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Performance Analysis of Exam Gloves Used for Aseptic Rodent Surgery

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Aseptic technique includes the use of sterile surgical gloves for survival surgeries in rodents to minimize the incidence of infections. Exam gloves are much less expensive than are surgical gloves and may represent a cost-effective, readily available option for use in rodent surgery. This study examined the effectiveness of surface disinfection of exam gloves with 70% isopropyl alcohol or a solution of hydrogen peroxide and peracetic acid (HP–PA) in reducing bacterial contamination. Performance levels for asepsis were met when gloves were negative for bacterial contamination after surface disinfection and sham 'exertion' activity. According to these criteria, 94% of HP–PA-disinfected gloves passed, compared with 47% of alcohol-disinfected gloves. In addition, the effect of autoclaving on the integrity of exam gloves was examined, given that autoclaving is another readily available option for aseptic preparation. Performance criteria for glove integrity after autoclaving consisted of: the ability to don the gloves followed by successful simulation of wound closure and completion of stretch tests without tearing or observable defects. Using this criteria, 98% of autoclaved nitrile exam gloves and 76% of autoclaved latex exam gloves met performance expectations compared with the performance of standard surgical gloves (88% nitrile, 100% latex). The results of this study support the use of HP–PA-disinfected latex and nitrile exam gloves or autoclaved nitrile exam gloves as viable cost-effective alternatives to sterile surgical gloves for rodent surgeries.

Abbreviations: HP–PA, hydrogen peroxide and peracetic acid.

The Guide for the Care and Use of Laboratory Animals (the *Guide*) states that "general principles of aseptic technique should be followed for all survival surgical procedures."[9]

'Aseptic technique' refers to practices that reduce microbial contamination to the lowest possible practical level and includes: preparation of the patient; preparation of the surgeon including decontaminated surgical attire, surgical scrub, and sterile surgical gloves; sterilization of instruments, supplies, and implanted materials; and careful tissue handling during surgery to reduce the likelihood of infection. The *Guide* also states that "The species of animal may influence the manner in which principles of aseptic technique are achieved."[9] Therefore, although aseptic technique should be followed for survival surgeries in rodents, flexibility exists in the means by which asepsis is achieved. Aseptic approaches that are more economical or efficient yet maintain performance standards should be acceptable to the IACUC overseeing the animal care program. The recommendation to wear sterile surgical gloves for survival surgeries in rodents exists to limit contamination of the surgical site by bacteria on the surgeon's hands and thus reduce the likelihood of a postsurgical infection. Under the Association for Practitioners in Infection Control guidelines, sterilization is defined as "the complete elimination or destruction of all forms of microbial life."[19-21] However, many laboratory workers fail to wear the recommended type of gloves for rodent surgery, primarily due to the high cost of sterile surgical gloves.[4]

The purpose of the current study was to evaluate the performance of more economical and efficient alternatives to sterile surgical gloves for use in rodent survival surgery. The alternatives chosen were surface disinfection with 70% alcohol, HP–PA, and autoclaving for preparation of standard nitrile and latex exam gloves. We evaluated latex and nitrile exam gloves because both are commonly available in the laboratory. Disinfectants are readily available in most animal use areas, inactivate most pathogenic microorganisms, and therefore represent a convenient option for aseptic glove preparation for rodent survival surgeries.[20] Isopropyl alcohol (70%) is used as an antiseptic for a variety of procedures in a medical setting including injection site preparation and as part of surgical site preparation. The *Guide*, however, states that "alcohol is neither a sterilant nor a high-level disinfectant."[9] Alcohol is classified as an intermediate-level disinfectant, meaning that it does not kill bacterial spores or hydrophilic viruses.[17] Nonetheless, alcohols at concentrations ranging from 60% to 90% are reported to have excellent microbicidal properties[2] and significantly reduce the microbial load on contaminated surfaces,[7] hands,[15,17,18,22] and gloves inoculated with test organisms.[5] A recent study found that soaking the fingertips of sterile surgical gloves in 70% isopropyl alcohol for 30 s between 5 serial mouse laparotomies effectively disinfected the gloves and prevented bacterial contamination.[10] Because unused exam gloves presumably have low levels of bacterial contamination, alcohol might render them aseptic.

