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Disinfection of Flexible Fiberoptic Laryngoscopes After In Vitro Contamination With *Staphylococcus aureus* and *Candida albicans*

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Objective: To determine the efficacy of various cleaning and disinfective methods in reducing bacterial and fungal load on flexible fiberoptic laryngoscopes (FFLs).

Design: In vitro model.

Subjects: Flexible fiberoptic laryngoscopes contaminated with *Staphylococcus aureus* and *Candida albicans*.

Interventions: Contamination with *S aureus* and *C albicans* was separately induced on FFLs, which were then disinfected with different protocols: 20-, 15-, 10-, and 5-minute soaks in ortho-phthalaldehyde (Cidex OPA; Johnson & Johnson) with or without presoaking in an enzymatic soap solution for 5 minutes; an isolated 5-minute soak in an enzymatic soap solution; a 30-second wipe with antibacterial soap and water; a 30-second wipe with isopropyl

alcohol; a 30-second wipe with antibacterial soap, followed by a 30-second scrub with isopropyl alcohol; and a 30-second wipe with germicidal cloth, all accompanied by previous rinsing with 30 seconds of running tap water.

Results: All protocols except the isolated 5-minute soak in enzymatic soap solution were successful in completely disinfecting the FFLs after experimental contamination with *S aureus* or *C albicans*.

Conclusion: Various different cleaning methods appeared to properly disinfect FFLs after inoculation with *S aureus* and *C albicans* in an in vitro model.

Arch Otolaryngol Head Neck Surg. 2012;138(2):119-121.
Published online January 16, 2012.
doi:10.1001/archoto.2011.1204

O TOLARYNGOLOGISTS FREQUENTLY use flexible fiberoptic laryngoscopes (FFLs) as part of their physical examination in the clinic, at the bedside in the hospital, and in the emergency department. The FFL also plays a critical role in the evaluation of a potentially unstable airway. In a busy, inpatient, tertiary care facility, it is not unusual for the same FFL to be used multiple times in a 24-hour period in a diverse patient population ranging from immunosuppressed transplant recipients to highly contagious methicillin-resistant *Staphylococcus aureus*-positive burn victims in contact isolation, sometimes in rapid succession. Although several studies have proved contamination of the FFL by blood, debris, and pathogenic organisms after contact with the mucous membranes (semicritical instrument), there are very few reports of cross-infection between patients due to use of a contaminated FFL.¹⁻³ Although gas sterilization protocols are very effective and limit processing damage to the scope, gas sterilization requires a great deal of time and is logistically difficult and prohibitively expensive. High-level disinfection is the elimination or kill-

ing of all vegetative bacteria, virus and fungal spores, and some, but not all, bacterial endospores. Currently, high-level immersion disinfection remains the most cost-effective and rapid technique to appropriately decontaminate FFLs. A disinfection protocol for FFLs used by otolaryngologists should consistently destroy all microorganisms and also be time efficient and cost-effective.

Although the incidence is low, previous research has implicated fiberoptic endoscopy in cross-contamination and cross-infection between patients; therefore, ensuring adequate disinfection between uses of an FFL is necessary.⁴⁻⁸ Nearly all decontamination protocols for nonchannel-containing FFLs have been adopted from studies of channel-containing gastroenterology endoscopes and bronchoscopes, which carry a much higher bioload after use and have different design properties from FFLs. To date, we are aware of only 2 studies analyzing immersion disinfection of nonchannel FFLs used in an outpatient setting. The landmark study by Abramson et al⁹ used a 3- to 5-second tap water rinse for pre-disinfection endoscope processing, followed by a 5-minute immersion in 3.2% glutaraldehyde solution. Growth was achieved in only 1 specimen, which the au-

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Table. Results of the Various Disinfective Techniques

Disinfective Technique	<i>Staphylococcus aureus</i>	<i>Candida albicans</i>
30-s antimicrobial soap scrub	No growth 5/5 plates	No growth 5/5 plates
30-s scrub with 70% isopropyl alcohol	No growth 5/5 plates	No growth 5/5 plates
30-s soap and water scrub, followed by 30-s 70% isopropyl alcohol scrub	No growth 5/5 plates	No growth 5/5 plates
30-s scrub with germicidal cloth	No growth 5/5 plates	No growth 5/5 plates
5-min immersion in enzymatic soap solution	No growth 5/5 plates	1/5 Plates positive for growth
5-min immersion in ortho-phthalaldehyde scrub ^a	No growth 5/5 plates	No growth 5/5 plates
10-min immersion in ortho-phthalaldehyde scrub ^a	No growth 5/5 plates	No growth 5/5 plates
15-min immersion in ortho-phthalaldehyde scrub ^a	No growth 5/5 plates	No growth 5/5 plates
20-min immersion in ortho-phthalaldehyde scrub ^a	No growth 5/5 plates	No growth 5/5 plates
Isolated 30-s tap water rinse	2/5 Plates positive for 4000 CFU/mL	Minimal growth

Abbreviation: CFU, colony-forming units.

