ORIGINAL ARTICLE

Effect of Chlorhexidine Whole-Body Bathing on Hospital-Acquired Infections Among Trauma Patients

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Objective: To demonstrate whether daily bathing with cloths impregnated with 2% chlorhexidine gluconate will decrease colonization of resistant bacteria and reduce the rates of health care–associated infections in critically injured patients.

Design: Retrospective analysis of data collected 6 months before and after institution of a chlorhexidine bathing protocol.

Setting: A 12-bed intensive care unit in a level I trauma center.

Patients: Two hundred eighty-six severely injured patients underwent daily chlorhexidine bathing during the 6-month intervention; 253 patients were bathed without chlorhexidine prior to the intervention.

Interventions: Daily chlorhexidine bathing.

Main Outcomes Measures: Rates of ventilator-associated pneumonia (VAP), bloodstream infection, and colonization with resistant organisms (methicillin-resistant *Staphylococcus aureus* [MRSA] or *Acinetobacter* species).

Results: Baseline patient and injury characteristics were similar between cohorts. Patients receiving chlorhexidine baths were significantly less likely to acquire a catheter-related bloodstream infection than comparators (2.1 vs 8.4 infections per 1000 catheter-days, $P = .01$). The incidence of VAP was not affected by chlorhexidine baths (16.9 vs 21.6 infections per 1000 ventilator-days in those with vs those without chlorhexidine baths, respectively, $P = .30$). However, patients who received chlorhexidine baths were less likely to develop MRSA VAP (1.6 vs 5.7 infections per 1000 ventilator-days, $P = .03$). The rate of colonization with MRSA (23.3 vs 69.3 per 1000 patient-days, $P < .001$) and *Acinetobacter* (1.0 vs 4.6 per 1000 patient-days, $P = .36$) was significantly lower in the chlorhexidine group than in the comparison group.

Conclusions: Daily bathing of trauma patients with cloths impregnated with 2% chlorhexidine gluconate is associated with a decreased rate of colonization by MRSA and *Acinetobacter* and lower rates of catheter-related bloodstream infection and MRSA VAP.

Arch Surg. 2010;145(3):240-246

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HEALTHCARE-ASSOCIATED infections pose a significant burden to patients admitted following major injury. The prevention of bloodstream infections (BSIs) and ventilator-associated pneumonia (VAP) has become a focus of critical care and a marker for quality among intensive care units (ICUs). Under new rules created by the Centers for Medicare and Medicaid Services that went into effect in 2008, a catheter-related BSI (CRBSI) is now one of the preventable complications that will not be incrementally reimbursed,[1] harkening a new era of punitive measures for infection-control failures.

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Colonization by resistant organisms is associated with a higher incidence of infection by these same organisms,[2] and successful efforts to decolonize patients demonstrate reduced rates of these infections.[3,4] Chlorhexidine gluconate is a water-soluble antiseptic preparation with broad activity against bacteria, yeasts, and viruses. Recent investigations of whole-body skin decolonization with chlorhexidine in medical ICU patients have demonstrated reduction in the acquisi-

tion of vancomycin-resistant enterococci (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), and *Acinetobacter baumannii* colonization, and an overall decrease in the incidence of CRBSI.[5-8]

We hypothesized that daily bathing with washcloths impregnated with 2% chlorhexidine gluconate would effectively decontaminate trauma patients admitted to a trauma ICU (TICU) with a known colonization pressure from MRSA and *A baumannii*. We expected to observe a commensurate reduction in the incidence of healthcare-associated infections and a specific reduction in infections caused by the resistant organisms that predominate in our unit.

METHODS

We used a before-and-after study design to evaluate the efficacy of daily bathing with no-rinse, disposable washcloths impregnated with 2% chlorhexidine gluconate compared with disposable washcloths without chlorhexidine. The main study outcomes were BSI and VAP; secondary study outcomes included other healthcare-associated infections and the rate of isolation of multidrug-resistant organisms. The University of Washington institutional review board approved the investigation and waived the need for informed consent.

