American Journal of Infection Control 42 (2014) 1178-81

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Long-term efficacy of a self-disinfecting coating in an intensive care unit

Akrum H. Tamimi PhD, Sheri Carlino BS, Charles P. Gerba PhD *

Department of Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ

Key Words:
Disinfection
Bacteria
Self-disinfecting surface
Efficacy

Background: Cleaning and disinfecting fomites can effectively remove/kill pathogens on surfaces, but studies have shown that more than one-half the time, surfaces are not adequately cleaned or are recontaminated within minutes. This study evaluated a product designed to create a long-lasting surface coating that provides continuous disinfecting action.

Methods: This study was performed in an intensive care unit (ICU) in a major hospital. Various sites within the ICU were cultured before treatment and then at 1, 2, 4, 8, and 15 weeks after application of an antimicrobial coating. Samples were cultured for total bacteria, as well as *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococcus, and carbapenemase-resistant Enterobacteriaceae.

Results: The average bacterial count on all treated surfaces was reduced by >99% (2 logs) for at least 8 weeks after treatment. Overall, average levels of bacteria never returned to those observed before treatment even after 15 weeks. Antibiotic-resistant bacteria were found on 25% of the sites tested before treatment, but were isolated at only 1 site during the 15 weeks after treatment.

Conclusions: The product assessed in this study was found to have persisted over 15 weeks in reducing the total number of bacteria and antibiotic resistant bacteria on surfaces within an ICU.

Contamination of inanimate objects (fomites) and surfaces are known to contribute to the transmission of health care–associated infections (HAIs), especially those related to antibiotic-resistant bacteria.[1] Some infection control guidelines recommend the routine disinfection of patient care surfaces, especially high-touch objects. Such objects presumably contribute to the transmission of pathogens by contaminating the hands of health care workers who subsequently contact patients.[1,2]

Routine and terminal cleaning of surfaces using hospital-grade disinfectants is an accepted method for controlling the spread of infectious agents. Cleaning and disinfecting fomites can effectively remove/kill pathogens on surfaces, but studies have shown that more than one-half the time, surfaces are not adequately cleaned and may be recontaminated within minutes.[2,3]

Commonly used disinfectants (eg, chlorine, hydrogen peroxide, quaternary ammonium compounds) provide no persistent residual activity after their application to disinfect surfaces, because they are easily washed away. In addition, application of disinfectants needs to be closely monitored, because cleaning cloths may reduce the effective concentration during actual use by cleaning crews.[4] Self-disinfecting surfaces that act against microbes on a continuing basis would specifically address these limitations in current cleaning and disinfecting practices.[5] Recently, copper surfaces have been shown to reduce the rate of occurrence of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococcus (VRE) colonization of patients in ICU rooms, as well as the numbers of the organisms on surfaces.[6,7] They also have been shown to continuously reduce the concentration of total bacteria on bed rails within intensive care unit (ICU) rooms.[8]

The present study was designed to assess the effectiveness of ABS-G2015 (Allied BioScience, Point Roberts, WA), a formulation of a quaternary ammonium organosilane compound that binds to surfaces and produces a residual (ie, long-term) disinfecting activity. Our initial laboratory work demonstrated ABS-G2015's effectiveness against a wide range of pathogenic bacteria (eg, MRSA, *Pseudomonas aeruginosa*) and viruses (eg, MS-2 virus). The goal of this study was to assess its efficacy in a practical application in a health care environment.

* Address correspondence to Charles P. Gerba, PhD, Department of Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ 85721.
E-mail address: gerba@ag.arizona.edu (C.P. Gerba).

This project was supported by Allied BioScience through funding supplied to the University of Arizona.
Conflict of interest: None to report.

http://dx.doi.org/10.1016/j.ajic.2014.07.005

Table 1
Culture methods used for microbial isolation and identification

Organism	Culture method	Incubation conditions	Further analysis	Reference
Total bacteria	Spread plating on R2A medium (BD Diagnostics, Sparks, MD)	24°C for 5 d		13
C difficile	Incubation for 7 days in 0.1% sodium taurocholate and cycloserine-cefoxin fructose broth	Anaerobic conditions at 37°C for up to 5 d	A 2-mL aliquot was mixed with equal amounts of absolute ethanol. Bacteria were concentrated by centrifugation and pellets were used to inoculate cycloserine-cefoxtin fructose agar.	14
MRSA	Trypticase soy agar amended with 5% sheep's blood, 10 mg/L colistin, and 25 mg/naladixic acid using spread plate method	35°C for 24-48 h	β-hemolytic colonies were isolated and subcultured on trypticase case soy agar with no amendments and incubated at 35°C for 24-48 h.	15
CRE	Modified Hodge test; Muller-Hinton agar	35°C for 24 h		16
VRE	Bile esculin azide agar	37°C in CO_2 incubator for 24-48 h	Gram stain, catalase test	17

NOTE. From an original volume of 4 mL of sponge stick eluate. A 0.1-mL volume of this eluate was used for each assay.

