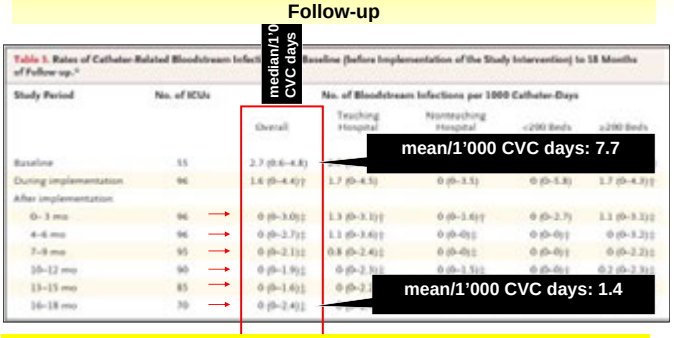

Table 3. Rates of Catheter-Related Bloodstream Infections from Baseline (before Implementation of the Study Intervention) to 18 Months of Follow-up.*

Study Period	No. of ICUs	No. of Bloodstream Infections per 1000 Catheter-Days				
		Overall	Teaching Hospital	Nonteaching Hospital	<200 Beds	≥200 Beds
Baseline	55	2.7 (0.6–4.8)				
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 (0–1.3)†	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)†

* Because the ICUs implemented the study intervention at different times, the total number of ICUs contributing data for each period varies. Of the 103 participating ICUs, 48 did not contribute baseline data. P values were calculated by the two-sample Wilcoxon rank-sum test.
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An evidence-based intervention resulted in a large and sustained reduction (up to 66%) in rates of catheter-related bloodstream infection that was maintained throughout the 18-month study period

Published results of use of Institute for Healthcare Improvement central catheter bundle

Table 1. Published results of use of Institute for Healthcare Improvement central catheter bundle

Study	Site	IHI Bundle?	Mean CRBSI per 1000 Catheter Days: Pre	Post
Berricl-Caas et al (13)	Single center	Yes + a,b,c	9.6	3.0
Pronovost et al (14)	Multicentered	Yes + a,b	7.7	2.3
Jain et al (15)	Single ICU	No + c	5.9	3.1
Bonello et al (16)	Multicentered	Yes + a	5.2	2.7
Costello et al (17)	Single CICU	No + a,b,c,d	7.8	2.3
Galpern et al (18)	Single center	Yes + a,b	5.0	0.9
Venkatram et al (19)	Single MICU	Yes + a,b,c,d	10.8	1.7

Paul Chittick, MD; Robert J. Sherertz Crit Care Med 2010 Vol. 38, No. 8 (Suppl.)

Characteristics of the Participating ICUs

Characteristic	No. of ICUs
Location	
Argentina	15
Turkey	14
Colombia	13
India	13
Mexico	7
Philippines	6
Brazil	5
Peru	5
El Salvador	2
Costa Rica	1
Cuba	1
Lebanon	1
Macedonia	1
Morocco	1
Panama	1

Characteristic	No. of ICUs
Type of hospital[a]	
Academic teaching	26
Private community	16
Public	15
Type of ICU	
Medical/surgical	51
Pediatric	6
[illegible]	9
Coronary	8
Burn	1
Surgical	4
Neurosurgical	3
Medical	3
Trauma	1

[a] By type of hospital, 46% academic teaching hospitals, 28% private community hospitals, 26% public hospitals.

Infection_Control_11

Rosenthal VD et al, Infect Control Hosp Epidemiol 2010; 31(12):1264-1272

Table 3. Central Venous Catheter–Associated Bloodstream Infections in the International Nosocomial Infection Control Consortium Intensive Care Units*