HP–PA solutions are common disinfectants within the animal vivarium for the disinfection of biosafety cabinets and gloves when working with SPF rodents. A solution comprising 1.00% hydrogen peroxide and 0.08% peracetic acid is considered to be a chemical sterilant suitable for use on critical items that come into contact with sterile patient tissues, as in surgery.[21] Product availability to animal users and use applications make HP–PA solution a reasonable choice for exam glove disinfection.

In addition to chemical disinfection of exam gloves, another readily available option in most animal facilities is steam sterilization in an autoclave. The surgical instruments used for rodent surgery are commonly prepared by using autoclaving, and the addition of standard exam gloves to the surgical pack

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is another possible alternative to sterile surgical gloves for rodent surgeries. The existing reports on autoclaving of medical gloves date back to the 1960s and refer to reusable surgical gloves. These studies found that autoclaving methods made the gloves unusable or increased breakage;[6,14] however ,glove materials, manufacturing practices, and quality control criteria have changed greatly since then,[23]and the most recent updates to test procedures and acceptance criteria for medical gloves in the United States were made in 2006.[3] The gloves we selected for evaluation conform to industry standards regarding leaks and visual defects, according to the manufacturer.

For this study, we hypothesized that surface disinfection of exam gloves with 70% isopropyl alcohol or HP–PA solution would effectively decrease microbial contamination of exam gloves to a level equivalent to that of sterile surgical gloves and that the disinfection process would not predispose the gloves to contamination from the surgeon's hands during use. In addition, we hypothesized that autoclaving of exam gloves would have a detrimental effect on performance compared with that of sterile surgical gloves and that autoclaving could render exam gloves unwearable, cause defects in the gloves, or increase the porosity of the glove materials.

Materials and Methods

Nitrile exam gloves (Performance Nitrile Examination Gloves, 0.09 mm thickness at the finger, size small, powder-free, textured, High Five Products, Chicago, IL) and latex exam gloves (Performance Latex Examination Gloves, 0.14 mm thickness at the finger, size small, powder free, microtextured, High Five Products, Chicago, IL) were used for this study. The cost of 2 exam gloves (1 pair) was approximately US$0.12. Each box of exam gloves was stored in a closed microisolation container and opened only inside a biosafety cabinet.(class II, type A; BioGard, Baker, Sanford, ME). Control gloves were sterile nitrile surgical gloves (KC500 Purple Nitrile Sterile Powder-Free Exam Gloves, 0.15 mm thickness at the finger, size small, Kimberly-Clark, Roswell, GA) and sterile latex surgical gloves (Criterion Surgeon Gloves, 0.22 mm thickness at the finger, size 6.5, latex, powdered, sterile, Henry Schein, Melville, NY). The cost of one package of surgical gloves was US$1.10.

For surface disinfection, 70% isopropyl alcohol (Priority Care 1 Isopropyl Alcohol 70%, First Priority, Elgin, IL) and a commercially available solution of 1.00% hydrogen peroxide and 0.08% peracetic acid (Spor-Klenz RTU, Steris, St. Louis, MO) were placed in a 1-L spray bottle for use.

To mimic aseptic surgical attire, the experimenter wore a disposable isolation gown, a bouffant cap, and face mask (Total MRO, Guilford, CT) for 2 or 3 consecutive glove testing trials before changing, similar to practices for rodent batch surgery. Within the disinfected biosafety cabinet, culture swabs were arranged in advance for ease in sampling, and the microisolation container of exam gloves was opened. Prior to each glove trial, the experimenter's hands were washed for 1 min with antibacterial hand soap containing triclosan (Clini-Clean Hand Soap, MWI, Meridian, ID) and warm water, followed by thorough drying of the hands with paper towels. Paper towels, instead of sterile, were used to reflect the typical actions performed for rodent survival surgery. As compared with survival surgery in USDA-regulated species, the surgeon typically does not perform an aseptic hand scrub for rodent surgery. The experimenter then proceeded to don the left glove and then the right glove, taking care to ensure that skin contact with the outside of the glove was restricted to the cuff area. For trials involving sterile surgical glove, a package of sterile gloves was opened and laid inside the biosafety cabinet prior to hand washing and then donned as described earlier. A second set of trials was done without hand-washing prior to donning gloves to determine whether this practice affected performance as assessed by bacterial contamination.