The study was conducted at Harborview Medical Center, a 413-bed level I trauma center that serves patients from 4 states. The TICU is a 12-bed unit with 87% of patients admitted to the trauma service. During the baseline period (November 2006 through April 2007), all patients admitted to the TICU were bathed at least once daily using a single-use, no-rinse, disposable cloth bath product (Impreva Bath; Sage Products Inc, Cary, Illinois). This product is not known to have antibacterial or antiseptic properties and has been shown to perform similarly to conventional basin baths with respect to postbath skin microbial counts.[9] In May 2007, we replaced Impreva with a similar product with 2% chlorhexidine gluconate impregnated within the cloth (Sage Products Inc), which was used throughout the 6-month intervention period (May 2007 through October 2007), hereafter referred to as the *chlorhexidine period*.

All trauma admissions to the TICU during the length of the study were included in the analysis, regardless of length of stay. Demographic information was collected at the time of admission in the emergency department. Severity of illness was evaluated at the time of admission by assessing for presence of shock (systolic blood pressure <90 mm Hg) and calculating the Injury Severity Score[10] and Acute Physiology and Chronic Health Evaluation (APACHE) II score.[11] Additional measures of shock obtained within the first 12 to 24 hours included base deficit, vasopressor use, crystalloid use, and blood transfusion amount. Associated outcome measures included length of mechanical ventilation, ICU length of stay, hospital length of stay, maximum multiple-organ dysfunction syndrome score,[12] and in-hospital mortality. Multiple-organ dysfunction scores were calculated retrospectively based on the worst values during ICU admission.

Centers for Disease Control definitions were used.[13,14] Infections were identified by retrospective review of microbiologic data and corroboration with medical record review. All infections occurred in the ICU. Bloodstream infections were classified as CRBSIs[13] or secondary BSIs that were confirmed by laboratory culture with another clinical site of infection and without concurrent positive central venous catheter culture. For CRBSIs, the causative organism was defined as that isolated on both blood cultures and the catheter tip. Other infections included VAP (defined by quantitative bronchoalveolar lavage culture $\geq 10^4$ colony-forming units/mL or brush specimen $\geq 10^3$ colony-forming units/mL), urinary tract infections, and *Clostridium difficile*–associated diarrhea. Contaminated blood cultures were defined as episodes in which a common skin commensal (eg, coagulase-negative *Staphylococcus*) was isolated from a single blood culture and infection criteria were not met.[13] In the case of multiple isolates from a single site, the causative organism was identified as that which was predominant in the culture. Colonization with MRSA or *A baumannii* was defined as positive identification on either routine surveillance cultures obtained on admission, weekly, and at discharge or on any clinically indicated cultures.

BATHING PROCEDURES

In the 6-month baseline period, patients admitted to the TICU were bathed daily on all areas of intact skin except around the mouth and eyes with Impreva Bath disposable washcloths. Perineal areas were cleansed with either Impreva or Comfort Shield (Sage Products Inc).

During the chlorhexidine period, daily baths were conducted with disposable cloths impregnated with a 2% chlorhexidine gluconate solution, equivalent to 500 mg of chlorhexidine gluconate per cloth. Perineal cleansing was performed as before with either Impreva or Comfort Shield. Two patients during the chlorhexidine period developed skin rashes concurrent with chlorhexidine cloth use; the chlorhexidine cloths were discontinued and replaced with mild soap and water bathing. Throughout the study, patients' skin was moisturized with lotion that does not interfere with chlorhexidine's biocidal activity. No other unit in the hospital used chlorhexidine bathing.

INFECTION-CONTROL PROTOCOLS

Active surveillance for *A baumannii* began in January 2005, including oral, wound, and rectal cultures within 24 hours of admission to the TICU for patients with expected ICU lengths of stay longer than 24 hours. Subsequent surveillance cultures were performed every 7 days while the patient was in the ICU and at discharge from the ICU. Screening for MRSA was performed in the same manner as for *A baumannii* beginning in June 2005, with the addition of nasal swabbing in October 2007. Monitoring of compliance with all surveillance cultures began in October 2007. On confirmation of a positive *A baumannii* culture, contact precautions were initiated; patients were placed in a private room when available, or cohorted (patients colonized with the same resistant organism were placed in the same room as each other), and health care workers put on gowns and gloves upon entering the room. Patients were not routinely isolated for MRSA, nor were health care providers screened for MRSA colonization.

