Targeted Use of Alcohol-Based Hand Rub on Gloves During Task Dense Periods: One Step Closer to Pathogen Containment by Anesthesia Providers in the Operating Room

David J. Birnbach, MD, MPH,*†‡ Taylor C. Thiesen, BS,* Nathan T. McKenty, BS,* Lisa F. Rosen, MA,† Kristopher L. Arheart, EdD,‡ Maureen Fitzpatrick, MSN, ARNP-BC,† and Ruth Everett-Thomas, PhD, RN§

BACKGROUND: Anesthesia providers’ hand hygiene practices in the operating room may contribute to the transmission of bacteria. There is a debate, however, over the best approaches for pathogen containment during task dense periods (induction and extubation) of anesthesia care. A novel approach to reducing pathogen spread during these task dense periods is the use of alcohol-based hand rub on gloves when it may be difficult to either change gloves or clean hands.

METHODS: To evaluate the impact of alcohol-based hand rub on gloves, we estimated perforation rates of 50 gloves that were worn as pairs by volunteers for 2 hours at a time applying alcohol-based hand rub every 15 minutes (total of 8 alcohol-based hand rub applications per pair of gloves). We also identified perforation rates of 50 new, unused gloves. To evaluate the ability to perform routine anesthesia functions, volunteers were asked to pick up a coin from a table top and document whether the gloves felt normal or sticky at each 15-minute period.

RESULTS: Fifty new gloves (not exposed to alcohol-based hand rub) were tested for integrity using the Food and Drug Administration–approved process, and one was found to have a microperforation. Of the 50 gloves that had been applied with alcohol-based hand rub 8 times, no microperforations were identified. All volunteers demonstrated tactile competence by picking up a coin from a table top after 8 alcohol-based hand rub applications; in addition, as the number of alcohol-based hand rub applications progressed, the volunteers reported increased stickiness.

CONCLUSIONS: This study suggests that the use of alcohol-based hand rub on commonly used nitrile examination gloves does not compromise glove integrity or hamper the ability to safely perform routine anesthesia functions. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

• Question: Does the use of alcohol-based hand rub on gloves compromise glove integrity or hamper the ability to perform routine anesthesia functions?

• Meaning: Gloves that were treated with alcohol-based hand rub 8 consecutive times had no microperforations suggesting that it is safe to use alcohol-based hand rub on commonly used nitrile examination gloves when it is difficult to clean hands.

• Findings: The use of alcohol-based hand rub on gloves does not compromise glove integrity or interfere with the ability to perform routine anesthesia functions.

The operating room is a high-stakes, high-demand environment with multiple pressures for anesthesia providers including the sustained and prolonged vigilance requirement to ensure patient safety.1 In particular, the anesthesia work environment has a high rate of invasive, infection-prone procedures.2 As with all aspects of clinical care, part of the safe administration of anesthesia is compliance with hand hygiene requirements; these can be especially onerous during the induction of anesthesia. It has been established, however, that pathogenic organisms are present in the intraoperative environment, potentially posing a risk of infection,3 and are a root cause of 30-day postoperative infections affecting as many as 16% of patients undergoing surgery.4

Individuals in the anesthesiology community have raised concerns about infection spread and cross-contamination for >3 decades5 and have also proposed numerous achievable containment strategies such as using alcohol-based hand rub on gloves, the use of double gloves, and improved environmental cleaning.6–13