Once exam gloves were donned, the experimenter obtained a baseline culture sample and then sprayed both sides of the hands twice with either 70% isopropyl alcohol or HP–PA solution. The hands were rubbed together, ensuring that disinfectant contacted all surfaces of the gloved hand, until the disinfectant had dried (30 s for isopropyl alcohol and 90 s for HP–PA solution). A second culture sample was obtained immediately after the disinfection procedure for exam gloves. Surgical gloves were assumed to be sterile after donning, in light of product assurances and strict adherence to asepsis by the experimenter. To assess for potential contamination of the glove surface by the surgeon's hands, a sham activity was performed to mimic 'exertion' (palm sweating), which commonly occurs during a surgical procedure. Specifically, the experimenter stepped away from the biosafety cabinet to minimize airflow disturbance, being careful not to touch anything with the gloved hands, and completed a timed 5-min run-in-place activity while flexing and extending the fingers on both hands. A culture sample was collected from both the exam gloves and surgical gloves after the sham activity.

Culture sample collections were done within the biosafety cabinet by swabbing the fingertips of the gloves with sterile applicator swabs (Kendall Curity Single Tipped Applicators, Sterile, Tyco Healthcare Group, Mansfield, MA) moistened with BHI broth (BBL Brain Heart Infusion Broth, BD, Franklin Lakes, NJ). Using the right hand, the experimenter rolled the broth-soaked culture swab back and forth 4 times over the palmar surface of each distal phalanx of the left hand, in order from the 1st to 5th digit; the swab was then replaced in the broth tube, which contained 5 mL of BHI broth, and the tube capped.

All culture tubes were incubated at 35 °C for 24 to 28 h before evaluation for evidence of growth. Tubes were considered to be positive for bacterial growth when the broth was cloudy. At least 20% of the growth-positive tubes from each group were further characterized by plating on sheep blood agar growth medium (Trypticase Soy Agar with 5% Sheep Blood [TSA II], Becton Dickinson, Franklin Lake, NJ) and incubating at 35 °C for 24 h. The microbiologist identified the organisms by using Gram staining and, as needed, biochemical identification test strips (API 20E, bioMerieux, Durham, NC) for gram-negative rods and Mannitol Salt Agar growth medium (Becton Dickinson) for *Staphylococcus* spp.

For evaluation of autoclaving for aseptic preparation of exam gloves, 3 pack arrangements were prepared: gloves wrapped in a drape (Surgical Huck Towel, Mednik Riverbend, St Louis, MO), gloves and instruments wrapped in a drape, and gloves and instruments sealed in a 7 × 12-in. autoclave pouch (Henry Schein). Multiple arrangements were evaluated to identify potential damaging effects of direct contact between surgical instruments and exam gloves during the autoclaving process. Each pack contained 10 gloves (5 pairs) and an autoclave indicator strip (Short OK, Henry Schein). The packs with instruments each included 4 new 4 × 4-in. gauze sponges (Jorgenson Laboratories, Massillon, OH), 1 pair forceps, 1 needle driver, and 1 pair sharp–blunt scissors. When packs were prepared for autoclaving, the exam gloves were visually inspected for defects (holes, tears), and any gloves found to be defective (n = 1, 0.004% of gloves inspected) were excluded from surgical packs. The cuffs of the exam gloves were folded over approximately 6 cm to allow for

aseptic gloving after sterilization, and the gloves were placed on top of instruments and gauze in the packs. Pouches then were closed, or packs were wrapped with a reusable drape and taped closed with temperature-indicator tape (Comply Class I Steam Indicator Tape, 3M, St. Paul, MN). Packs were autoclaved in an Amsco Century Steam Sterilizer (V-116 Prevac, Steris, Mentor, OH) at 270 °F for 4 min with a dry time of 20 min, removed from the autoclave within 10 min of cycle completion, and allowed to cool on the countertop. Packs were stored in a room temperature cabinet after autoclaving until performance testing was completed by 7 d poststerilization.

When the pack was opened, the temperature-indicator tape on the inside and the autoclave tape on the outside were checked to verify that the autoclave reached the needed parameters for effective sterilization. On the day of testing, one pair of gloves was removed from the pack. Each glove was considered an individual measurement (n = 54 for each combination of glove and pack type). Standard exam gloves that had not been autoclaved and sterile surgical gloves underwent performance testing as controls (minimum n = 6 for each glove type).

