Leakage of Virus through Used Vinyl and Latex Examination Gloves

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A total of 480 examination gloves (240 vinyl and 240 latex) were stressed by using manipulations designed to
mimic patient care. At the highest use level, 38 (63%) of 60 vinyl gloves leaked bacteriophage \( \Phi X174 \) compared
with 4 (7%) of 60 latex gloves. At lower use levels, there was no statistically significant difference in leakage.

Recently, there has been concern among health care personnel about the use of vinyl and latex gloves as barriers
against the transmission of microorganisms. A recent outbreak of herpes whitlow among intensive care nurses who
wore gloves (7) has focused attention on the integrity of gloves during use. We previously investigated vinyl and
latex examination gloves as barriers against bacteria and found that both types of gloves provided some protection,
but latex gloves maintained integrity longer under in-use conditions (6). Dalgleish and Malkovsky (2) have reported
that the quality of latex gloves varies with the manufacturer and that latex gloves may not give total protection from
human immunodeficiency virus penetration. In fact, gloves scanned by electron microscopy have shown 30- to 50-\( \mu \)m holes, suggesting that viruses could penetrate the gloves (1). Degoort-Kosolcharoen and Jones (3) investigated the permeability to water and blood of sterile latex gloves and examination latex and vinyl gloves and found greater leakage in examination gloves. Health care personnel continue to question the barrier effectiveness of latex and vinyl examination gloves used in clinical practice. This study was conducted to determine whether bacteriophage \( \Phi X174 \) could penetrate used vinyl and latex examination gloves after standardized manipulations.

Procedure for glove manipulation. Because of findings in our previous study (6), standardized manipulations designed to mimic patient care activities were performed on groups of gloves in advance of testing (Table 1). Participants wore no rings or nail polish and had their fingernails filed short and smooth. Sixty gloves of each type were tested at each use level. As positive controls, vinyl and latex gloves had either two or five holes punctured in the index finger with a 21-gauge hypodermic needle and were assayed for bacteriophage leakage. In addition, one latex glove was torn approximately 1 cm at the index finger.

Preparation and assay of phage. Stock suspensions of \( \Phi X174 \) bacteriophage were prepared by growth in liquid culture with \textit{Escherichia coli} C (ATCC 13706) at 37°C (5). The titer of \( \Phi X174 \) was determined by plaque formation using the tryptone top-agar layer method (5, 8). Phosphate-buffered saline (100 ml; pH 7.4) containing \( 10^4 \) to \( 10^7 \) PFU of \( \Phi X174 \) was poured into each glove. The quantity of liquid was enough to fill the glove to just about the fingers. Each glove was held over an empty collection container for 1 min

and observed for leakage of liquid. Each glove was then draped for 4 min over the edge of a collection container such that the fingers were submerged in the interior of the container and the empty remainder of the glove fell over the exterior. Phosphate-buffered saline (100 ml) was poured into the collection container, and the fingers were immersed for 5 min more. Samples (1 ml) of the collection buffer were obtained after up-and-down agitation and removal of the glove. In this study, a visible leak was defined as a leak observed by the naked eye. A viral leak was one in which virus was detected in the collection container. The effective volume leaked from each glove was calculated in microliters as the total number of virus particles in the collection container divided by the virus concentration inside the glove. The chi-square and the Fisher exact tests were used to assess differences in the proportions of gloves which leaked. The Mann-Whitney U test was used to test for differences in the volume of fluid leaked.

A total of 480 (240 vinyl and 240 latex) examination gloves were tested, with 60 each in the four categories of use. None of the latex gloves with needlestick holes had visible leaks or were positive for viral leakage. However, the torn latex glove was positive for both visible and viral leaks (5.0 \( \times 10^6 \) PFU). The punctured vinyl gloves had both visible and viral leakage (two holes, 7.6 \( \times 10^5 \) PFU; five holes, 4.9 \( \times 10^5 \) PFU). All test gloves with visible leaks also leaked virus (Fig. 1). Virus leakage was found in both types of gloves: 55 (22.9%) of 240 vinyl and 18 (7.5%) of 240 latex gloves (\( \chi^2 = 20.94, P = 0.00005 \)). In addition, in 34 (14.1%) of 240 vinyl gloves and 16 (7%) of 240 latex gloves, visible leaks were not observed, but virus still leaked through: \( 5 \times 10^2 \) to \( 1 \times 10^7 \) PFU per glove for vinyl and \( 5 \times 10^4 \) to \( 1.3 \times 10^4 \) PFU for latex.

There were no statistically significant differences in leakage rates for latex or vinyl gloves at use level 0, 1, or 2. However, as with visible leaks, there was a statistically significant difference in viral leaks at use level 3. Of the vinyl gloves, 63% (38 of 60) in use level 3 leaked virus compared with 7% (4 of 60) of the latex gloves (Fisher exact test, two-tailed; \( P = 0.000001 \)). There was a wide range in the volume leaked at each of the four use levels (Table 2). Vinyl gloves leaked more than latex gloves (Mann-Whitney U test; \( P = 0.0001 \)).

This study demonstrated that some vinyl and some latex examination gloves permit viral leakage. At use levels 0, 1, and 2, the proportions with viral leakage were not signifi-
TABLE 1. Procedures for preparation of gloves prior to test

<table>
<thead>
<tr>
<th>Use level*</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Remove from box</td>
</tr>
<tr>
<td>1</td>
<td>Don gloves and remove them</td>
</tr>
<tr>
<td>2</td>
<td>Levels 0 and 1 plus rub each gloved hand with a washcloth in the following sequence: palm, each finger in a twisting motion, thumb, and back of hand</td>
</tr>
<tr>
<td>3</td>
<td>Levels 0–2 plus (i) attach a capped needle to a Luer-Lok syringe and then remove it 30 times; (ii) connect and disconnect Luer-Lok syringe to intravenous tubing and manipulate a stopcock eight times; (iii) wrap, tape, and unwrap a blunt object two times to simulate bandaging an amputation stump</td>
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* Use level in previous paper refers to manipulation level (6).

significantly different between glove types. At use level 3, more vinyl gloves than latex gloves leaked virus, and the volume leaked was higher. The needlestick punctures in the fingertips of gloves which were meant to serve as positive controls resulted in visual and viral leaks in the vinyl gloves but not in the latex gloves. This result was unexpected and may have been caused by the elastic resealing property of latex.

The high proportion of gloves that leaked some amount of φX174 indicates that the effective hole size is greater than 27 nm, since that is the diameter of the virus particle. These findings are consistent with the work of Kotilainen et al. (7), who were able to detect leakage of poliovirus (20 to 30 nm in diameter) through a glove barrier. Further evidence suggests that microorganisms can pass from the outside of a glove, through the glove, and onto the hand (4, 6).

These results, from the testing of a single brand of vinyl gloves, suggest that holes can be formed during procedures related to routine patient care. Under the conditions of this study, latex gloves appeared to be less susceptible to hole formation than vinyl gloves. Although these experiments should be expanded to include other brands of both types of gloves, our results suggest the need to change gloves after moderate periods of use. In addition, since there may be viral leakage during glove use, a conscientious handwashing technique should be used after glove removal.

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LITERATURE CITED