The task dense periods during anesthesia care may preclude optimal hand hygiene practices and compliance and thus create greater opportunity for pathogen transmission to the patient and surrounding environment.14–17 Further, the number of tasks performed during certain key
portions of an anesthetic procedure would suggest that it is virtually impossible for the anesthesia provider to conform to the World Health Organization’s Five Moments, especially during induction and immediately after intubation and extubation. This may also explain why anesthesia providers underscore the importance of hand hygiene after patient contact and within the anesthesia workspace. During these task dense periods when it is difficult to either change gloves or clean hands, the use of alcohol-based hand rub on gloves is a potentially viable option. Specifically, the literature has shown that the use of alcohol-based hand rub on nonsterile nitrile gloves has no deleterious effect on the gloves (cumulative permeation and movement). Furthermore, multiple applications of alcohol-based hand rub on gloves to protect health care workers is advised when treating patients with Ebola virus disease. In addition to the use of alcohol-based hand rub on gloves, the use of double gloves during intubation with the removal of the outer set after completion of intubation has been shown to reduce, but not eliminate, pathogen spread in the operating room. The primary aim of this study was to evaluate whether the use of alcohol-based hand rub on gloves compromises glove integrity, and the secondary aim was to determine whether repeated use of alcohol-based hand rub on gloves hampers the ability to perform routine anesthesia functions.

METHODS
This study was granted exempted status by the University of Miami Miller School of Medicine Institutional Review Board. To evaluate the impact of alcohol-based hand rub containing 70% ethyl-alcohol (Purell; Gojo Industries Inc, Akron, OH) on gloves, we estimated perforation rates of 50 single gloves that were repeatedly exposed to alcohol-based hand rub. The 50 alcohol-based hand rub exposed gloves were worn (as pairs) by volunteers for 2 hours at a time with alcohol-based hand rub applications every 15 minutes (total of 8 alcohol-based hand rub applications). We also identified perforation rates of 50 new, unused gloves. All gloves in the study were 6.2 mil (Medichoice, XTS Nitrile exam gloves; Owens and Minor, Mechanicsville, VA). Volunteers were instructed to administer 2 pumps of alcohol-based hand rub (approximately 1.5 mL) and cover the surface of the gloves until dry. Gloves were provided in sizes small, medium, and large as are currently available in clinical settings. All study gloves were coded with a randomized number on the cuff of the glove. A blinded evaluator, previously trained to perform the Food and Drug Administration water leak test, assessed all gloves for microperforations. The evaluator was unaware if gloves were or were not exposed to alcohol-based hand rub, and a pilot study showed that most gloves to which alcohol-based hand rub was administered were visually identical to the new gloves. All gloves (100) in the study were evaluated for microperforations using the Food and Drug Administration test method. First, gloves were inspected for visual defects by carefully removing the glove from the package (a clear plastic bag). Visually defective gloves did not require further testing, although they were included in the total number of defective gloves counted for the sample. Second, we used the Food and Drug Administration water leak method using 1000 mL of water and, after 2 minutes, visually inspected for water leaks. A leak is defined as the appearance of water on the outside of the glove. This emergence of water from the glove constitutes a watertight barrier failure.

To evaluate tactile competence, at each 15-minute period, volunteers were asked to pick up a dime from a table top to assess the ability to maintain dexterity that would allow them to perform routine anesthesia tasks. The volunteers were also queried as to the stickiness of the gloves. Procedures requiring optimized tactile abilities, such as invasive procedures, would require the use of sterile gloves.

Statistical Analysis
The proportion of water leaks in new gloves and in alcohol-based hand rub gloves was tested separately with a 1-sample test of proportions with $P_0 = .15$. A 1-sided 97.5% CI was also computed. Two linear mixed models were used to assess the percentage of gloves exhibiting stickiness and to test the trend in stickiness of alcohol-based hand rub–treated gloves at 15-minute intervals. The models for the repeated-measures design included time as a fixed within-subjects (gloves) variable and gloves as the random between-subjects. To determine the percentage of gloves that were sticky at each time interval, the repeated measure (time) was considered to be a categorical variable; a compound symmetric covariance matrix was used to represent the correlated data structure. Least square means and 95% CIs were reported. The model for the trend analysis included time as a continuous variable; the regression beta and 95% CI for the slope were reported. SAS 9.4 (SAS Institute, Inc, Cary NC) was used for all analyses.

