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Evaluation of Stethoscopes as Vectors of *Clostridium difficile* and Methicillin-Resistant *Staphylococcus aureus*

Healthcare workers' stethoscopes are potential vectors for transmission of pathogens because they frequently come in contact with the skin of patients and are not routinely cleaned between examinations. Point-prevalence culture surveys have demonstrated that stethoscope diaphragms may be contaminated with pathogens such as *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA).[1-5] However, previous publications have not directly quantified the risk for transmission of *C. difficile* and MRSA by stethoscopes. Here, we examined the risk for transmission of these pathogens by stethoscopes in the laboratory and during simulated examinations of patients and evaluated methods to disinfect contaminated stethoscopes.

The study protocol was approved by the Cleveland Veterans Affairs Medical Center's Institutional Review Board. The efficiency of direct and indirect transfer of nontoxigenic *C. difficile* spores (American Type Culture Collection 43593) and MRSA (a clinical isolate of pulsed-field gel electrophoresis type USA300) by stethoscope diaphragms was tested in the laboratory. Ten-microliter aliquots containing 1–4 $\log_{10}$ colony-forming units (CFUs) of spores or 1–3 $\log_{10}$ CFUs of MRSA were inoculated directly onto disinfected diaphragms (McCoy) or onto skin surfaces and allowed to dry for 10 minutes. For *C. difficile*, the skin site was the forearm of a human volunteer. For MRSA, a processed pig skin surface was used. To assess direct transfer, the contaminated diaphragms were imprinted for 10 seconds directly onto prereduced *C. difficile* brucella agar[6] for isolation of *C. difficile* and onto CHROMagar (Becton Dickinson) containing 10 μg/mL cefoxitin for MRSA. To assess indirect transfer, disinfected stethoscope diaphragms were pressed onto contaminated skin sites for 10 seconds and imprinted onto selective agar. *Clostridium difficile* brucella agar plates were incubated anaerobically, and MRSA plates were incubated in room air at 37°C for 48 hours. All experiments were repeated 3 times, with the inclusion of uninoculated control stethoscopes in each experiment.

To assess methods of stethoscope disinfection, 10-μL aliquots of the pathogens were inoculated onto the diaphragm and allowed to dry. The diaphragm was wiped for 10 seconds with a 1 × 2-inch 70% isopropyl alcohol pad (Medline), a 2 × 2-inch gauze pad (Tyco Healthcare) moistened with sterile water, or the same gauze pad moistened with 70% ethanol. The diaphragm was imprinted onto selective agar and cultured as described previously.

We assessed the transfer of pathogens by stethoscopes from the skin of patients with *C. difficile* infection or MRSA colonization during a standardized simulated examination of the heart, lungs, and abdomen (12 skin sites total and 5-second contact time for each site). After auscultation, the diaphragm was imprinted onto selective agar and cultured as described previously. For comparison, the same skin sites were palpated with sterile gloves premoistened with sterile water, and the fingers were imprinted onto selective agar. Identification and susceptibility testing for MRSA was performed on the basis of Clinical and Laboratory Standards Institute guidelines.[7] Suspected *C. difficile* isolates were confirmed as previously described.[6] Paired *t* tests were used to compare colony counts transferred by stethoscopes versus hands. A Fisher exact test was used for categorical data.

Figure 1 shows the findings for direct and indirect transfer of the pathogens by stethoscopes. Stethoscopes directly transferred nearly 100% of *C. difficile* spores inoculated onto the diaphragm to agar plates, whereas the number of MRSA colonies transferred directly to the agar plate was ~2 $\log_{10}$ CFUs fewer than the original inoculum, presumably due to loss of viability with desiccation. For indirect transfer from skin, stethoscopes acquired and transferred on average 1–1.5 $\log_{10}$ CFU fewer spores or MRSA than were transferred directly.

Gauze moistened with sterile water or alcohol was more effective than alcohol wipes in removing *C. difficile* spores from stethoscope diaphragms (98%–99% vs 92%–94% removal; $P < .05$). Alcohol wipes and ethanol-moistened gauze were more effective than water-moistened gauze for removal of MRSA (100% vs 94% removal).

