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Major article

Impact of daily chlorhexidine baths and hand hygiene compliance on nosocomial infection rates in critically ill patients

Michel Fernando Martínez-Reséndez MD [a], Elvira Garza-González PhD [b,c], Soraya Mendoza-Olazaran MSc [b,c], Alexis Herrera-Guerra MD [d], Juan Manuel Rodríguez-López RN [a], Edelmiro Pérez-Rodriguez MD [e], Roberto Mercado-Longoria MD [f], Adrián Camacho-Ortiz MD [a,*]

[a] Infectious Diseases Department, Hospital Epidemiology, University Hospital "Dr José Eleuterio González", Monterrey, México
[b] Gastroenterology Department, University Hospital "Dr José Eleuterio González", Monterrey, México
[c] Clinical Pathology Department, University Hospital "Dr José Eleuterio González", Monterrey, México
[d] Internal Medicine Department, University Hospital "Dr José Eleuterio González", Monterrey, México
[e] Hospital Administration Subdirection, University Hospital "Dr José Eleuterio González", Monterrey, México
[f] Pulmonary and Critical Care Department, University Hospital "Dr José Eleuterio González", Monterrey, México

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Background: Up to 25% of all nosocomial infections (NIs) develop in critically ill patients. Our objective was to evaluate chlorhexidine (CHX) bathing and hand hygiene (HH) compliance in the reduction of NIs in the intensive care unit.

Methods: The study comprised three 6-month periods: preintervention (PIP; soap/water bathing), intervention (IP; bathing with CHX-impregnated wipes), and postintervention (PoIP; soap/water bathing). An HH program was implemented during the IP and PoIP. Primary outcomes were global and specific NI rates.

Results: A total of 1007 patients were included. Infection rates per 100 discharges were higher in the PIP compared with the IP and also higher in the PoIP compared with the IP ($P = .0004$ and .0109, respectively). Global infection rates per 1000 hospital-days were higher in the PIP than in the IP ($P = .0268$). The rates of ventilator-associated pneumonia (VAP) and catheter-associated urinary tract infection (CAUTI) were higher in the PIP than in the IP ($P = .036$ and .0001, respectively). Isolation of *Acinetobacter baumannii* from VAP specimens ($P = .0204$) and isolation of *Candida* spp from CAUTI specimens ($P = .0005$) decreased as well.

Conclusion: The combined intervention reduced global and specific infection rates, including rates of VAP associated with *A baumannii* and CAUTI associated with *Candida* spp.

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Nosocomial infections (NIs) are important causes of morbidity and mortality, affecting approximately 10%-13% of hospitalized patients.[1-3] Up to 25% of all NIs develop in critically ill patients, and almost 70% of NIs caused by multidrug-resistant microorganisms (MDR-M).[4,5] Such infections constitute a serious threat for any health system owing to the sparse development of novel antibiotics, especially those aimed at gram-negative organisms. They are associated with increased duration of hospitalization and health-related costs, ultimately imposing a large socioeconomic burden.[2,6] In the context of this adverse scenario, various preventive measures have been undertaken to reduce the incidence of NIs, including programs involving the promotion of hand hygiene (HH), chlorhexidine (CHX) baths, nosocomial surveillance, and antibiotic stewardship.[3,7-11]

CHX is a topical antiseptic with a wide range of activity against gram-positive and gram-negative bacteria, molds, and some viruses. It has no sporicidal activity,[12] but exerts a residual effect for up to 24 hours after topical application.[13] Some previous studies have demonstrated that CHX baths reduce NIs in critically ill patients, primarily central line– associated bloodstream infections (CLABSIs), especially those associated with gram-positive bacteria.[14,15] Other

* Address correspondence to Adrián Camacho-Ortiz, MD, Servicio de Infectología, Coordinación de Epidemiología Hospitalaria, Hospital Universitario "Dr José Eleuterio González," Universidad Autónoma de Nuevo León, Avenida Francisco I. Madero s/n, Colonia Mitras Centro, Monterrey, NL 64460, México.
E-mail address: acamacho_md@yahoo.com (A. Camacho-Ortiz).
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Table 1
Demographic characteristics of the study population