^aOrtho-phthalaldehyde is sold commercially as Cidex OPA by Johnson & Johnson.

thors explained as having been obtained from a scope with a very high bioload. Notably, they attributed the single post-disinfection isolated microorganism persistence to inadequate rinsing with tap water (only 3-6 seconds) before disinfection. Their conclusion was that immersion in glutaraldehyde was sufficient to disinfect FFLs as long as the bioload was sufficiently reduced by an adequate tap water rinse; however, no follow-up studies with a longer-duration running tap water rinse were performed. The second study by Bhat-tacharyya and Kepnes,¹⁰ which was performed in an outpatient clinic setting, consisted of a 5-minute enzymatic soap soak, followed by a 20-minute immersion in ortho-phthalaldehyde (Cidex OPA; Johnson & Johnson). Only 1 endoscope was found to be positive for fungal growth in their study.

To our knowledge, no studies have been performed as yet to determine whether other cleaning and disinfection methods may be adequate in preventing nonmycobacterial and nonviral cross-contamination, as may be applicable in an emergency or hospital-based setting with a potential need for rapid reuse of an FFL. In this study, we sought to use an in vitro model to test the cleaning and decontamination of nonchannel-containing FFLs with different disinfectants and cleansing protocols (soap and water, isopropyl alcohol, or a germicidal wipe) after in vitro contamination with *S aureus* and *Candida albicans*.

METHODS

To serve as a negative control and as a method of ensuring adequate disinfection after each experimental trial, a nonchannel-containing flexible fiberoptic laryngoscope (Olympus) was rinsed with tap water for 30 seconds and subsequently immersed in an enzymatic soap solution (Enzol; Johnson & Johnson) for 5 minutes, followed by immersion in a solution of ortho-phthalaldehyde for 20 minutes. For the experimental protocols, a clean FFL was placed for 30 seconds in a 0.1 solution (approximately 10-8 microorganisms per milliliter; spectrophotometric wavelength, 570 nm [Spectronic 20; Bausch & Lomb]) of *S aureus* (ATCC 12600) that was previously cultured in a liquid nutritious medium (Todd Hewitt Broth; Becton Dickinson & Co), subsequently transferred to a test tube with a height of 9 mL of sterile saline, and vortexed for 15 seconds, and then 25 µL of the solution was plated on an agar plate (BBL; Becton Dickinson & Co). This method served as our positive control.

Additional experiments were carried out with the same method, but with the addition of a tap water rinse for 30 seconds before

each disinfection experimental trial. The different experimental disinfection protocols included a 30-second scrub with hospital soap (Fresh and Clean; Kimberly Clark); a 30-second scrub with 70% isopropyl alcohol (IA) (Aron); a 30-second soap and water scrub, followed by a 30-second IA scrub; a 30-second scrub with a germicidal cloth (Steris Corp); a 5-minute immersion in enzymatic soap solution; and a 5-, 10-, 15-, and 20-minute immersion in ortho-phthalaldehyde separately with and without a previous 5-minute immersion in the enzymatic soap solution. The same experimental protocols were also carried out with immersion into a 0.1 spectrophotometric solution of *C albicans* (ATCC 14063) that was previously cultured in Sabouraud dextrose broth (Becton Dickinson & Co), and 100 µL of the solution was plated onto Sabouraud dextrose agar. All plates were placed in an incubator and examined at 24 and 48 hours, and colony counts were performed. Each different experimental protocol with each organism was performed 5 separate times.

RESULTS

Negative controls were always negative, and positive controls were always positive. Positive control plates of *S aureus* were always too numerous to count. Also, *S aureus* growth averaged 4000 colony-forming units per milliliter on 2 out of 5 plates after an isolated 30-second tap water rinse. Minimal growth of *C albicans* was also observed with an isolated 30-second tap water rinse. No growth was observed with either *S aureus* or *C albicans* with the 30-second antimicrobial soap scrub, the 30-second 70% isopropyl alcohol scrub, or the 30-second germicidal cloth scrub. There was 1 plate that yielded *C albicans* in the isolated 5-minute immersion in enzymatic soap solution. No growth of *S aureus* or *C albicans* was observed with immersion in the ortho-phthalaldehyde disinfectant for 5, 10, 15, or 20 minutes with or without the 5-minute preimmersion in the enzymatic soap solution (**Table**).