Kampf and Lemmon reported leakage rates of up to 15% after only 5 alcohol-based hand rub treatments. We based our sample size on being able to detect a reduction in leakage of 14% testing gloves treated 8 times in our study. Using a Z test to compare the failure rate of the sample with the reported 15%, a 2-tailed $\alpha = .05$, and a sample size of 50 gloves, we should have >95% power to detect a significant reduction from the reported 15% to 1%. The 1% is considered to be the expected perforation rate of unused gloves.

RESULTS
Fifty new gloves (not exposed to alcohol-based hand rub) were tested for integrity using the Food and Drug Administration– approved process, and 1 new glove had a microperforation ($Z = 2.57; P < .010$). Of the 50 gloves that had been applied with alcohol-based hand rub 8 times, none had a microperforation ($Z = 0.00; P < .010$). A 1-sided 97.5% CI estimated that the upper limit to the perforation rate might be as high as 7.1%. The percentages of participants who reported that alcohol-based hand rub–treated gloves were sticky over the 8 periods of 15 minutes resulted in a significant positive trend ($P < .001$; Table). All volunteers completed the observation period and demonstrated tactile competence by picking up a coin from a table top after each alcohol-based hand rub application.
Table. Respondents Reporting Alcohol-Based Hand Rub–Treated Gloves Being Sticky

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Applications*</th>
<th>Percent Sticky* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1</td>
<td>4 (0–15)</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>20 (9–31)</td>
</tr>
<tr>
<td>45</td>
<td>3</td>
<td>32 (21–43)</td>
</tr>
<tr>
<td>60</td>
<td>4</td>
<td>46 (35–57)</td>
</tr>
<tr>
<td>75</td>
<td>5</td>
<td>53 (42–64)</td>
</tr>
<tr>
<td>90</td>
<td>6</td>
<td>72 (61–83)</td>
</tr>
<tr>
<td>105</td>
<td>7</td>
<td>86 (75–97)</td>
</tr>
<tr>
<td>120</td>
<td>8</td>
<td>92 (81–100)</td>
</tr>
</tbody>
</table>

Regression slope β = 12.8; 95% CI (11.5–14.1); P < .001.
*Cumulative applications of alcohol-based hand rub.
*Percent (95% CI).

DISCUSSION

Despite the evidence that the operating room is frequently contaminated by providers’ hands, there are no established hand hygiene guidelines specifically tailored for anesthesia providers. While it has been reported in one study that anesthesia providers touched >1000 objects during 8 hours of observation and performed only 13 hand disinfections, there are points of contact during induction where it is logistically difficult and potentially harmful to the patient to perform hand hygiene.

The use of alcohol-based hand rub on gloves may be one method to help address this challenge. Several studies have established the safety of using alcohol-based hand rub on gloves when changing gloves or cleaning hands is not possible. Moreover, the literature has shown no significant weight or thickness change or observable signs of material degradation with nitrile or latex gloves after exposure to ethanol for up to 2 hours. The Centers for Disease Control and Prevention, when faced with the Ebola crisis, issued guidelines for the performance of frequent disinfection of gloved hands using alcohol-based hand rub particularly after contact with body fluids. In addition, Kampf and Lemmon concluded that disinfection of gloved hands is at least as effective as treating bare hands and that this practice might contribute to patient safety more than most health care workers would anticipate. Even with the complex issue of *Clostridium difficile* spores, it has been reported that glove disinfection may be a useful adjunctive measure. Nevertheless, World Health Organization states that the use of gloves does not replace the need for hand hygiene and that gloves become a major risk for germ transmission. Clearly, providers should, whenever possible and feasible, perform hand hygiene in accordance with the Centers for Disease Control and Prevention and World Health Organization guidelines, and the use of gloves does not replace hand hygiene. This study has shown, however, that the limited repeat use of alcohol-based hand rub does not compromise glove integrity, impede tactile skills essential for routine anesthesia care, and is a practical, achievable intervention.

