BRIEF REPORT

Effectiveness of Gloves in the Prevention of Hand Carriage of Vancomycin-Resistant *Enterococcus* Species by Health Care Workers after Patient Care

Allan R. Tenorio, Sheila M. Badri, Nishi B. Sahgal,[a] Bala Hota, Marian Matushek, Mary K. Hayden, Gordon M. Trenholme, and Robert A. Weinstein

Rush-Presbyterian-St. Luke's Medical Center, Rush Medical College, Chicago

Gloving reduces acquisition of vancomycin-resistant *Enterococcus* species (VRE) on the hands, and it should be considered for routine inpatient care, even for contact with the intact skin of patients who may be colonized with VRE. However, gloving does not completely prevent contamination of the hands, and hand washing is necessary after glove removal.

Colonization with vancomycin-resistant *Enterococcus* species (VRE) usually precedes clinical infection. Horizontal spread occurs largely through the contaminated hands of hospital personnel. The Centers for Disease Control and Prevention's Hospital Infection Control Practices Advisory Committee (CDC-HICPAC) recommends the use of gloves, gowns, and hand washing to prevent person-to-person transmission of VRE [1]. However, for every recognized infection, as many as 10 patients may be colonized with VRE [2]. The CDC's standard precautions, which recommend gloving for contact with nonintact skin [1], may allow health care workers to acquire VRE from the intact skin of patients who are colonized, but not infected, with VRE [3]. We conducted a study to assess the effectiveness of routine gloving in the prevention of hand carriage of VRE by health care workers during patient care activities.

Patients and methods. We identified medical inpatients with clinical VRE isolates by searching the records of the Rush-Presbyterian-St. Luke's Medical Center microbiology laboratory (Chicago). After the selected inpatients provided informed consent, we performed cultures for VRE by use of swab (Becton Dickinson Microbiology Systems) samples obtained from the perianal area and from 10-cm^2 areas of the back and the upper arm of 10 patients.

Five health care workers participated per patient. Prior to patient contact, each subject placed his or her hands and wrists into sterile sampling bags (size, 38.1 cm × 13.97 cm; Fischer Scientific) that contained 50 mL of a sterile buffer sampling solution that contained neutralizer [4] and were vigorously agitated by the investigator for 30 s. The subjects dried their hands with paper towels, donned nonsterile powdered latex examination gloves (Allegiance Healthcare Group) provided by the investigators, and proceeded with providing patient care. The duration of patient care activity was recorded. After completing each activity, the subjects removed their gloves and placed them in a sterile sampling bag. A total of 50 mL of sampling solution was added to the bag, and the gloves were agitated for 1 min. Immediately after glove removal, specimens obtained from both of each subject's hands were cultured using the aforementioned technique. Samples of gloves and paper towels from the same lots were also cultured.

Sampling solutions were filtered through cellulose nitrate membranes (diameter, 47 mm) with a pore size of 0.2 μm. Membranes were inoculated onto Enterococcosel agar (Becton Dickinson Microbiology Systems) supplemented with vancomycin, 6 μg/mL. Plates were examined after 24 h and 48 h of incubation at 37°C in ambient air. Colonies were counted, and isolates were identified to the species level by use of the API 20 S Strep System (bioMerieux Vitek), by observation of the production of yellow pigment on blood agar, and by use of the 30C motility test [5].

Swabs obtained from the patients were inoculated directly onto Enterococcosel agar with vancomycin, 6 μg/mL, and were processed as described above. The number of quadrants with VRE colonies was recorded for each culture.

*Sma*I-digested total genomic DNA (Gibco BRL) underwent pulsed-field gel electrophoresis (PFGE) in a 1% agarose gel (SeaKem LE; FMC Bioproducts) by use of a CHEF-DRII apparatus (BioRad Laboratories), as described elsewhere [6]. Iso-

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Appropriate informed consent was obtained, and clinical research was conducted in accordance with guidelines for human experimentation, as specified by the US Department of Health and Human Services, Washington, DC.

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[a] Present affiliation: Metro Infectious Diseases Consultants, Hinsdale, IL.

Reprints or correspondence: Dr. Allan Tenorio, 600 S. Paulina St., Ste. 143, Chicago, IL 60612 (allan_tenorio@rsh.net).

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lates were considered distinct if their patterns differed by >6 bands [7].

Student *t* test was used to determine differences between groups for continuous variables, and the χ^2 test and Fisher's exact *z* test were used to determine associations between categorical variables. The *P* value for determination of statistical significance was <.05.

Results. Ten patients with clinical VRE isolates participated in the study. Five of these patients had bacteremia. Three patients had cultures of sterile body-site specimens (bile, pleura, and peritoneum) that yielded VRE, and 2 had cultures of wound specimens (sacral and hip decubiti) that yielded VRE. All patients had VRE isolates recovered from their perianal areas. Four patients had VRE isolates recovered from intact skin over their arms and back; 3 of these 4 patients had fecal incontinence, and 2 of them had diarrhea (>4 bowel movements per day). Cultures of unused gloves and paper towels did not yield VRE.