COMMENT

Concern over nosocomial transmission of infectious microorganisms is an important aspect of medical practice, and numerous articles in the infectious disease and epidemiological literature have cited the importance of hand washing by all health care professional staff.¹¹⁻¹⁵ With the advent of advanced technological breakthroughs in fiberoptic en-

doscopy and their increased use in both inpatient and outpatient settings, the prevention of disease transmission via contaminated equipment is of paramount importance. Although numerous studies have been performed on the disinfection of heat-sensitive flexible endoscopes, most have involved channel-containing bronchoscopes and gastrointestinal endoscopes.^{16,17} There is a lack of studies investigating the effectiveness of disinfective techniques on fiberoptic scopes used in the field of otolaryngology. Materials such as soap and water, isopropyl alcohol, and germicidal wipes containing quaternary ammonium compounds are ubiquitous to any health care setting and were specifically tested in the study. The compounds analyzed in our study were chosen because they have previously been shown to prevent the transfer of health care-associated pathogens and to effectively reduce bacterial counts on the hands.¹⁸⁻²⁰

The results of our study demonstrate that washing scopes contaminated and inoculated by either *S aureus* or *C albicans* with alcohol wipes, germicidal wipes, or simple soap and water for 30 seconds was sufficient sterilization to result in negative culture results. Predictably, more involved protocols with ortho-phthalaldehyde soaks of up to 20 minutes separately and in conjunction with enzymatic washes also yielded negative culture results. Although we do not advocate simply washing scopes with soap or alcohol wipes between patients, our findings demonstrate that less-involved cleaning techniques appear to be effective in preventing the growth of *S aureus* and *C albicans*. Our findings also show that significantly shorter and simpler protocols for the disinfection of FFLs may be possible without sacrificing efficacy. This knowledge may be beneficial in emergency situations in which the full 20-minute ortho-phthalaldehyde soak might be impractical and even sometimes impossible.

Although we tested only 2 microorganisms in this study, we chose 2 that are clinically relevant and known to be tenacious and ubiquitous organisms. Also, we chose to contaminate the FFL for 30 seconds with each organism, as that is the maximum duration for the vast majority of procedures that are performed by otolaryngologists using an FFL. According to accepted clinical practice guidelines that are important for the prevention of biofilm formation, cleaning began immediately after inoculation. Our study is limited in that multiple different bacteria, fungi, or even viruses were not tested. Therefore, we do not conclude that simple cleaning techniques are sufficient to prevent the growth of all bacteria, fungi, or viruses. However, our results do demonstrate that less-involved cleaning techniques reduce the bioburden of microorganisms and may prevent cross-contamination in emergency situations in which time is of the essence. Further studies are needed to analyze organisms with higher adherence properties, such as *Pseudomonas*, as well as those that are notoriously difficult to eradicate, such as *Mycobacteria* and viruses.

In conclusion, pre-disinfection using a 30-second running tap water rinse is important for reducing the bioburden on contaminated FFLs. A 30-second soap and water scrub; a 30-second IA scrub; a 30-second soap and water scrub, followed by a 30-second IA scrub; a 30-second germicidal cloth scrub; and a 5-, 10-, 15-, or 20-minute immersion in ortho-phthalaldehyde with and without preimmersion for 5 minutes in an enzymatic soap

solution were all equally effective at disinfecting FFLs contaminated in vitro with *S aureus* and *C albicans*.

Submitted for Publication: August 8, 2011; accepted October 27, 2011.

Published Online: January 16, 2012. doi:10.1001/archoto.2011.1204

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Chang, Florea, and Rowe. **Acquisition of data:** Chang, Florea, and Rowe. **Analysis and interpretation of data:** Chang, Florea, Rowe, and Seiberling. **Drafting of the manuscript:** Chang, Florea, Rowe, and Seiberling. **Critical revision of the manuscript for important intellectual content:** Florea and Seiberling. **Statistical analysis:** Florea. **Obtained funding:** Florea. **Administrative, technical, and material support:** Chang and Florea. **Study supervision:** Chang, Florea, Rowe, and Seiberling.

Financial Disclosure: None reported.

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