Insertion of central venous catheters in patients in the TICU was conducted using a sterile technique, skin preparation with 2% chlorhexidine gluconate, and maximum barrier precautions; second-generation chlorhexidine and silver sulfadiazine–coated catheters (Arrow International Inc, Reading, Pennsylvania) were used throughout the study and placed in the subclavian site unless clinical circumstances were prohibitive. There was no formalized protocol for removal of central venous catheters. As part of the ventilator bundle, in addition to maintaining the head of the bed higher than 30° and daily sedation interruption, 15 mL of 0.12% chlorhexidine mouthwash was applied twice daily during oral care for ventilated patients starting in October 2007. There were no other systematic changes in infection-control procedures throughout the study period.

Table 1. Baseline Characteristics of Patients With or Without Chlorhexidine[a] Bathing

Characteristic	No. (%) of Patients		
	Without Chlorhexidine (n=253)	With Chlorhexidine (n=286)	*P* Value
Age, mean (SD), y	40 (15)	39 (16)	.46
Male sex	174 (68.8)	211 (73.8)	.24
Race			
White	218 (86.1)	239 (84.0)	.47
Black	16 (6.3)	17 (5.8)	.99
Asian	17 (6.7)	23 (8.0)	.23
Other/unknown	2 (0.8)	7 (2.3)	.25
Body mass index,[b] mean (SD)	28 (10)	29 (8)	.20
Comorbid disease			
None	189 (74.7)	211 (73.8)	.89
Cardiac	16 (6.3)	19 (6.6)	.99
Pulmonary	27 (10.7)	25 (8.7)	.54
Hepatic	13 (5.1)	9 (3.1)	.34
Renal	9 (3.6)	7 (2.4)	.62
Endocrine, diabetes	30 (11.8)	36 (12.6)	.89
Mechanism of injury			
Motor vehicle crash	183 (72.3)	202 (70.6)	.73
Pedestrian in a motor vehicle crash	17 (6.7)	26 (9.1)	.39
Fall	21 (8.3)	19 (6.6)	.57
Other blunt mechanism	6 (2.4)	8 (2.8)	.99
Penetrating, gun shot wound	16 (6.3)	18 (6.3)	.99
Penetrating, stab wound	10 (4.0)	13 (4.6)	.89

[a] Administered in a washcloth as 2% chlorhexidine gluconate.
[b] Calculated as weight in kilograms divided by height in meters squared.

Table 2. Injury Characteristics in Patients With or Without Chlorhexidine[a] Bathing

Characteristic	Mean (SD)		
	Without Chlorhexidine (n=253)	With Chlorhexidine (n=286)	*P* Value
Mean Injury Severity Score	18 (13)	19 (16)	.43
Maximum AIS	3.7 (1.9)	3.9 (2.1)	.25
Chest injury score	1.9 (1.7)	2.1 (1.6)	.16
Abdominal injury score	3.4 (1.3)	3.6 (1.8)	.14
APACHE II score	2.5 (7)	19.7 (6)	.16
Shock,[b] No. (%)	94 (37.2)	102 (35.7)	.79
Worst base deficit in first 12 hours	−8.55 (0.83)	−8.57 (0.65)	.75
Vasopressor use in first 24 hours, No. (%)	13 (5.1)	11 (3.8)	.60
Crystalloids in first 12 hours, L	6.8 (3.2)	7.2 (3.0)	.14
Blood transfusion >6 U/ 12 hours, No. (%)	71 (28.1)	86 (3.1)	.68
Blood transfusion in first 12 hours, U	2.1 (3.2)	2.4 (1.7)	.17

Abbreviations: AIS, Abbreviated Injury Score; APACHE II, Acute Physiology and Chronic Health Evaluation II.
[a] Administered in a washcloth as 2% chlorhexidine gluconate.
[b] Defined as systolic blood pressure of less than 90 mm Hg in the prehospital phase or at anytime during emergency department evaluation.

STATISTICAL ANALYSIS

We performed an intention-to-treat analysis. Patients in the chlorhexidine group who did not undergo the chlorhexidine bathing procedure owing to rash (n=2) were considered part of the intervention arm. To determine whether there was a difference in primary outcomes, we calculated the incidence difference (per 1000 device-days) between the 2 groups and reported the associated 95% confidence interval (CI). We compared patient characteristics and rates of infection between the baseline and chlorhexidine groups using the Wilcoxon rank-sum test or the *t* test for continuous variables and χ^2 test for categorical variables. Univariate analysis was performed to compare the characteristics between those who did and did not develop CRBSI. Significant factors ($P<.1$) were included in a multiple logistic regression analysis along with the study period variable to determine factors that predict development of CRBSI. The rate of colonization with MRSA was estimated using Cox proportional hazards regression analysis after adjustment for sex, Injury Severity Score, and blood transfusion, factors chosen based on their significance in the univariate analysis. Collected data were entered into a protected database and then converted into Stata files (Stata, version 9.1; Stata Corp, College Station, Texas) for analysis. Significance was reported at $P\leq.05$.