Variable	Total	PIP	IP	PoIP	PIP vs IP, *P* (range 95% CI)	IP vs PoIP, *P* (range 95% CI)
Patients, n	1007	351	327	329	—	—
Males, n	648	237	197	214	.058	.23
Mean age (years)	48.44	47.47	49.74	48.19	.093	.27
					−2.28 (−4.94 to 0.38)	−1.55 (−4.33 to 1.22)
Mean length of hospital stay (days)	8.74	7.89	8.73	9.67	.15	.24
					−0.86 (−2.04 to 0.32)	0.99 (−0.65 to 2.64)
Surgical patients, n (%)	521	195 (55.5)	161 (49.2)	165 (50.2)	.12	.87
Medical patients, n (%)	486	156 (44.5)	166 (50.8)	164 (49.8)	—	—
Overall mortality, n/N	357/1007	111/351	128/327	118/329	—	—
Urethral catheter- days/patient	8.36	7.62	8.33	9.21	.25	.30
					−0.71 (−1.93 to 0.50)	0.88 (−0.78 to 2.53)
Mechanical ventilation- days/patient	7.39	6.60	7.60	8.04	.15	.63
					−1.00 (−2.36 to 0.35)	0.44 (−1.34 to 2.21)
Central catheter-days/patient	8.02	7.28	8.07	8.78	.20	.40
					−0.79 (−2.01 to 0.43)	0.70 (−0.95 to 2.36)

studies have shown that basins used for traditional bathing (with soap and water) serve as reservoirs for bacteria and may be a source of hospital-acquired infection transmission.[16,17] HH, an inexpensive and practical measure, is the cornerstone of NI control; however, paradoxically, low compliance with HH by health care personnel, among whom the practice should be almost automatic, creates continuous work for hospital infection control units.[18-21] The majority of previous studies have evaluated the use of CHX and HH measures separately, although a few have examined them simultaneously.[22,23] In the present study, we evaluated the combined effects of CHX bathing and adequate HH compliance in reducting NIs.

METHODS

Setting

This study was performed at the Dr José Eleuterio González University Hospital, a 450-bed tertiary care teaching hospital in Monterrey, Nuevo Leon, Mexico. The hospital has 2 adult intensive care units (ICUs), medical and surgical, each with 10 beds, which handle an average of 450-500 hospitalizations annually. These ICUs receive patients transferred from other hospitals in the region and throughout northeastern Mexico. The local Ethics Committee approved this study without the requirement for written informed consent.

Study design

The study was conducted over an 18-month period, from January 1, 2012, to June 30, 2013. The study was divided into three 6-month periods: a preintervention period (PIP; January 1 to June 30, 2012) involving observation and registration of variables, during which patients were bathed in the traditional manner with soap and water; an intervention period (IP; July 1 to December 31, 2012), during which all patients were bathed daily with 2% CHX-impregnated wipes (Clorhexi-Wipes One Step; G70 Antisepsis, Leon, Mexico) and their hair was washed with no-rinse 0.12% CHX foam shampoo (Chlorhexidine Shampoo One Step; G70 Antisepsis) from day of ICU admission through to ICU discharge; and a postintervention period (PoIP; January 1 to June 30, 2013), during which patients were bathed with soap and water. An HH maintenance program was initiated during the IP and continued throughout the PoIP.

All patients admitted to the ICUs during the study period were included in our analysis, with the following exceptions: patients age $<$18 years, those with burn injuries covering $\geq$20% of body surface area, pregnant women, and patients with a history of allergic reaction to CHX. No additional infection control interventions were implemented during the study period.

Training and evaluation of health care providers

During the 2 weeks before the implementation of CHX bathing, all ICU personnel received instructions and practical training in the use of a step-based corporal washing technique that uses 10 CHX wipes to bathe a patient comprehensively from chin to feet without mucosal membrane contact. Before use, the wipes were preheated for 15 seconds in a conventional microwave oven, in accordance with the manufacturer's instructions. All personnel also received practical training in shampooing. Caregiver compliance with these procedures was evaluated periodically throughout the study. During the IP and PoIP, all ICU personnel were instructed in HH practices in various small group discussions and received given verbal reminders and constant feedback regarding compliance. Daily, the head nurse and the nurses in charge of the units supervised bathing practices, as well as registration in a bathing journal. As additional confirmation, empty towel packs were counted at the end of each shift.

