American Journal of Infection Control xxx (2015) 1-7

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Effect of daily chlorhexidine bathing on acquisition of carbapenem-resistant *Acinetobacter baumannii* (CRAB) in the medical intensive care unit with CRAB endemicity

Yun Kyung Chung MD, PhD [a,1], Jae-Seok Kim MD, PhD [b,1], Seung Soon Lee MD [c,*], Jeong-a Lee MD [c], Han-Sung Kim MD, PhD [d], Kyong-sok Shin MD, MPH [e], Eun Young Park MS [b], Bog Soun Kang MSN, RN [f], Hee Jung Lee MSN, RN [f], Hyun Joo Kang RN [g]

[a] *Department of Occupational and Environmental Medicine, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Anyang, South Korea*
[b] *Department of Laboratory Medicine, Kangdong Sacred Heart Hospital, Hallym University College of Medicine, Seoul, South Korea*
[c] *Division of Infectious Diseases, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Anyang, South Korea*
[d] *Department of Laboratory Medicine, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Anyang, South Korea*
[e] *Department of Occupational and Environmental Medicine, Seegene Medical Foundation, Seoul, South Korea*
[f] *Medical Intensive Care Unit, Hallym University Sacred Heart Hospital, Anyang, South Korea*
[g] *Department of Infection Control, Hallym University Sacred Heart Hospital, Anyang, South Korea*

Key Words:
Chlorhexidine gluconate
Baths
Acinetobacter baumannii
Drug resistance
bacterial
Intensive care units

Background: There is insufficient evidence for daily chlorhexidine bathing to reduce nosocomial spread of carbapenem-resistant *Acinetobacter baumannii* (CRAB) in endemic situations.
Methods: An interrupted time series study was performed to evaluate the effect of daily chlorhexidine bathing on the acquisition of CRAB in a medical intensive care unit (ICU) with CRAB endemicity. There was a 14-month control period and 12-month chlorhexidine bathing period. Segmented Poisson regression analysis was performed to assess the impact of chlorhexidine bathing on the level and trend of the series of prevalence rates and incidence density. Also, chlorhexidine susceptibility testing was performed on CRAB isolates collected during the chlorhexidine bathing period.
Results: There was a 51.8% reduction of CRAB acquisition rates after an introduction of daily chlorhexidine bathing (44.0 vs 21.2 cases/1,000 at-risk patient days, $P < .001$). There was a significant reduction in the level (−0.604; 95% CI, −0.904 to −0.305; $P < .001$) of incidence density of CRAB, whereas there was no significant change in both level and trend of CRAB prevalence rates. Minimum inhibitory concentration of chlorhexidine against a total of 98 CRAB isolates ranged from 8-64 μg/mL.
Conclusion: Daily chlorhexidine bathing significantly reduces the acquisition of CRAB in a medical ICU with CRAB endemicity.

Carbapenem-resistant *Acinetobacter baumannii* (CRAB) is a globally important nosocomial pathogen. We have performed active surveillance culture (ASC) and preemptive contact precautions (CPs) with enhanced environmental cleaning (EC) for the control of CRAB endemicity in a medical intensive care unit (ICU) since June 2012. However, there was no significant reduction in the rates of acquisition and environmental contamination of CRAB in spite of a 14-month implementation of these infection control measures. Therefore, advanced source control, such as daily chlorhexidine bathing, was considered. It was reported that daily chlorhexidine bathing may prevent the acquisition of vancomycin-resistant enterococci or methicillin-resistant *Staphylococcus aureus*.[1-5] However, there is insufficient evidence for daily chlorhexidine bathing to reduce nosocomial spread of CRAB in endemic situations.[6,7] Also, some nonfermenting gram-negative organisms may be resistant to chlorhexidine.[8-10] Therefore, we investigated

* Address correspondence to Seung Soon Lee, MD, Division of Infectious Diseases, Department of Internal Medicine, Hallym University Sacred Heart Hospital, 896 Pyeongchon-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-070, South Korea.
E-mail addresses: hushh93@hallym.or.kr, hushh93@gmail.com (S.S. Lee).
Funding/Support: This work was supported by a grant from AbbVie Inc. and Hallym University Specialization Fund (HRF-S-41).
Conflicts of interest: None to report.
[1] Y.K. Chung and J.-S. Kim contributed equally to this work.

0196-6553/$36.00 - Copyright © 2015 by the Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ajic.2015.07.001

whether daily chlorhexidine bathing could prevent the acquisition of CRAB in a medical ICU with CRAB endemicity.

METHODS

Study design

Study setting

Hallym University Sacred Heart Hospital is a Korean, university-affiliated, tertiary-care hospital with 829 beds, including 16 beds in the medical ICU. The medical ICU is divided into 4 rooms with 4 beds about 2 m apart per room. Twenty-four registered nurses with 1 duty nurse per room (low nurse/patient ratio, 1:4), 6 nursing assistants, and 1 environmental management assistant worked in the medical ICU. Also, 1 intensivist and 2 internal medicine residents stayed at the medical ICU. Two infectious diseases specialists had the responsibility for infection control and antibiotic control in the ICU. Two infection control nurses assisted infection control in the ICU. There was a 14-month control period between June 2012 and July 2013 and a 12-month chlorhexidine bathing period between August 2013 and July 2014.