To test autoclaved exam glove performance, the following were done: initial visual inspection, stretch test 1, surgical manipulations, visual inspection after manipulation, and stretch test 2. For the visual inspection, gloves were assessed for defects (holes, breaks, or tears) by using gross visual examination. Gloves that had such defects were exempt from further testing. The stretch test consisted of grasping the fingertip of each glove with the thumb and index finger of the opposite hand and pulling it 15 cm past the end of the finger and then stretching both the dorsal and ventral sides of the cuff 15 cm. The surgical manipulations performed by the experimenter were selected to reflect typical surgical activity. Specifically, 5 simple interrupted sutures were placed in a synthetic model (catalog no. SCS-10, Subcuticular Suturing Model, Simulab, Seattle, WA) by using needle holders and tissue forceps. The second visual inspection and stretch test were performed as described.

Gloves free of visible defects from the initial performance testing were removed from the hands and pressure-tested to evaluate for the presence of defects not grossly visible. The pressure test used a small-animal anesthetic machine (SurgiVet, Smiths Medical, Dublin, OH) arranged with an F-circuit and a 0.5-L breathing bag. The pop-off valve was closed, and the circuit was pressure-tested to ensure there were no leaks in the system. The bottom 5 cm of the glove cuff was stretched tightly around the end of the breathing circuit and secured tightly by using a hook-and-loop cable tie (One-Wrap Ties, Velcro, Manchester, NH), with the soft side against the glove to avoid inadvertently creating defects (Figure 1). The glove was filled with oxygen at a rate of 3 L/min until the pressure (cm H_2O) plateaued for 5 s, representing peak pressure. The oxygen flow valve then was turned off. The final pressure of the inflated glove was recorded after 5 min and the subsequent pressure loss calculated.

Statistical analysis. The threshold for statistical significance was a P value of less than 0.05. The Cochran–Mantel–Haenszel test for repeated 2×2 tests of independence was used to evaluate the effects of glove type, hand washing, and disinfectant on the number of growth-negative postdisinfection cultures.[13] The Fisher Exact Test (Instat3, GraphPad Software, La Jolla, CA) was used to compare the percentage of growth-negative cultures and the performance failure rate between experimental and control groups. A Kruskal–Wallis test and the Dunn Multiple Comparisons Test (GraphPad Prism 6, GraphPad Software, La Jolla, CA) were performed to compare the performance of autoclaved exam gloves with that of nonautoclaved exam gloves and sterile surgical gloves for calculated pressure loss and peak pressure.

Figure 1. Pressure test apparatus. An anesthetic machine was arranged with an F-circuit and a 0.5-L breathing bag, and the pop-off valve was closed. The circuit was pressure-tested to ensure there were no leaks in the system. The bottom 5 cm of the glove cuff was stretched tightly around the end of the breathing circuit and secured tightly by using a hook-and-loop cable tie, with the loop side against the glove.

Results

Prior to surface disinfection, 48% of standard exam gloves were positive for microbial growth immediately after donning. Because no effect of glove type or hand-washing status was identified, data were combined for subsequent analysis. The disinfectant had a significant ($P < 0.05$) effect on the number of negative cultures after disinfection. After chemical decontamination, 97% of gloves disinfected with HP–PA solution were negative for bacterial growth, whereas 56% of exam gloves disinfected with alcohol were growth-negative. The sham activity did not change the contamination rates of exam gloves disinfected with HP–PA. However, exam gloves disinfected with alcohol showed less contamination (75% negative cultures) after the activity. Effects were statistically significant at both the postdisinfection and the postsham time points ($P< 0.0001$ and $P < 0.05$, respectively; Figure 2).

Exam gloves were considered to have passed, or met the level of asepsis needed for survival surgery when they were negative for bacterial contamination after surface disinfection and remained growth-negative after sham activity (Figure 3). Alcohol-disinfected exam gloves had significantly ($P < 0.0001$) lower passing rates (47% pass rate) compared with HP–PA-disinfected exam gloves (94% pass rate) and sterile surgical gloves (100% pass rate). The control group (sterile surgical gloves) was assumed to be sterile after aseptic donning and had no growth-positive cultures after the sham activity; therefore all trials were considered passing (100% pass rate). Microbial analysis revealed that 46% of contaminants were *Bacillus* spp., 14% were *Staphylococcus* spp. (not *aureus*), and fewer than 5% each of *Streptococcus* spp., *Pasteurella* spp., *Sphingomonas paucimobilis*, *Chryseomonas luteola*, and *Stenotrophomonas maltophilia*.