Data collection

We collected demographic and clinical data, including patient age and sex, length of stay, outcome of ICU hospitalization, and rate of indwelling device use. All patients' primary diagnoses were categorized as medical or surgical. Clinical culture results were obtained from the hospital laboratory's microbiological database and patients' medical charts. The hospital's infection control unit performed NI surveillance throughout the study period. The surveillance team had knowledge of the interventions and bathing techniques, but not of the study objective. HH compliance was measured through direct observation by the same personnel throughout the entire study. Opportunities for HH evaluation were evaluated during intervals of 2-3 hours during morning shifts and 2 hours during afternoon shifts. No measurements were performed during the night shift.

ICU-acquired infections were defined based on criteria from the Centers for Disease Control and Prevention and Klompas et al.[24,25] The primary outcomes were global and specific NI rates, which were compared among the 3 study periods. In addition, the impacts of CHX and HH measures were evaluated by comparing the IP with the PoIP and the PIP with the PoIP, respectively Secondary outcomes were the results of microbiological analysis of each specific infection type.

Statistical analysis

Analyses were performed with descriptive statistics and standard nonparametric tests. Wilcoxon's rank-sum test was used to

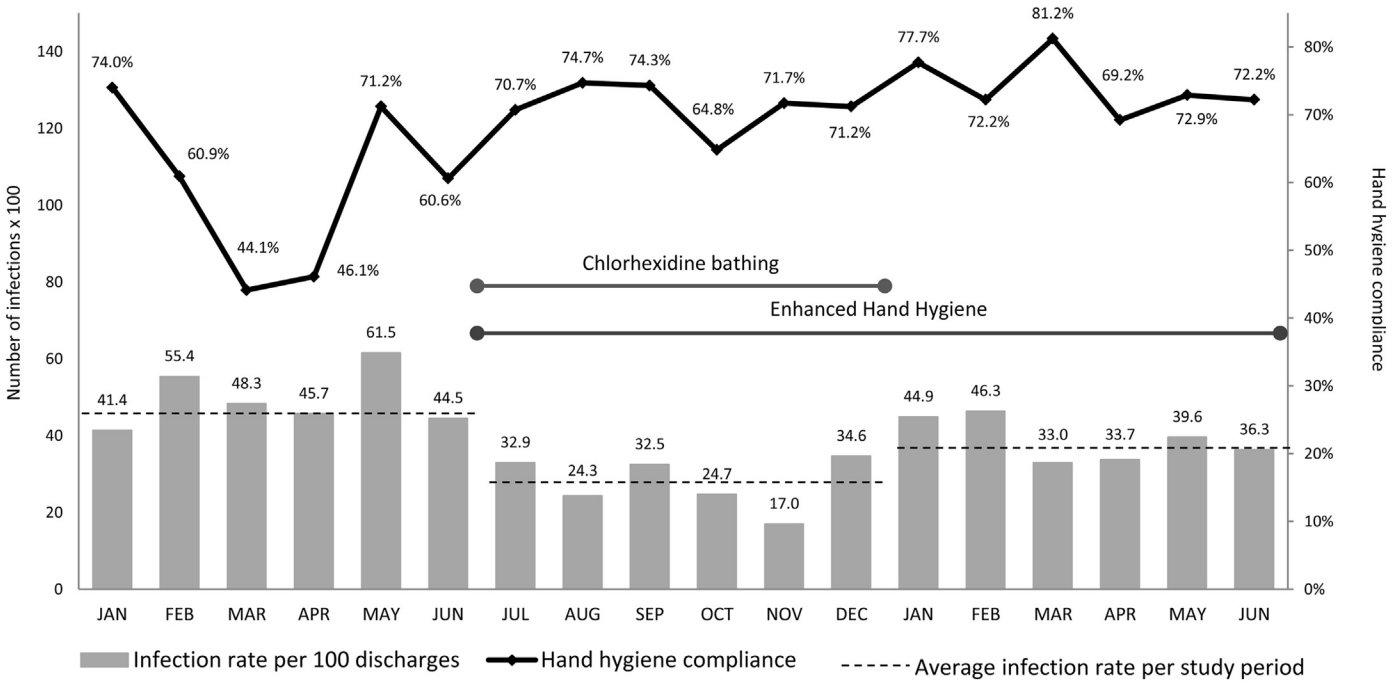

Fig 1. HH compliance and NI rates during the 3 study phases.

compare means, and the χ^2 test or Fisher exact test was used for dichotomous variables. A P value $\leq .50$ was considered statistically significant. SPSS version 15.0 (SPSS, Chicago, IL) was used for all analyses.