Variable	Country A	B	C	D	E	F	G	H	Overall
CVC-associated bloodstream infections, n	19	66	126	100	151	11	35	293	930
Rate per 100 patients (range)†	1.3 (0.0–13.0)	5.1 (0.0–11.3)	5.8 (0.0–9.0)	3.2 (0.0–5.2)	10.0 (1.0–15.2)	2.75	2.5 (0.0–3.3)	12.7 (1.0–47.6)	4.4 (1.3–12.7)
Rate per 1000 CVC days		10.0 (0.0–25.8)	11.3 (0.0–20.3)	8.8 (0.0–15.4)	16.3 (4.2–23.3)	18.54	7.8 (0.0–10.7)	17.9 (5.0–41.5)	12.5 (7.8–18.5)
Proportion of cases, %									
Enterobacteriaceae		26	31	42	29	33	19	22	27
Pseudomonas spp.		5	5	13	15	18	10	9	9
Acinetobacter spp.	4	8	7	10	3	9	5	22	13
Staphylococcus aureus	14	20	37	8	8	18	38	26	25
Enterococci	5	5	1	5	0	0	0	4	3
Candida species	1	7	2	10	4	9	24	4	5
Susceptibility to isolated microorganisms, %									
MRSA	64	100	70.6	100	0	33	80	92	85
Ceftriaxone-resistant Enterobacteriaceae	31	100	33.3	71	50	95	50	100	57
Fluoroquinolone-resistant P. aeruginosa	56	70	0.0	0	100	0	100	51	49
Vancomycin-resistant enterococci	9	0	0.0	0	0	0	0	0	3

* CVC = central venous catheter; MRSA = methicillin-resistant Staphylococcus aureus.
† Ranges for individual countries are for the individual hospitals; overall ranges are for the individual countries.
‡ Range not given because only 1 participating hospital was from country F.
§ Partial listing of major pathogens; does not total 100%.

Rosenthal V. Ann Intern Med. 2006 Oct 17;145(8):582-91.

Deaths in Patients with Central Line-Associated Bloodstream Infection (CLABSI) during Baseline and Intervention Periods

Cohort	No. of ICUs	No. of patients at risk	CLABSI-associated deaths: No.	No. per 100 patients, %	RR* (95% CI)	P
Months 1–3 (baseline)	86	7,376	77	1.04	Reference	
Months 5–7	86	7,522	46	0.61	0.59 (0.41–0.84)	.004
Months 11–13	68	4,718	22	0.47	0.45 (0.28–0.72)	.001
Months 17–19	43	3,527	16	0.45	0.43 (0.25–0.74)	.002
Months 23–25	28	2,264	10	0.44	0.42 (0.22–0.82)	.008

NOTE. CI, confidence interval; RR, relative risk.
* All periods compared with the first 3 months (baseline).

Rosenthal VD et al, Infect Control Hosp Epidemiol 2010; 31(12):1264-1272

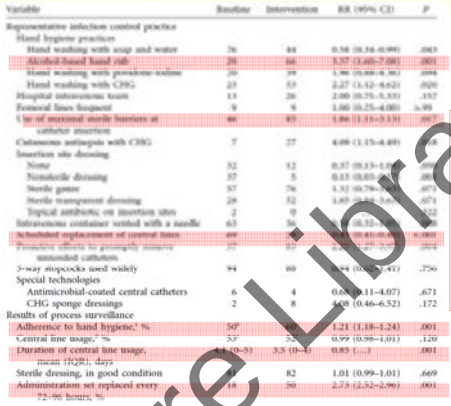
Characteristics of Patients at Baseline and During the Intervention Period

Characteristic	Baseline	Intervention	RR (95% CI)	P
No. of patients	7,751	45,968	…	
No. of central line–days	30,889	160,016	…	
Age, mean (IQR), years	53.6 (40–70)	55.7 (42–72)	…	
Sex, no. (%) of patients				
Male	4,756 (61)	27,603 (60)	0.98 (0.95–1.01)	.169
Female	2,995 (39)	18,365 (40)	1.03 (0.99–1.07)	.090
Service, no. (%) of patients				
Adult	6,247 (81)	41,540 (90)	…	
Pediatric	430 (6)	1,459 (3)	…	
Neonatal	874 (11)	2,966 (6)	…	
ASIS, mean (IQR)	2.96 (2–4)	2.91 (2–4)	…	.806
Underlying diseases, no. (%) of patients				
Cardiac surgery	228 (3)	1,464 (3)	1.00 (0.87–1.15)	.967
Cancer	205 (3)	1,320 (3)	1.00 (0.86–1.16)	.999
Abdominal surgery	323 (4)	1,882 (4)	0.90 (0.80–1.02)	.096
Thoracic surgery	43 (1)	212 (0.5)	0.77 (0.55–1.106)	.109
Trauma	188 (2)	1,111 (2)	0.92 (0.79–1.07)	.276

NOTE. ASIS, Average Severity of Illness Score; CI, confidence interval; IQR, interquartile range; RR, relative risk.