Performance testing of autoclaved exam gloves found that 23% of the latex gloves and 0% of nitrile gloves could not be donned after the autoclaving process. Failure of the latex exam

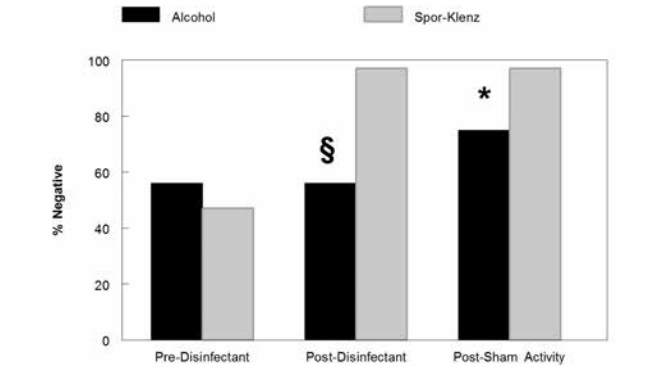

Figure 2. Culture results according to disinfectant used. Exam gloves were evaluated at 3 time points: immediately after donning (predisinfectant), after disinfection with either alcohol or commercial disinfectant (postdisinfectant), and then after a run-in-place activity (postsham activity). Percentages were significantly different at the postdisinfection and postsham activity time points (§, $P < 0.0001$ and *, $P < 0.05$, respectively).

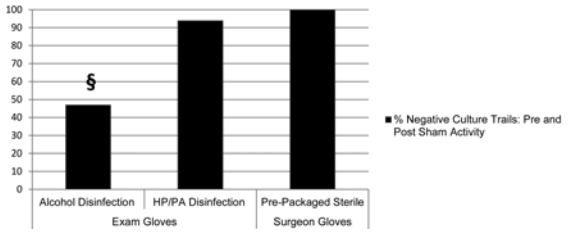

Figure 3. Gloves considered to have passed according to bacterial culture results. Exam gloves were evaluated after surface disinfection with either alcohol or HP–PA (1.00% hydrogen peroxide and 0.08% peracetic acid). Exam gloves were considered to have passed (that is, acceptable for use during surgery) when bacterial cultures were negative immediately after disinfection and after the sham activity. Prepackaged surgical gloves were assumed to be sterile immediately after donning, because they were donned by using open sterile gloving technique, and were considered to have passed when the bacterial culture after the run-in-place activity was negative. The percentage of exam gloves that was considered to have passed after disinfection with alcohol was significantly different (§, $P < 0.0001$) from those for HP–PA-disinfected exam gloves and sterile surgical gloves.

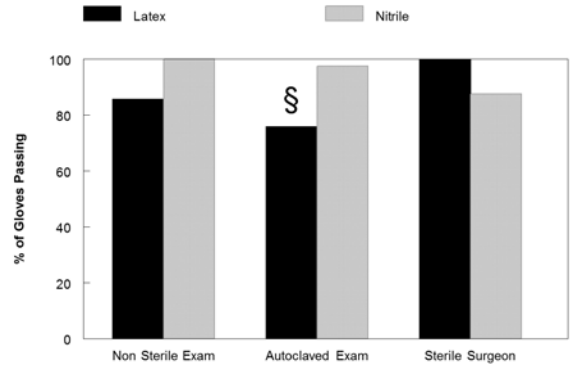

Figure 4. Gloves considered to have passed according to results of visual defects test and stretch test performance. Gloves were considered to have passed when they were wearable and free of defects after both the visual and stretch tests. The percentage of exam gloves considered to have passed after autoclaving was significantly (§, $P < 0.0001$) lower for the latex group as compared with the nitrile group.