Simulated examinations were conducted on 35 *C. difficile* infection patients and 57 MRSA carriers. In comparison to hand imprints, stethoscope imprints resulted in nonsignificant trends toward less frequent acquisition and transfer of *C. difficile* (5/35 [14%] vs 11/35 [31%]; $P = .15$) and MRSA (11/57 [19%] vs 15/57 [26%]; $P = .5$). The numbers of *C. difficile* colonies acquired and transferred by stethoscopes and gloved hands were similar (mean ± SD, 1.2 ± 2.0 and 7.3 ± 14.6; $P = .20$), but stethoscopes acquired and transferred fewer colonies of MRSA (mean ± SD, 5.9 ± 8.6 and 14.3 ± 11.4; $P = .01$).

Our findings suggest that stethoscopes may be an underappreciated vector for transmission of pathogens. During

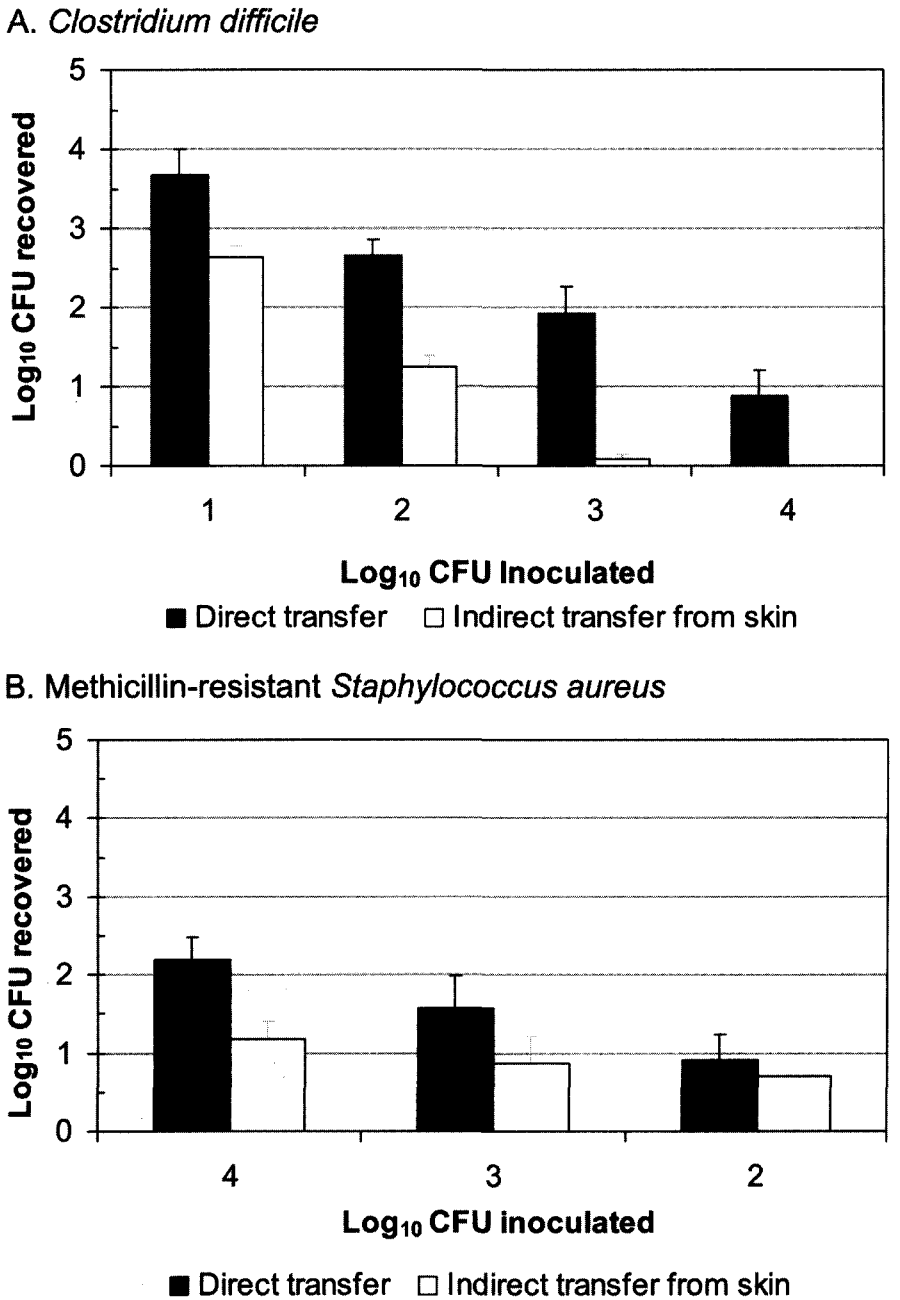

FIGURE 1. Transfer of *Clostridium difficile* spores (*A*) and methicillin-resistant *Staphylococcus aureus* (MRSA; *B*) by stethoscopes. Direct transfer (solid bars) indicates organisms directly inoculated onto the stethoscope diaphragm, air dried, and diaphragm imprinted onto selective agar. Indirect transfer from skin (open bars) indicates organisms inoculated onto skin and air dried, contacted by stethoscope diaphragm, and diaphragm imprinted onto selective agar. Nontoxigenic *C. difficile* spores were inoculated onto a human forearm, and MRSA was inoculated onto pig skin. CFU, colony-forming unit.

simulated examinations, stethoscopes acquired and transferred *C. difficile* and MRSA nearly as often as gloved hands. These findings provide support for the recommendation that healthcare workers should use dedicated ward stethoscopes when caring for patients carrying multidrug-resistant organisms or *C. difficile*.[8-9] Alternatively, healthcare workers may clean their stethoscopes after examination of these patients. Our data suggest that direct contact with friction is sufficient to remove more than 90% of *C. difficile* spores from stethoscope diaphragms. Pads or gauze containing alcohol removed 100% of MRSA.

Our study has some limitations. We studied 1 strain of