RESULTS

Study population

During the 18-month study period, 1071 patients were admitted to the ICU; 64 of these patients were excluded owing to burn injuries (n = 19), pregnancy (n = 11), underage (n = 33), or underage and pregnancy (n = 1). Thus, the study sample comprised 1007 patients with an ICU stay during the PIP (n = 351), IP (n = 327), or PoIP (n = 329). The mean patient age was 47.47 in the PIP, 49.74 in the IP, and 48.19 years in the PoIP (PIP vs IP, $P = .0930$; IP vs PoIP, $P = .2720$). Males predominated (Table 1).

Clinical data and infection rates

Median length of stay was 7.89 days in the PIP, 8.73 days in the IP, and 9.67 days in the PoIP (PIP vs IP, $P = .1512$; IP vs PoIP, $P = .2363$). The numbers of patients with surgical and medical diagnoses did not differ significantly across the 3 periods. Overall mortality rates were 31.62% (111 of 351) in the PIP, 39.14% (128 of 327) in the IP, and 35.86% (118 of 329) in the PoIP.

Infection rates per 100 discharges were 49.42 in the PIP, 27.63 in the IP, and 38.93 in the PoIP. This rate differed significantly between the PIP and the IP ($P = .0004$) and also between the IP and the PoIP ($P = .0109$). Global infection rates per 1000 hospital-days were 64.44 in the PIP, 43.30 in the IP, and 58.45 in the PoIP. This rate differed significantly between the PIP and IP ($P = .0268$), and the difference between the IP and PoIP approached significance ($P = .0532$) (Fig 1).

Infection rates stratified by type are presented in Table 2. The rates of ventilator-associated pneumonia (VAP) per 1000 ventilator-days were 17.47 in the PIP, 8.91 in the IP, and 12.40 in the PoIP, with a significant difference between the PIP and IP ($P = .036$). The rates of catheter-associated urinary tract infection (CAUTI) per 1000 catheter-days were 16.68 in the PIP, 12.62 in the IP, and 20.32 in the PoIP. This rate differed significantly between the PIP and IP ($P = .0001$), but not between the IP and PoIP ($P = .0697$). The rates of CLABSI per 1000 central venous catheter-days were 14.37 in the PIP, 8.00 in the IP, and 15.23 in the PoIP, with no significant difference between the PIP and IP ($P = .0713$) or between the IP and PoIP ($P = .0842$).

Microbiological data

During the PIP, most VAP infections (n = 43) were caused by gram-negative species, with gram-positive bacteria isolated in 11 cases. During the IP, we observed a global reduction in the number of VAP infections, with gram-negative species remaining predominant (n = 17 vs n = 5 gram-positive isolations). Gram-negative and gram-positive bacteria were isolated from CAUTIs in 19 and 9 cases, respectively, during the PIP; the predominance of gram-negative bacteria persisted during the IP (n = 18 vs n = 5 gram-positive isolations). Clinical culturing of CLABSI samples yielded gram-negative bacteria in 33 cases and gram-positive bacteria in 7 cases in the PIP, and gram-negative bacteria in 21 cases and gram-positive bacteria in 4 cases in the IP. The number of *Acinetobacter baumannii* infections decreased from 21 in the PIP to 7 in the IP ($P = .02$). Analysis of infections by bacterial species revealed significant reductions in the number of VAP infections caused by *A baumannii* ($P = .0204$) and in the number of CAUTIs associated with *Candida* spp ($P = .0005$) between the PIP and the IP.

Compliance with HH and the CHX bathing protocol

Among the 52 nurses in the ICUs, a total of 1483 observations of HH compliance were made (506 in the PIP, 511 in the IP, and 466 in the PoIP). Average HH compliance rates during the 3 periods were 59.48%, 71.23%, and 74.24%, respectively. We observed a significant difference in compliance between the PIP and IP ($P = .0001$), but not