Table 1. Peak pressure and pressure loss (cm H_2O; mean ± 1 SD) for sterile surgical, nonsterile exam, and autoclaved exam gloves

		n	Peak pressure	Pressure loss
Latex	Sterile	6	18.00 ± 1.60	7.02 ± 5.29
	Nonsterile exam	6	19.10 ± 0.20	4.25 ± 1.92
	Autoclaved exam	124	16.50 ± 1.47	2.19 ± 2.83[b]
Nitrile	Sterile	7	30.10 ± 1.00	14.29 ± 0.9
	Nonsterile exam	6	26.00 ± 0.00	12.50 ± 0.45
	Autoclaved exam	158	20.50 ± 1.18[a]	8.75 ± 1.17[b]

[a]Mean peak pressure of autoclaved exam gloves was significantly ($P < 0.001$) lower than that of sterile surgical gloves
[b]Mean pressure loss for autoclaved exam gloves was significantly less than that of sterile surgical gloves

gloves occurred when they were stuck to the other gloves in the pack or sealed shut in a manner that caused them to break or tear when being donned. Autoclaved nitrile exam gloves had no initial failures; however, during the second stretch test, 2.5% of these gloves failed. Gloves that survived both visual examinations and stretch tests without noticeable defects were considered to have passed, that is, to have met the level of asepsis needed for survival surgery. Analysis of autoclaved exam gloves determined that nitrile gloves passed at a significantly ($P < 0.0001$) greater rate than did latex gloves (Figure 4). A single defect each was observed among the latex nonsterile exam gloves ($n = 7$), noted during the assembly of surgical packs, and the nitrile sterile surgical gloves ($n = 8$), noted during the second stretch test. No visual defects (holes, breaks, or tears) were found among the latex sterile surgical gloves ($n = 6$) and nitrile nonsterile exam gloves ($n = 6$).

The pressure test data for all pack types were combined to obtain an overview of the effect of autoclaving on latex and nitrile exam gloves (Table 1). There was no significant difference between the peak pressure and pressure loss in autoclaved gloves of either type compared with their nonsterile exam glove controls. For nitrile gloves, the autoclaved exam gloves had a significantly ($P < 0.05$) lower peak pressure and reduced pressure loss compared with nitrile sterile surgical gloves. In addition, a significantly ($P < 0.05$) reduced pressure loss was observed for autoclaved latex exam gloves relative to latex sterile surgeon gloves.

Discussion

The use of sterile surgical gloves is considered the 'gold standard' for aseptic surgery; however, modifications in aseptic technique for rodents may be permissible given equivalent postsurgical outcomes. In this study, we found that approximately half of the standard exam gloves were contaminated with microbial colonies at the fingertips after donning, confirming that without further processing, exam gloves do not meet standards for asepsis. Hand washing with antibacterial soap prior to donning gloves did not have an effect on the initial contamination levels of the gloves, provided that care was taken to avoid skin contact with the outer glove surface.

Disinfection of standard exam gloves with the HP–PA solution was more successful at eliminating bacterial contamination than was disinfection with 70% isopropyl alcohol. The culture results showed that the microbial contamination of both latex and nitrile exam gloves disinfected with HP–PA solution did not differ from that of sterile surgical gloves. In contrast, alcohol was ineffective at eliminating bacteria to the same level as on surgical gloves or HP–PA-disinfected exam gloves. The results of alcohol performance are consistent with other studies using this product for unsuccessful disinfection of reusable pressure transducers, resulting in bacterial infection.[1]

Surprisingly, alcohol performed better after the sham activity; reflected by an increased number of growth- negative cultures. Although residual activity of alcohol is not generally recognized due to its evaporative properties,[8] some residual effect could account for these findings. The use of microsurgical instruments likely limits the level of contamination from the gloves to the surgical site during rodent surgeries, causing some authors to dispute the need for sterile gloves altogether.[4] However, the potential exists for the surgical instruments to carry bacteria from the gloves into the wound. One group[4] noted that even sterile gloves become contaminated during multiple surgeries. This information further supports the idea that exam gloves disinfected with HP–PA solution may achieve the same performance standards as sterile surgical gloves. Our findings further suggest that surface disinfection of the gloves with HP–PA solution between surgeries may limit the contamination of gloves (and thus instruments and surgical sites) during batch surgeries. Our study did not evaluate in vivo outcomes of these methods. Although glove contamination after disinfection with HP–PA did not differ from that of surgical gloves, differences in postoperative outcomes due to bacterial contamination or tissue irritation are possible. Facilities should monitor postoperative complication rates when changing surgical practices to ensure that they achieve the same performance outcomes.