RESULTS

During the 6-month chlorhexidine period, 286 trauma patients were admitted to the TICU and underwent daily chlorhexidine bathing. Data from 253 trauma patients admitted during the baseline period in the 6 months prior to introduction of chlorhexidine bathing were compared with data acquired during the chlorhexidine period. Baseline characteristics of the populations were similar and representative of the average trauma patient requiring intensive care in the United States: they were predominantly white, male, and young with few comorbidities, 75% of patients having sustained blunt injury secondary to a motor vehicle crash (**Table 1**). Injury characteristics were also similar between the 2 groups as demonstrated in **Table 2**. There were no differences in severity of illness, ICU length of stay, or in-hospital mortality, but hospital length of stay was significantly longer in the control group (**Table 3**). Additionally, no difference was observed between the baseline or chlorhexidine periods in the use of total parenteral nutrition (11 [4.3%] vs 16 [5.6%] cases, respectively, $P=.22$) or number of patients with a central line (246 [97.2%] vs 275 [96.2%], respectively, $P=.96$).

Table 4 summarizes the overall incidence of infections, which did not substantially differ between the 2 groups, except in the case of CRBSIs. The incidence of *C difficile* colitis was not significantly different between the baseline and chlorhexidine bathing groups (10 [4.0%] vs 6 [2.1%] cases, respectively, $P=.21$). No infection was caused by a fungal organism. During the chlorhexidine period, patients were significantly (74%) less likely to develop a CRBSI (2.1 vs 8.4 BSIs per 1000 catheter-days, $P=.01$), but there was no difference in the incidence of secondary BSI. Univariate analysis was performed to compare patients who developed CRBSI with those who did not (data not shown). Using the significant variables, including age, sex, ISS, and transfusion of more than 6 units of packed red blood cells in the first 12 hours, and chlorhexidine body washing, logistic regression analysis was performed. Transfusion of more than 6 units of

Table 3. Outcome Variables Associated With Method of Bathing

Variable	Mean (SD)		*P* Value
	Without Chlorhexidine (n=253)	With Chlorhexidine[a] (n=286)	
Mechanical ventilation, d	10.3 (7.9)	9.5 (8.5)	.26
ICU length of stay, d	12.5 (12.7)	10.9 (15.2)	.19
Hospital length of stay, d	18.7 (14.3)	15.8 (11.8)	.01
Maximum MODS score	4.1 (3.5)	3.6 (3.1)	.08
Mortality, No. (%)	17 (6.7)	16 (5.6)	.72

Abbreviations: ICU, intensive care unit; MODS, multiple-organ dysfunction syndrome.
[a] Administered in a washcloth as 2% chlorhexidine gluconate.

Table 4. Comparison of Infection Incidence by Method of Bathing

Infection	No. (No. per 1000 Device-Days)		Difference (95% CI)	*P* Value
	Without Chlorhexidine	With Chlorhexidine[a]		
CRBSI	15 (8.4)	4 (2.1)	6.2 (1.6 to 1.9)	.01
UTI	14 (7.1)	12 (6.5)	0.6 (–4.5 to 5.7)	.82
VAP	38 (21.6)	33 (16.9)	4.7 (–4.2 to 13.6)	.30
Secondary BSI	6 (3.0)	5 (2.5)	0.5 (–2.7 to 3.8)	.76

Abbreviations: BSI, bloodstream infection; CI, confidence interval; CRBSI, catheter-related bloodstream infection; UTI, urinary tract infection; VAP, ventilator-associated pneumonia.
[a] Administered in a washcloth as 2% chlorhexidine gluconate.