Rosenthal VD et al, Infect Control Hosp Epidemiol 2010; 31(12):1264-1272

Representative Infection Control Practices and the Results of Process Surveillance



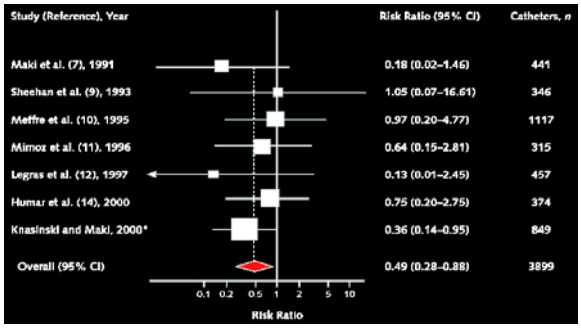
Note. Data are % of opportunities, unless otherwise indicated. CHG, chlorhexidine gluconate; CI, confidence interval; IQR, interquartile range; IV, intravenous; RR, relative risk.
[a] No. of times hand hygiene performed / no. of opportunities where indicated, during random periods of process surveillance.
[b] 7,831/15,728.
[c] 48,574/80,557.
[d] No. of central line–days / no. of patient-days.
[e] 30,889/58,742.
[f] 160,016/306,340.

Rosenthal VD et al, Infect Control Hosp Epidemiol 2010; 31(12):1264-1272

Infection Control Activity

Catheter Site Care

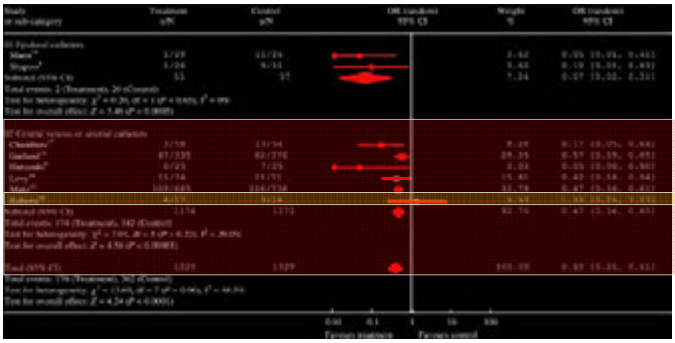
Chlorhexidine vs PVP Iodine for catheter site care



8 RTCs (4143 catheters):
Risk Ratio for BSI = 0,49 (95%-CI 0,28-0,88)

Chaiyakunapruk N. *Ann Intern Med.* 2002;136:792-801.

Forest plot : Effect of chlorhexidine-impregnated dressing on bacterial colonization of the catheter or exit-site on skin



Ho KM & Letton E, J Antimicrob Chemother 2006 Jun

Table 3. Hazard Ratios in the Intention-To-Treat and Per-Protocol Analyses

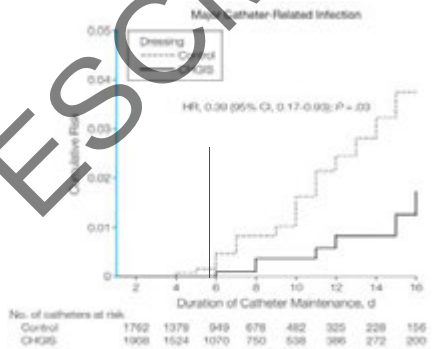
	Dressing					
	Incidence, No./1000 Catheter-Days		ITT Analysis		Per-Protocol Analysis[a]	
Variable	Control (n = 1825)	CHGIS (n = 1953)	HR (95% CI)	P Value	HR (95% CI)	P Value
Catheter colonization >10 CFUs/plate	15.8	6.3	0.36 (0.27-0.48)	<.001	0.35 (0.27-0.45)	<.001
Catheter-related bloodstream infection	1.3	0.4	0.24 (0.09-0.65)	.005	0.24 (0.09-0.63)	.004
Major catheter-related infection	1.4	0.6	0.39 (0.16-0.93)	.03	0.38 (0.16-0.92)	.03

Abbreviations: CFU, colony-forming unit; CHGIS, chlorhexidine gluconate–impregnated sponges; CI, c
[a]Analysis adjusted on imbalanced parameters for presence of ≥1 chronic disease for comparison of