Table 2
Comparison of total and individual infection rates by study period

Variable	PIP	IP	PoIP	PIP vs IP, *P* (range 95% CI)	IP vs PoIP, *P* (range 95% CI)	PIP vs PoIP, *P* (range 95% CI)
Infection rate per 100 discharges	49.42	27.63	38.93	.0004 21.79 (12.51 to 31.07)	.0109 −11.30 (−19.37 to 3.22)	.0216 10.49 (1.89 to 19.099)
Infection rate per 1000 hospital-days	64.44	43.30	58.45	.0268 21.13 (2.97 to 39.29)	.0532 15.15 (−0.25 to 30.55)	.4476 −5.98 (−22.84 to 10.88)
VAP infections, n	46	25	33	—	—	—
VAP rate per 1000 ventilator- days	17.47	8.91	12.40	.036 8.55 (0.68 to 16.43)	.2557 3.49 (−2.96 to 9.94)	.0860 −5.06 (−10.99 to 0.86)
CAUTIs, n	54	25	47	—	—	—
CAUTI rate per 1000 catheter-days	16.68	12.62	20.32	.0001 8.72 (5.48 to 11.969)	.0697 6.61 (−0.64 to 13.87)	.5067 −2.10 (−8.93 to 4.71)
CLABSIs, n	43	25	41	—	—	—
CLABSI rate per 1000 central venous catheter-days	14.37	8	15.23	.0713 6.36 (−0.66 to 13.39)	.0842 7.2 (−1.17 to 15.62)	.8101 0.85 (−6.89 to 8.60)
Observations of HH compliance, n	506	511	466			
HH compliance, n (%)	301 (59.48)	364 (71.23)	346 (74.24)	.0001	.3248	.0001

between the IP and PoIP ($P = .3248$). Compliance with the CHX bathing protocol was 97% during the intervention phase.

DISCUSSION

The combined measures of routine daily CHX bathing and enhanced HH compliance reduced the global rate of infection per 100 discharges in critically ill patients. This infection rate increased significantly after the discontinuation of CHX bathing, indicating that the impact of this measure was greater than that of enhanced HH compliance alone. The combined intervention also reduced the global infection rate per 1000 hospital-days; this rate increased significantly after the discontinuation of CHX bathing, again demonstrating the impact of this measure.

We found that the combined intervention reduced the rates of VAP and CAUTIs, but that these rates did not decrease any further after discontinuation of the CHX protocol. The intervention did not reduce the rate of CLABSIs to a significant degree. This result may be explained in part by high turnover among medical personnel dedicated to the care of central venous catheters; the observed high prevalence of gram-negative infections, in contrast to previous reports of the predominance of gram-positive infections[26,27]; the greater resistance of MDR-M to CHX[28]; and the shortage of CHX supplies for use in the care of these devices.

The reduced number of VAP infections caused by *A baumannii* is an important finding, given the high prevalence of infections caused by this microorganism in our hospital and this species' association with high morbidity and mortality rates in critically ill patients. No previous study has reported a reduction in *A baumannii* isolations from any type of infection due to a CHX bathing intervention. We speculate that the reduced rates of VAP and CAUTIs, especially those caused by gram-negative organisms, is related in part to the residual effect of CHX in the patient, as well as in the environment, thereby reducing the risk of colonization and subsequent infection from manipulation of devices associated with the patient. In our ICU, gram-negative pathogens such as *Acinetobacter* spp are more prevalent than gram-positive pathogens. In recent years, *A baumannii* has become the principal cause of VAP; thus, a reduction in global hospital-acquired infections may be associated with a specific reduction in gram-negative infections. The combined intervention was also associated with a significant reduction in the number of CAUTIs caused by *Candida* spp, similar to the results reported by Climo et al.[29] The significant increases in the isolation rates of these 2 microorganisms after the discontinuation of CHX bathing implies that this measure had a greater impact compared with enhanced HH compliance alone.

Our results demonstrate that this combined intervention is an effective preventive approach. Given the lack of studies assessing such interventions,[30] further research is needed to determine whether such multifaceted interventions can reduce or eliminate the threat of NIs caused by MDR-M.

We acknowledge that the combined intervention is a limitation in some instances for a clear analysis of the impact that a single intervention had in infection rates. Another limitation is the fact that HH evaluations were performed by direct observation during the morning and afternoon shifts; although the same trained personnel made the evaluations throughout the entire study (blinded to the study objective), we believe that bias could be present, because direct observations of HH compliance are suboptimal.

In conclusion, our CHX bathing protocol reduced global infection rates and rates of VAP and CAUTI. Specifically, and importantly, reductions in VAP associated with *A baumannii* and in CAUTIs associated with *Candida* spp were observed.

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