Table 5. Causative Microorganisms in Catheter-Related Bloodstream Infections

Microorganism	No. of Cases	
	Without Chlorhexidine (n=15)	With Chlorhexidine[a] (n=4)
Gram-positive bacteria		
Coagulase-negative *Staphylococcus* species	6	3
Bacillus species	1	0
Enterococcus species	1	0
Staphylococcus aureus	4	0
Gram-negative bacteria		
Escherichia coli	1	1
Klebsiella pneumoniae	1	0
Pseudomonas aeruginosa	1	0

[a] Administered in a washcloth as 2% chlorhexidine gluconate.

packed red blood cells in the first 12 hours of hospital admission was found to be a positive independent predictor of development of CRBSI (odds ratio, 3.48; 95% CI, 1.23-9.82), while use of chlorhexidine body washing was protective (odds ratio, 0.32; 95% CI, 0.13-0.79). Causative organisms for CRBSI were predominantly gram-positive throughout (**Table 5**). Although there were infections with a variety of bacterial species in the baseline period, after initiation of chlorhexidine bathing, CRBSIs were limited to coagulase-negative *Staphylococcus* (n=3) and *Escherichia coli* (n=1).

Although we did not observe a decrease in the incidence of VAP after the institution of chlorhexidine bathing (Table 4), as demonstrated in **Table 6**, there appeared to be a shift in the microbiology from resistant to nonresistant organisms. There were fewer cases of MRSA and *A baumannii* VAP, though only the decrease in MRSA VAP reached statistical significance (1.6 vs 5.7 cases of MRSA VAP per 1000 ventilator-days, $P=.03$). Likewise, the rate of MRSA colonization was significantly reduced during the chlorhexidine bathing period (23.3 vs 69.3 cases per 1000 patient-days, $P<.001$), but the rate of *A baumannii* colonization was not significantly lower (**Table 7**). Based on Cox regression analysis, protection against MRSA colonization was apparent 4 or more days after admission to the ICU (**Figure**). The probability of colonization was almost 3-fold higher in the baseline group compared with the chlorhexidine bathing group (hazard ratio, 2.9; 95% CI, 1.4-4.5; $P=.02$). This difference persisted after adjusting for sex, Injury Severity Score, and blood transfusions (adjusted hazard ratio, 2.7; 95% CI, 1.2-4.8; $P=.006$).

COMMENT

Introduction of 2% chlorhexidine gluconate to routine, daily whole-body bathing with disposable washcloths in trauma patients in the ICU was associated with a reduction in the incidence of CRBSI and a change in the microbiology of both CRBSI and VAP. Following introduction of chlorhexidine bathing, we observed no CRBSI caused by *S aureus*, *Enterococcus* species, or *Bacillus* species and one-half the incidence from baseline of CRBSIs caused by coagulase-negative *Staphylococci*. Furthermore, though the incidence of VAP was similar during the 2 periods, there were fewer cases of VAP caused by multidrug-resistant organisms, with a significant reduction in VAP caused by MRSA and a trend toward reduced *A baumannii* VAP. Our results, the first reported in a critically ill trauma population, are consistent with a recent clinical trial in medical ICU patients, in whom use of the same chlorhexidine washcloths resulted in decreased incidence of BSI and gram-positive isolates.[5] To our knowledge, this is the first study of universal decontamination with chlorhexidine bathing on ICU admission to demonstrate an associated decrease in MRSA VAP, supported by an overall decrease in the isolation of MRSA on any clinical microbiologic culture.

Antibiotic-resistant bacteria pose a unique challenge, and substantial resources are devoted to infection control to reduce their transmission. Patients with severe disease, recent surgery, and indwelling devices are at higher risk of colonization and infection[15]; trauma patients, in particular, are at risk of MRSA and VRE acquisition.[16,17] Colonization is a risk factor for infection with MRSA,[2,18,19] VRE,[20] and *A baumanii*.[21] Poor compliance with hand hygiene,[22] reluctance to adopt barrier precautions owing to unintended consequences of isolation,[23-25] and controversy over the cost-effectiveness and

Table 6. Microbiological Incidence of Ventilator-Associated Pneumonia by Method of Bathing

Microorganism	No. (No. per 1000 Ventilator-Days) Without Chlorhexidine (n=38)	With Chlorhexidine[a] (n=33)	Difference (95% CI)	*P* Value
Gram-positive organisms				
MSSA	5 (2.8)	6 (3.1)	0.3 (–3.7 to 3.2)	.91
MRSA	10 (5.7)	3 (1.6)	4.1 (0.2 to 8.9)	.03
Gram-negative organisms				
Enterobacter species	4 (2.3)	5 (2.6)	0.3 (–3.4 to 2.8)	.87
Haemophilus influenza	3 (1.7)	4 (2.0)	0.3 (–3.1 to 2.4)	.83
Pseudomonas aeruginosa	8 (4.5)	10 (5.1)	0.6 (–5.0 to 3.9)	.81
Klebsiella pneumoniae	4 (2.3)	4 (2.0)	0.3 (–2.7 to 3.2)	.89
Acinetobacter species	4 (2.3)	1 (0.5)	1.8 (–0.6 to 4.2)	.18

Abbreviations: CI, confidence interval; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*.
[a]Administered in a washcloth as 2% chlorhexidine gluconate.