ASC and preemptive CPs with enhanced EC

ASC and preemptive CPs with enhanced EC have been performed for the control of CRAB endemicity in the medical ICU since June 2012. These infection control strategies performed during the control period continued during the chlorhexidine bathing period. ASC for patients admitted to the medical ICU for >48 hours was performed at ICU admission if CRAB was not isolated at clinical or surveillance culture during the previous year and once per week and at ICU discharge (or within the second day after ICU discharge) if CRAB was not isolated at clinical or surveillance culture after ICU admission. The collection of specimens for ASC was through both nasal and rectal swabs, and chromogenic media (CHROMagar and Acinetobacter with selective supplement CR102; CHROMagar, Paris, France) were used for detection of CRAB.[11-13] Species identification and antimicrobial susceptibility testing were performed using the MicroScan Walkaway-96 system and MicroScan Neg BP Combo 42 Panel (Siemens, West Sacramento, CA). Average time from acquisition of surveillance swab to reporting of positive culture results was 48-72 hours. Negative ASC results were available the next day.

CPs were started preemptively on all ICU patients, pending the result of ASC requested at ICU admission, and was discontinued if CRAB was not isolated at surveillance or clinical culture. Warning posts for preemptive CPs were displayed at the head side of a bed of patients. If positive culture results of CRAB were reported, warning posts were maintained until ICU discharge. Hand hygiene according to World Health Organization recommendations and the use of gloves, vinyl gowns, and dedicated medical equipment were needed for CPs.[14] Personal protection equipment organizers were used to improve compliance with CPs.

Enhanced EC with wipes for surface disinfection (Clinell Universal Wipes; GAMA Healthcare, London, United Kingdom) consisted of twice-daily cleaning of high-touch areas by an environmental management assistant and cleaning of critical medical equipment by duty nurses 3 times a day. A checklist for EC was used to prevent omission of EC.

Daily chlorhexidine bathing

All ICU patients received routine daily bed baths with nonmedicated, wet towels according to local ICU policy before the chlorhexidine bathing period. Nurses and nursing assistants received education on the proper techniques for chlorhexidine bathing 1 week before the introduction of chlorhexidine bathing.

Table 1
Acquisition of carbapenem-resistant *Acinetobacter baumannii* before and after daily chlorhexidine bathing

Variable	Control period	Chlorhexidine bathing period
No. of admissions to the medical ICU	1,514.0	1,540.0
No. of patients <18 y of age	17.0	9.0
No. of patients admitted <48 h	904.0	977.0
No. of admissions of eligible patients*	593.0	554.0
No. of prevalent cases	153.0	101.0
Prevalence rates (%)	25.8	18.2
At risk patient days	2,844.0	2,685.0
No. of incident cases	125.0	57.0
Incident density	44.0	21.2

ICU, intensive care unit.
*Eligible patients were defined as nonpregnant adults admitted to the medical ICU for >48 hours, to whom surveillance culture for carbapenem-resistant *A baumannii* was requested.

Daily bathing with no-rinse 2% chlorhexidine-impregnated washcloths (Clinell Chlorhexidine Wash Cloths; GAMA Healthcare, London, United Kingdom) was performed for ICU patients by both nurses and nursing assistants from August 1, 2013. Washcloths were used in sequential order to rinse all body surface according to the manufacturer's instructions, with the avoidance of contact with eyes and on genitals. Safety data for most chlorhexidine products have not been established in children (age <18 years).[15] If the patient is a child age <18 years, daily bathing with nonmedicated, wet towels was performed and excluded from the analyses. If patients were admitted for <48 hours, they were excluded from the analyses but did receive chlorhexidine bathing. Duty nurses in the medical ICU monitored patients for skin reactions and reported them to the investigators, who graded skin reactions on a scale of 1 to 4, and determined whether the reactions were attributable to bathing as previously described.[2]

Chlorhexidine susceptibility testing

All of the initial CRAB isolates from surveillance or clinical cultures were shipped to the department of laboratory medicine, Kangdong Sacred Heart Hospital, for chlorhexidine susceptibility testing during chlorhexidine bathing period. Minimum inhibitory concentrations (MICs) of chlorhexidine against CRAB were determined by the broth microdilution method in concentrations that ranged from 0.125-128 μg/mL (corresponding to chlorhexidine concentrations of 0.0000125% to 0.0128%) for chlorhexidine.[8,16-18] Minimum bactericidal concentrations (MBCs) of chlorhexidine against CRAB were also determined by the growth on trypticase soy agar. Because CRAB isolates were not collected during the control period, we could not evaluate a change of chlorhexidine susceptibility in CRAB isolates before and after intervention. Instead, MICs and MBCs of chlorhexidine were compared between CRAB isolates from prevalent cases and incident cases during the chlorhexidine bathing period.

Environmental culture

Environmental cultures for CRAB in the medical ICU were performed 1 month before the introduction of chlorhexidine bathing and about every 3 months during the interventional period. We did not give advance notice of environmental sampling for CRAB. Environmental sampling was performed by 2 infectious diseases specialists and 2 infection control nurses at certain times of the day (between 2:00 and 4:00 PM) after EC and chlorhexidine bathing every morning. An environmental swab system (3M Quick Swabs; 3M, St Paul, MA) was used for handling environmental samples. CHROMagar Acinetobacter was used for the selection of CRAB in environmental samples. Rates of CRAB culture were compared between the control and chlorhexidine bathing periods.