Table 2
Average (arithmetic mean) total bacterial numbers (cfu) isolated on 100 cm^2 from fomites and percent reduction after treatment

		Weeks after treatment				
Variable	Baseline*	1	2	4	8	15
Number of samples	95	81	64	64	64	45
Average number of bacteria	233,064	98	80	43	2,247	3,320
Range	10-7,000,000	10-2,500	10-840	10-2,500	10-44,000	10-57,000
% reduction	NA	99.96	99.97	99.98	99.04	98.58

NA, not applicable.
*Before treatment.

Table 3
Percent cfu of total bacteria per 100 cm^2 exceeding values indicated

		Weeks after treatment				
Count, cfu per 100 cm^2	Baseline*	1	2	4	8	15
>100	71.5	11.1	17.2	12.8	51.2	33.3
>1,000	51.5	2.4	1.5	0	17.1	24.4
>10,000	25.2	0	0	0	4.6	11.1

*Before treatment.

MATERIALS AND METHODS

This study was conducted in a 24-bed ICU of a community hospital in Los Angeles County, California, between May 10 and September 30, 2013. Initial microbial sampling of various fomites was conducted to assess the levels of bacteria on various hospital surfaces before selection of study sites. After review, 95 sites in the ICU were selected for study.

In each patient room of the ICU, cultures were collected from the following sites: bed rails, bed controls, tray table, and wall above the sink. Samples also were collected from the 2 ICU nursing stations and waiting lobby, including countertops, phones, computer keyboards, chair armrests, and end tables. All movable items were inconspicuously tagged and coded over the course of the study so that the same objects (ie, surfaces) could be sampled.

Each of the sites was cultured before application of the ABS-G2015 product and at 1 week (6-8 days), 2 weeks (13-17 days), 4 weeks (29-32 days), 8 weeks (59-62 days), 15 weeks (104-107 days) after application. Some objects were removed and were not available for culture at some of the subsequent time points. The ABS-G2015 coating comprises both quaternary ammonium silyl oxide and titanyl oxide moieties, and is not commercially available at present.

The ABS-G2015 coating was applied with an electrostatic spray applicator on all surfaces in the ICU, including hard surfaces (eg, beds, tray tables, bed rail, walls.) and soft surfaces (eg, drapes, cloth- and vinyl-covered chairs), and left wet to dry. Surface preparation and application were done by trained certified technicians following a structured protocol. All applications were monitored for quality control by a manufacturer's representative. During the course of the study, hospital staff maintained their normal daily cleaning schedule, which involved disinfecting with reusable cloths containing bleach and/or reusable disposable quaternary ammonium wipes (PDI Sani-cloth; Professional Disposables International, Orangeburg, NY) containing dimethyl ethylbenzyl ammonium chloride and dimethyl benzyl ammonium chloride as active ingredients. No clinical interventions (eg, changes in hand hygiene practices) were instituted during the study period.

Microbial methods

Areas of 100 cm^2 were sampled using a sponge stick containing Letheen broth (3M, St Paul, MN) to neutralize any residual disinfectant. After collection, the samples were immediately placed on ice packs and sent overnight to the University of Arizona. On receipt, the broth was extracted from the sponge stick by manual agitation, and 4 mL of extracted broth was assayed using selective media for isolation of the various bacteria. Samples were cultured for total bacteria, *Clostridium difficile*, MRSA, VRE, and carbapenemase-resistant *Enterobacteriaceae* (CRE). Test methods for each organism are presented in Table 1. Total bacteria were measured using R2A medium and 5 days of incubation, which have been found to be sensitive for detecting bacteria in environmental samples.[9,10]

Data analyses

The data on bacterial concentrations did not demonstrate a normal distribution. Even after log transformation, the data did not meet the conditions of normality and homogeneity. Thus, we used bootstrapping techniques to conduct analysis of variance for each stage between the baseline concentrations of the sampled fomites and the intervention concentrations of the same fomites to determine statistical significance differences, based on a rejection region of 5%.[11,12]

RESULTS

The average numbers of total bacteria detected per 100 cm^2 at all locations and percent reductions in total bacterial numbers after