1238 JAMA, March 2[illegible]—Vol 301, No. 12

Timsit JF JAMA 2009;301:1231-1241

Cumulative Risk of Catheter-Related Infection and Catheter Colonization



Median duration of catheterization was 6 days (interquartile range, 4-10 days) for all curves

y-Axis in blue indicates values in the range of 0-0.05

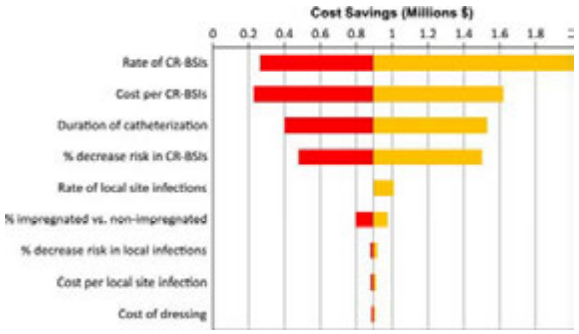
CHGIS indicates Chlorhexidine gluconate-impregnated sponge

CI, confidence interval

HR, hazard ratio

Timsit JF JAMA 2009;301:1231-1241

Sensitivity analysis of key input parameters in the model. CR-BSI, catheter-related bloodstream infection



Xin Ye Am J Infect Control 2011;39:647-54

Sensitivity analysis of key input parameters in the model on CR-BSI

Cost per CR-BSI	CR-BSIs per 1,000 CVC-days						
	0.5	1.5	2.5	3.5	4.5	5.5	6.5
$6,000	$71,959	$181,200	$290,441	$399,682	$508,923	$618,164	$727,405
$11,000	$117,476	$317,751	$518,026	$718,302	$918,577	$1,118,852	$1,319,127
$16,000	$162,993	$454,302	$745,612	$1,036,921	$1,328,231	$1,619,540	$1,910,849
$21,000	$208,510	$590,854	$973,197	$1,355,541	$1,737,884	$2,120,228	$2,502,572
$26,000	$254,027	$727,405	$1,200,783	$1,674,160	$2,147,538	$2,620,916	$3,094,294
$31,000	$299,544	$863,956	$1,428,368	$1,992,780	$2,557,192	$3,121,604	$3,686,016
$36,000	$345,061	$1,000,508	$1,655,954	$2,311,400	$2,966,846	$3,622,292	$4,277,738
$41,000	$390,579	$1,137,059	$1,883,539	$2,630,019	$3,376,500	$4,122,980	$4,869,460
$46,000	$436,096	$1,273,610	$2,111,125	$2,948,639	$3,786,154	$4,623,668	$5,461,182

Antiseptic dressings

	type of device	in vitro studies	clinical studies
 BIOPATCH®	chlorhexidine-sponge	positives	positives
 Tegaderm™ CHG	chlorhexidine-gel	positives	ongoing
	silver	positives	ongoing

Chlorhexidine-impregnated sponge

Control **Sponge**

n/1'000 CVC-days **n/1'000 CVC-da**

7.2 **3.8**

p=0.02

Dwell-times: 15.8 (control), 16.6

Ruschulte. *Ann Hematol* 2008;88:267

Effect of Octenidin on the Incidence of CR-BSIs

Randomized Controlled Clinical Trial

- **Fewer laboratory-confirmed BSIs**
  (analysis of 387 patients with information about BSI)

		Odds Ratio	95%-CI	p-value
Treatment	Group A vs. Group B n=8 (4.1%) vs. n=16 (8.3%) *	0.44	[0.18 , 1.09]	0.075

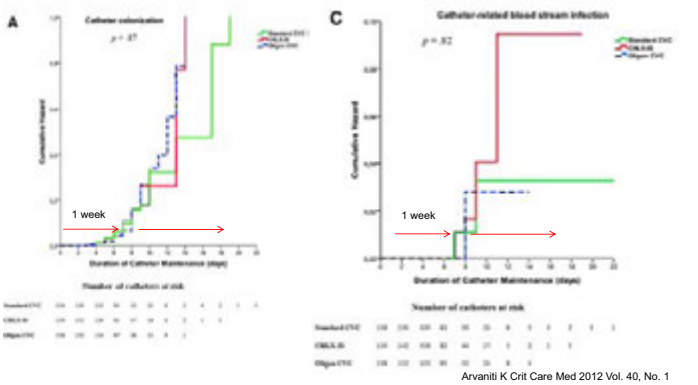
* CNS: 39%; *E. coli*: 25%; species matched between blood and catheter culture in 4 cases ('catheter related')

** No laboratory-confirmed BSI in surgical patients (Basel)

- **No relevant difference in side effects (i.e. skin irritation) between the groups**