Table 7. MRSA and *Acinetobacter* Species Colonization Rate by Method of Bathing

Microorganism	No. (No. per 1000 Patient-Days) Without Chlorhexidine (n=253)	With Chlorhexidine[a] (n=286)	Difference (95% CI)	*P* Value
MRSA	137 (69.3)	47 (23.3)	46.0 (32.6-59.4)	<.001
Acinetobacter species	9 (4.6)	2 (1.0)	3.6 (0.2-6.8)	.36

Abbreviations: CI, confidence interval; MRSA, methicillin-resistant *Staphylococcus aureus*.
[a]Administered in a washcloth as 2% chlorhexidine gluconate.

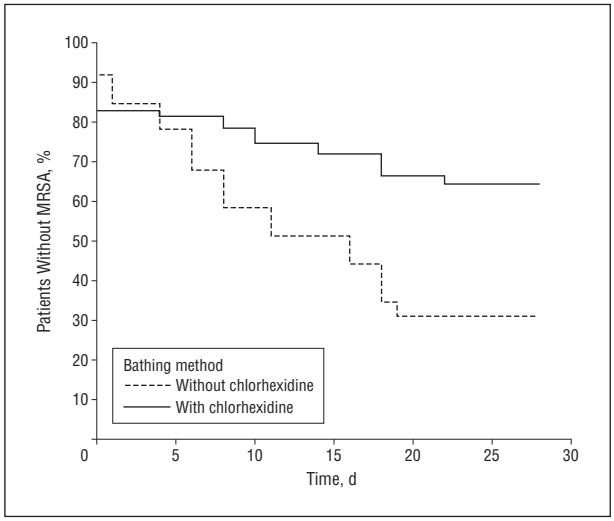

Figure. Proportion of patients with and without bathing with 2% chlorhexidine gluconate washcloths who did not have methicillin-resistant *Staphylococcus aureus* (MRSA) colonization during intensive care unit stay, *P*=.02.

feasibility of legislated universal surveillance have been barriers to effective infection control.[26,27] Furthermore, while these methods (when practiced consistently) may prevent transmission to other patients, they confer little or no protection to the patient who becomes colonized with the resistant organism.

Skin cleansing with chlorhexidine has been demonstrated since the 1970s to reduce skin flora, whether used for hand washing or whole-body bathing.[28] Although, there is inconclusive evidence that preoperative chlorhexidine bathing affects surgical site infection rates,[29] it is effective in preventing BSI when used for skin preparation at the time of central line insertion[30,31] and in reducing contamination rates in blood culture acquisition.[32] Bathing with chlorhexidine has been demonstrated in 4 studies to reduce colonization with *A baumanii*,[6] VRE,[7] and MRSA,[5] as well as to reduce the rates of BSI.[5] It stands to reason that chlorhexidine bathing may be particularly suited to trauma patients who, by the very nature of unforeseen and/or contaminating injury, may arrive with a significant bioburden, even after visiting the operating room. A recent study of universal chlorhexidine bathing in a medical ICU demonstrated decreased VRE isolates not only from the patients, but also from the hands of providers, suggesting that it may exert its effect through decontamination that extends beyond the index patient.[7] The reduction of BSI rates may in part represent a decrease in the false-positive rate of blood cultures affected by an overall reduction in the colonization on patients, providers, and equipment at the point of care.

While chlorhexidine bathing should not be considered a replacement for contact precautions, use of a routine decontamination bathing regimen can decrease the potential for organism transmission even before results of surveillance testing are available. Furthermore, in a recent epidemiologic investigation of the impact of universal active surveillance for MRSA conducted in an academic medical center with a long history of comprehensive infection-control practices, more than half of MRSA colonizations were demonstrated to occur after a negative surveillance culture was confirmed on admission,[33] suggesting that there is room for potential benefit from daily inpatient decontamination procedures in addition to the current infection-control efforts.