In an attempt to limit pathogen spread and improve anesthesia practices, new approaches are necessary, which may include the use of alcohol-based hand rub on gloves. As a temporizing measure, these situations may include (1) when a single set of gloves is contaminated and there is no time to change gloves and (2) when the outside set of double gloves is contaminated and anesthesia providers want to safely remove them without contaminating the inner set. Even when using double gloves, the results suggest that anesthesia providers may be able to effectively use alcohol-based hand rub on gloves during task dense periods such as induction as a temporizing measure.

With regard to manual dexterity, we asked the volunteers to pick up a coin from a table top. While this test has not been correlated with dexterity in performing anesthesia tasks, the Sollerman Hand Function Test lists the ability to pick up a coin from a flat surface as a subset of their validated grip function test. Furthermore, “grip and pinch” strength is part of occupational therapists’ assessment of hand function.

This study had several limitations. First, despite a pilot study demonstrating no visible staining of gloves that were treated with alcohol-based hand rub, of the 50 gloves that were examined by the blinded evaluator, 5 (10%) showed some visible signs of discoloration. The blinded observer might have suspected that these were in the alcohol-based hand rub group. Second, although we did not have any microperforations after 8 applications of alcohol-based hand rub, the gloves were not stressed in the same way they might be during routine anesthesia care. Third, this study neither tested for microbial contamination in the 2 groups nor did it address how well alcohol-based hand rub decontaminates gloves. However, the application of alcohol-based hand rub has been shown to disinfect solid surfaces and is recommended to increase the safety margin during treatment of patients with the Ebola virus. Fourth, the study was conducted in a nonclinical setting rather than the operating room. The physical stress on gloves during use in the operating room may lead to a different result, and future studies should be conducted in a clinical environment to assess glove integrity and manual dexterity during routine anesthesia tasks. Finally, the determination of “stickiness” by the study volunteers was a subjective assessment.

Given the nominal cost of nonsterile gloves and alcohol-based hand rub compared to the annual cost of $9.8 billion from health care–associated infections in the United States, the cost of applying alcohol-based hand rub to gloves becomes irrelevant. With increased attention being paid to anesthesia providers regarding their role in pathogen spread in the operating room, the use of alcohol-based hand rub on gloves during task dense periods may represent a simple, yet vital, solution.

ACKNOWLEDGMENTS

The authors acknowledge the contributions of the following members: Albert L. Lee, Elaheh Nirooemand, Prashant Angara, and Preetha D. Kamath who helped design and conduct the study.

DISCLOSURES

Name: David J. Birnbach, MD, MPH.
Contribution: This author helped design and conduct the study, analyze the data, and write the manuscript.
Name: Taylor C. Thiesen, BS.
Contribution: This author helped design and conduct the study.
Name: Nathan T. McKenty, BS.
Contribution: This author helped design and conduct the study and write the manuscript.
Alcohol-Based Hand Rub on Gloves to Contain Pathogens

Name: Lisa F. Rosen, MA.

Contribution: This author helped design the study and write the manuscript.

Name: Kristopher L. Arheart, EdD.

Contribution: This author helped design the study, perform statistical analyses, and write the manuscript.

Name: Maureen Fitzpatrick, MSN, ARNP-BC.

Contribution: This author helped conduct the study and write the manuscript.

Name: Ruth Everett-Thomas, PhD, RN.

Contribution: This author helped conduct the study and write the manuscript.

This manuscript was handled by: Richard C. Prielipp, MD, MBA.

REFERENCES


25. Centers for Disease Control and Prevention. Guidance on personal protective equipment (PPE) to be used by healthcare workers during management of patients with confirmed Ebola or persons under investigation for Ebola who are clinically unstable or have bleeding, vomiting, or diarrhea in U.S. hospitals including procedures for donning and doffing PPE. Available at: https://www.cdc.gov/vhf/ebola/hcp/healthcare-us/ ppe/guidance.html. Accessed July 9, 2018.