Fifty health care workers participated as subjects. Twenty-two performed physical examinations; 9 manipulated wound dressings, endotracheal tubes, colostomy bags, or iv, enteral, or urinary catheters; 9 checked vital signs or assisted in patient transfers; 7 bathed patients; and 3 manipulated items in patient rooms without touching the patients. Sixteen (32%) had a VRE strain on their hands prior to patient contact. Six of those 16 health care workers had a patient's VRE strain on their hands and were excluded from the analysis (figure 1).

Of 44 subjects who did not have a patient's VRE strain on their hands prior to patient contact, 17 (39%) acquired a patient's strain on their gloves after patient contact. After glove removal, 5 (29%) of the 17 subjects who acquired VRE on their gloves also had a patient's VRE strain on their hands. One subject had VRE on his hands after glove removal, but he did not have VRE on his gloves (figure 1). None of 10 subjects who were previously colonized with other VRE strains acquired a patient's VRE strain on their hands after glove removal. The 3 subjects who manipulated items in patient rooms without touching a patient acquired a patient's VRE strain on their gloves, but they did not acquire it on their hands after glove removal. The mean VRE colony counts ($\pm$SEM) on contaminated gloves and hands were 93 $\pm$ 40 colonies and 27 $\pm$ 16 colonies, respectively.

Twenty-three distinct strains of VRE were identified. Ten were found on patients, 7 others were found on the health care workers' hands before the patient care activity, and 6 distinct strains were recovered from the health care workers' gloves or hands after the activity.

On univariate analysis, the following factors were associated with the acquisition of VRE on gloves during patient care: duration of contact, contact with a patient's body fluids, presence of diarrhea in a patient, mean VRE colony counts on a

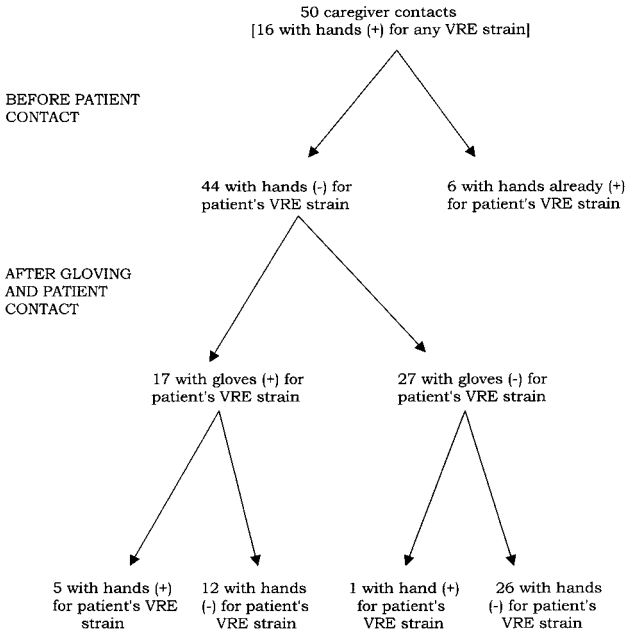

Figure 1. Diagram of results of culture of specimens obtained from 50 caregiver contacts. Strains of vancomycin-resistant *Enterococcus* (VRE) species differed from each other by >6 bands on pulsed-field gel electrophoresis. The plus sign (+) denotes positive culture results, and the minus sign (−) denotes negative results.

patient's skin, and the number of patient body sites colonized with VRE (table 1). All health care workers who had contact with a patient with diarrhea acquired VRE on their gloves, compared with 12 (44%) of 27 health care workers who had contact with a patient without diarrhea. The technique used for glove removal (in particular, whether the subject's hand touched the outside surface of the glove during removal) was not associated with the acquisition of a patient's VRE strain after glove removal.

Discussion. We found that, after having contact with a patient who was colonized or infected with VRE, 17 health care workers (39%) acquired the patient's VRE strain(s) on their gloves. Five health care workers had a patient's strain on their hands after glove removal, whereas 12 did not. Gloves reduced the risk of acquisition of VRE on the health care workers' hands by 71% (12 of 17 subjects), but the protection afforded by the gloves was incomplete. For 1 subject, precontact hand and glove samples did not yield VRE on culture, but VRE was recovered from the subject's hands after glove removal. This may be due to contamination of the hands that occurred during or after glove removal, or it may be due to failure to recover VRE from the gloves as a result of the presence of a low inoculum.

Olsen et al. [8] showed that gloves prevented contamination of the hands during procedures in which exterior surfaces of the glove were contaminated with gram-negative rods or enterococci after patient care. Our study expands on their inves-

Table 1. Risk factors for acquisition of vancomycin-resistant *Enterococcus* species (VRE) on health care workers' gloves and on health care workers' hands after gloving.