The study was conducted in a high-volume, high-acuity ICU that underwent no major changes in staffing during the investigation. The control group was similar with respect to injury and severity of illness. Because the

bath products differed only in the impregnation of 2% chlorhexidine gluconate, the bathing procedure was consistent throughout, and nurses easily adopted chlorhexidine bathing. Although we collected no nursing compliance data, feedback was positive and our unit continued use of the product after the trial period. We witnessed only 2 rashes during the chlorhexidine period that prevented continued use of the product, both of which were attributed to antibiotic therapy and resolved without intervention.

Our study has a number of limitations. The before-and-after study design precludes establishing causation, but demonstrates the practical adoption of a new infection-control method. We did not control for nontrauma patients concurrently admitted to the ICU. Because the size of this population was consistent throughout, all patients were bathed according to the same protocol, and the beneficial effects of chlorhexidine bathing were previously demonstrated in medical ICU patients,[5] we would not expect that this minority population of medical patients boarding in the trauma ICU would significantly skew the results. We conducted active surveillance and contact isolation for *A baumannii*, which could have influenced the transmission of MRSA, but the number of *A baumannii* isolates was low overall, and therefore there was likely insufficient power to detect a substantial effect. Although the procedure for obtaining MRSA surveillance cultures was altered in the final month of the chlorhexidine period, contact precautions were not initiated upon determination of positive MRSA culture until several months after the study concluded. It has been established that reliance on clinical cultures underestimates the carriage rates of MRSA.[34,35] Owing to increasing surveillance and the expected increased colonization pressure due to seasonal variation,[36] we might have expected to observe an increase in the total number of MRSA isolates in the chlorhexidine period, but in fact, we witnessed a significant decrease. Future studies might include a cost-benefit analysis, as the cost of chlorhexidine cloths, estimated to be $5.52 per bath at the time of the trial, is considerably more than the disposable bath product that does not contain chlorhexidine ($1.23 per bath).

Bathing trauma patients in the ICU with disposable cloths containing 2% chlorhexidine gluconate was associated with a decrease in the incidence of CRBSI and MRSA VAP. Our findings support the use of routine chlorhexidine bathing as an adjunctive infection-control measure to reduce transmission of MRSA, *A baumannii*, and potentially other epidemiologically important organisms that colonize the skin of critically ill hospitalized patients.

Accepted for Publication: April 27, 2009.
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Financial Disclosure: None reported.
Funding/Support: Dr Nathens is supported through a Canada Research Chair.
Previous Presentations: This study was presented at the 28th Annual Meeting of the Surgical Infection Society; May 7, 2008; Hilton Head, North Carolina.
Additional Contributions: The authors acknowledge Mary Catlin, MPH, for her contribution to this study.

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INVITED CRITIQUE

A Bath a Day

Chlorhexidine gluconate is becoming the premier preventive antimicrobial drug. Modern evidence supports its application as a surgical scrub, surgical skin preparation, oral decontaminant, and skin preparation for central line placement. This is a valiant comeback from the reviews that showed that preoperative chlorhexidine scrubs do not reduce surgical site infections.

This study and others demonstrate benefits of daily baths with chlorhexidine in the ICU, with an overall decrease in surgical site infections, VAP, and other nosocomial infections. Most prominent is the reduction in infections attributed to MRSA, VRE, and other gram-positive bacteria. This study specifically addresses these findings in the TICU population, and an important point is that these patients benefited just as much as other study cohorts.

A weakness of this study is that it is a before-and-after study from a single institution with no monitoring of the nursing staff's compliance or their technique. Nevertheless, its results have been replicated by others, including a recently published multi-institutional study.[1] This reveals the strength of the chlorhexidine bathing procedure: daily baths using chlorhexidine solution works in the ICU, and it works despite differences in nursing compliance, technique of application, and type of applicator. Also, its use may transfer added benefit to hospitalized patients as a whole by preventing bacterial transmission outside of the ICU.

Daily bathing with chlorhexidine cloths results in a significant decrease in common multi-drug resistant bacterial infections such as from MRSA and VRE, presumably owing to decreased colonization rates. However, as seen in this study, there is a worrisome shift toward infections from gram-negative bacteria. It is possible that nationwide application of chlorhexidine in the ICU may result in an upswing in new and even multi-drug–resistant gram-negative infections. The fate of chlorhexidine bathing will have to be tested with time.

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Financial Disclosure: None reported.

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