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each pathogen in the laboratory. Desai et al[10] recently demonstrated significant variability among MRSA strains in survival and transmission from fomites. Therefore, we cannot be certain that the in vitro data are applicable to a majority of strains. We studied only stethoscope diaphragms. Stethoscope tubing could also contribute to pathogen transmission because it is infrequently cleaned and may come in contact with patients and healthcare workers' hands and clothing.

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Quantitative Efficacy of Alcohol-Based Handrub against Vancomycin-Resistant Enterococci on the Hands of Human Volunteers

We recently reported an outbreak of vancomycin-resistant enterococci (VRE) colonization and disease due to a new VRE clone at our hospital[1] that occurred despite the presence of an active alcohol-based handrub (ABHR) hand hygiene program, decreasing rates of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia,[2] and management of VRE-colonized patients according to Centers for Disease Control and Prevention (CDC) guidelines.[3] To assess whether differences in the activity of ABHR against these strains may have explained the outbreak, we formally compared the in vivo efficacy of an ABHR product (70% isopropyl alcohol, 0.5% chlorhexidine, and skin emollient) against both the dominant preoutbreak VRE strain (AUS-0021) and the new outbreak strain (AUS-0085) among healthcare worker volunteers using a standard hand hygiene protocol that mimicked clinical day-to-day practice.

ABHR efficacy was assessed against 2 previously well-characterized nosocomial strains of *van*B *Enterococcus faecium*: AUS-0021 (a 2004 bacteremia isolate typical of the dominant preoutbreak clones [CC17, ST 17]) and AUS-0085 (a 2009 outbreak bacteremia isolate [CC17, ST203]).[1] Following an approach similar to that described elsewhere,[4] 20 consenting volunteers each had the palm of their preferred hand contaminated with a high concentration of VRE (0.5 mL saline containing 1.5×10^8 colony-forming units [CFU]/mL *E. faecium*),[5,6] which was massaged for 30 seconds using the fingertips of the participant's alternate hand and then allowed to air dry. The presence of viable VRE was confirmed by placing the exposed hand into a sterile clipseal bag (Defries Industries) containing 10 mL of tryptone soy broth (TSB; Oxoid).[4,5] The hand was gently massaged to ensure even distribution of the medium before removal of the TSB to obtain