Risk factor	Acquisition of VRE[a] on gloves			Acquisition of VRE[a] on hands after gloving		
	Yes (n = 17)	No (n = 27)	P	Yes (n = 6)	No (n = 38)	P
Contact with patient's body fluids						
Yes	9	6	.04	3	12	.39
No	8	21		3	26	
Contact with patient with diarrhea						
Yes	5	0	<.01[b]	2	3	.13
No	12	27		4	35	
Patient fecal incontinence						
Yes	9	15	.87	4	20	.67
No	8	12		2	18	
No. of sites on patient colonized with VRE						
1	7	18	.01	3	22	.55
2	0	4		0	4	
3	10	5		3	12	
Source of VRE clinical isolate						
Wound	6	3	.07	3	6	.09
Blood/other sterile body sites	11	24		3	32	
Presence of VRE on intact skin[c]						
Yes	9	9	.20	2	16	.68
No	8	18		4	22	
Exposure during glove removal[d]						
Yes	NA	NA		3	14	.66[b]
No	NA	NA		3	24	
Semiquantitative VRE colony counts on patient skin, mean no. ± SEM[e]	3.3 ± 0.2	2.2 ± 0.2	<.01	2.8 ± 0.6	2.7 ± 0.2	.79
Duration of contact, mean min ± SEM	8.9 ± 1.4	4.8 ± 0.7	.02	9.8 ± 2.8	5.9 ± 0.8	.08

NOTE. Data are no. of patients, unless otherwise indicated.

[a] Same VRE strain type as that found in colonized patients, as determined by pulsed-field gel electrophoresis.

[b] Fisher's exact z test.

[c] Arm or back.

[d] Did subject's hand touch outside of glove surface during removal?

[e] Semiquantitative VRE colony counts per patient were reported as the no. of quadrants of agar plate that had colonies of VRE.

tigation by (1) determining whether the health care workers' hands were contaminated prior to patient contact and (2) performing cultures of samples obtained from patients and using a molecular typing method (PFGE) to assess the association between strains on hands, gloves, and patients.

Hand washing is recommended after glove removal because of the potential for contamination of the hands to occur during glove removal or via glove leaks. Noskin et al. [9] showed that artificially inoculated VRE can last for at least 60 min on hands and that hand washing for 30 s will eliminate colonization. Our study supports the use of hand washing even if gloves are worn, although we were not able to determine the independent or added protection afforded by hand washing or the reason for the incomplete protection afforded by gloves.

In our study, the incidence of acquisition of VRE on gloves (39%) approximated the prevalence of colonization of VRE on hands (32%), which suggests that such colonization may be a transient phenomenon. The frequency of colonization of health care workers, even after transient contact with the intact skin of VRE-infected or -colonized patients, may result in frequent horizontal transmission of VRE. This helps maintain a high endemic level of patient colonization. A previous study showed

that 33% of patients in general medicine wards and 47% of patients admitted to Rush-Presbyterian-St. Luke's Medical Center from chronic care facilities were colonized with VRE [10]. The high number of VRE strains identified by PFGE suggests an extensive reservoir. Although CDC-HICPAC guidelines are followed for patients with clinical VRE infection, surveillance for VRE colonization is not done routinely; therefore, the majority of patients who would test positive for VRE are not likely to be identified. Our data support the potential benefit of universal gloving of health care workers who are participating in patient care activities at institutions with a high prevalence of VRE colonization.

The role of environmental contamination is suggested by the acquisition of a patient's VRE strain by 3 subjects who did not have patient contact and also by the acquisition of 6 nonsubject, nonpatient VRE strains during the course of routine patient care activities. The role of environmental factors in the transmission of VRE has been reported [11], but its significance requires further study.

Our data identify patients for whom—and settings in which—increased risk of VRE transmission is likely. The presence of diarrhea in a patient with VRE, the number of sites colonized with VRE on each patient, the mean VRE colony counts on a patient's skin, and the duration of contact between a health care worker and a patient were associated with an increased risk of acquisition of VRE on a health care worker's gloves. These findings suggest that contamination is most likely to occur under circumstances of increased bacterial inoculum size or prolonged exposure to contaminated surfaces.

Our conclusions are limited by the absence of a control group, since all patients were being cared for according to isolation precautions. Also, we did not study the mechanism of glove-to-hand contamination, in part because our culture technique did not allow us to distinguish between contamination of the external and internal glove surfaces. Although we conclude that universal gloving may be useful in settings that are highly endemic for VRE, studies are needed to test this hypothesis. Likewise, the efficacy of hand washing alone versus hand washing plus gloving needs to be determined.

In summary, the rate of transmission of VRE to health care workers is very high. Gloving can reduce acquisition of VRE on the hands, and it should be considered as part of routine inpatient care, even for care that involves contact with the intact skin of patients who may be colonized with VRE. However, gloving does not completely prevent contamination of health care workers' hands, and hand washing or "de-germing" is necessary after glove removal.

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