Autoclaved nitrile exam gloves appear to be a viable alternative to sterile surgical gloves. Nitrile gloves survived processing in the autoclave and performed well in the visual and stretch tests. Overall levels of performance of autoclaved nitrile gloves did not differ from those of sterile surgical gloves, supporting the option as a suitable alternative for survival rodent surgery. Although some of the latex gloves did not withstand the autoclaving process, gloves that could be worn performed satisfactorily in the subsequent testing. This option might be feasible, albeit more expensive than nitrile exam gloves, assuming that twice as many latex exam gloves would need to be autoclaved. Pack arrangement did not influence the performance of gloves after autoclaving.

The duration of glove use may significantly affect glove failure rates.[11,16] With the exception of one trial, all of the gross defects we discovered occurred during the second stretch test, which is consistent with a longer duration of use. The user noted that by this time point, the moisture accumulation within the gloves was causing the gloves to stick to the hands during the stretch test, potentially necessitating the application of more force during this test. Although gloves remained intact, the 15-cm stretch length was not achieved in 4 trials during the second stretch test. However, glove failures can occur during surgical procedures, even when sterile surgical gloves are used.[12]

In our study, if only those gloves that survived autoclaving were evaluated, the overall defect rate was 0.8% (1 of 125) for latex gloves and 2.5% (4 of 162) for nitrile gloves. The USDA set Acceptable Quality Levels (AQL) standards for surgeon and exam gloves, allowing for a defined number of defects during a standard water-leak evaluation.[3] For donned autoclaved exam gloves, both nitrile and latex, the number of defects observed fell within acceptable parameters for sterile surgical gloves, assuming an equivalent sample size.[3] Furthermore, the performance tests we used far exceeded the forces of the standard water-leak test, which specifically limits glove manipulation.[3] The autoclaved nitrile exam gloves survived autoclaving, performed well, and could be changed as needed for longer procedures to avoid potential breaks in asepsis with minimal effect on overall cost. Glove types not tested here may have different performance results and should be evaluated prior to use for rodent surgeries.

The results of the pressure tests on the autoclaved exam gloves were not significantly different from those of standard exam gloves, indicating that the autoclaving process had minimal effect on these parameters. The nature of the product, latex or nitrile, in addition to the thickness of the glove may influence the measured parameters. Peak pressure and pressure loss were lower for all latex gloves relative to nitrile, likely due to the more elastic nature of latex. Furthermore, the lower peak pressure of autoclaved nitrile exam gloves compared with sterile nitrile surgical gloves likely reflects the decreased flexibility of the thicker surgical gloves. In fact, surgeons may prefer the increased dexterity afforded by exam gloves, given equivalent performance. Data were consistent regarding pressure loss, as the autoclaved exam gloves, both latex and nitrile, showed less pressure loss than did the thicker sterile surgical gloves. The extent of pressure loss over the 5-min test period may reflect the porosity of the gloves, the presence of small defects, or an imperfect seal in the pressure testing apparatus. Overall, given that autoclaved exam gloves showed less pressure loss over time than did surgical gloves, we strongly suspect that the decreased peak pressures result from the increased elasticity of the exam glove material rather than reflect greater porosity or defects. Furthermore, because the results of the other performance tests were satisfactory, it seems unlikely that the observed changes in the pressure test parameters will negatively affect glove performance during surgery.

The results of this study support the use of HP–PA surface disinfection or autoclaving of exam gloves as a viable alternative to the use of sterile surgical gloves for survival rodent surgery. Disinfecting standard latex or nitrile exam gloves by using an HP–PA solution as we describe here provides a glove surface aseptically comparable to that of sterile surgical gloves. Alternatively, the addition of nitrile exam gloves to a standard instrument pack prior to autoclaving provides aseptic gloves appropriate for survival rodent surgery. Including a few extra pairs of nitrile gloves is recommended when using autoclaving, for longer procedures. Cost savings for an average rodent survival surgery study, involving 10 surgeries each week, is more than US$500 (US$572 to US$620) annually for equivalent performance results. This savings may vary depending on the context of the institution's operations, given that we did not consider the costs of stocking and storing supplies. Both options serve as cost-effective alternatives to the use of sterile surgical gloves and likely meet the performance standards of rodent aseptic surgery as recommended in the *Guide*.

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