Dettenkofer & Widmer AF. Clin Microbiol Infect 2009

A multicenter RCT comparing silver-coated or CHX biopatch to standard CVCs in Greek ICUs



Arvaniti K Crit Care Med 2012 Vol. 40, No. 1

JOURNAL OF CLINICAL MICROBIOLOGY, Jan. 1982, p. 166–168
0095-1137/82/010166-03$02.00/0
Vol. 15, No. 1

Isolation of Chlorhexidine-Resistant *Pseudomonas aeruginosa* from Clinical Lesions

HIDEOMI NAKAHARA AND HIROYUKI KOZUKUE*
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Received 31 March 1981/Accepted 24 July 1981

The chlorhexidine resistance of 317 strains of *Pseudomonas aeruginosa* isolated from hospital patients was determined. The distribution pattern of their susceptibility to chlorhexidine clearly revealed two peaks, and the frequency of resistance to chlorhexidine was 84.2%.

Education, Training and Staffing

1. Educate healthcare personnel regarding the indications for intravascular catheter use, proper procedures for the insertion and maintenance of intravascular catheters, and appropriate infection control measures to prevent intravascular catheter-related infections [7–15]. Category IA
2. Periodically assess knowledge of and adherence to guidelines for all personnel involved in the insertion and maintenance of intravascular catheters [7–15]. Category IA

Guidelines for the Prevention of Intravascular Catheter-Related Infections 10

3. Designate only trained personnel who demonstrate competence for the insertion and maintenance of peripheral and central intravascular catheters. [14–28]. Category IA
4. Ensure appropriate nursing staff levels in ICUs. Observational studies suggest that a higher proportion of "pool nurses" or an elevated patient–to-nurse ratio is associated with CRBSI in ICUs where nurses are managing patients with CVCs [29–31]. Category IB

Catheter Site Dressing Regimens

1. Use either sterile gauze or sterile, (semi)-transparent dressing to cover the catheter site . IA

2. If the patient is diaphoretic or if the site is bleeding or oozing, use a gauze dressing until this is resolved . II
3. Replace catheter site dressing if the dressing becomes damp, loosened, or visibly soiled IB
4. Do not use topical antibiotic ointment or creams on insertion sites, except for dialysis catheters, because of their potential to promote fungal infections and antimicrobial resistance IB
5. Do not submerge the catheter or catheter site in water. Showering should be permitted if precautions can be taken to reduce the likelihood of introducing organisms into the catheter (e.g., if the catheter and connecting device are protected with an impermeable cover during the shower) IB
6. Replace dressings used on short-term CVC sites every 2 days for gauze dressings. II
7. Replace dressings used on short-term CVC sites <every 7 days for transparent dressings, IB
8. Replace transparent dressings used on tunneled or implanted CVC sites no more than once per week (unless the dressing is soiled or loose), until the insertion site has healed. II
9. No recommendation can be made regarding the necessity for any dressing on well-healed exit sites of long-term cuffed and tunneled CVCs. UI
10. Ensure that catheter site care is compatible with the catheter material IB
11. Use a sterile sleeve for all pulmonary artery catheters IB
12. ped
13. No recommendation is made for other types of chlorhexidine dressings. UI
14. Monitor the catheter sites visually when changing the dressing or by palpation through an intact dressing on a regular basis, depending on the clinical situation of the individual patient. If patients have tenderness at the insertion site, fever without obvious source, or other manifestations suggesting local or bloodstream infection, the dressing should be removed to allow thorough examination of the site
IB
15. Encourage patients to report any changes in their catheter site or any new discomfort to their provider. II

CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections, 2011

Differences between industralized and less industrialized contries

- Infrastructure of hospitals
  - Catheters, sterile supplies
  - Dressings / disinfectants

- Average Education in infection control
  - SHEA-ESGNI courses
  - Access to medical data

- Resources
  - Coated catheters
  - Staff per patient

CONCLUSIONS

- Low infection rates with CVC is feasible at low cost (< 2 CLABSI/1000 patient days)
  - Surveillance of CLABSI
  - Hand antisepsis with alcoholic compound
  - Optimal choice of access site and catheter
    - CVC: Jugular access < 1 week / Suclavian > 1 week
  - Full barrier precautions at insertion
  - Sterile dressing after insertion
  - Insertion site care with chlorhexidine
    - Biopatch, Tegaderm CHX, daily disinfection with remanent disinfectant
      - CHX, Octenidin, Polihexanid