A Comparison of Commonly Used Surface Disinfectants

November 1, 2000

Relevant Topics

A Comparison of Commonly Used Surface Disinfectants Alcohol-, Phenol-, Chlorine-, and Quaternary Amine-Based Disinfectants

A Comparison of Commonly Used Surface Disinfectants Alcohol-, Phenol-, Chlorine-, and Quaternary Amine-Based Disinfectants

By Lauren Crawford, BS; *Zhi-Jian Yu*, PhD; *Erin Keegan*, BS; and *Tina Yu*, MS

Using proper surface disinfection can prevent infections that develop during hospitalization that are neither present nor incubating at the time of a patient's admission. There are important factors to consider when selecting a surface disinfectant. This paper discusses a comparison of the product types on the basis of the health-related issues of infection prevention, compatibility with equipment and gloves, as well as the safety of the disinfectant to hospital personnel.

Some ideal characteristics of disinfectants used on environmental surfaces include rapid action in a broad antimicrobial spectrum, maintained efficacy in the presence of protein or blood, low toxicity, user safety, and material compatibility. Some disinfectants have limited use because they do not meet all of these criteria. Table 1 shows a list of 10 disinfectants, the active ingredients, manufacturer, characteristics of the disinfectant, and a recommendation of the types of gloves that can be used with the product for up to one hour.

Spectrum and Rapidity of Antimicrobial Activity

The spectrum refers to the range of recommended product usage and the sphere of microbial kill tested, as well as the contact time and temperature, according to the manufacturer and the EPA-approved label. The 10 products that are mentioned in Table 1 are similar in antimicrobial activity because they all claim to be bactericidal, fungicidal, and virucidal. However, not all disinfectants claim to be tuberculocidal. Envirosafe, Coverage HB, Coverage Spray, and Ascend are all low-level disinfectants and they do not kill the tubercule bacillus (i.e., M. Bovis). Based on the disinfectant class, the range of antimicrobial activity is discussed in further detail below.

High concentration alcohol-based
Lysol I.C. Disinfectant Spray has a broad spectrum of antimicrobial activity with 79% ethyl alcohol and has a recommended surface contact time of 10 minutes. High concentration alcohol products are generally not advocated for instrument immersion since the high alcohol content volatilizes easily, and thus diminishes antimicrobial activity. Additionally, alcohols cannot be used as cleaners, which then requires the user to purchase a separate cleaner.

Chlorine-based
Dispatch can be used as a cleaner due to the presence of added surfactants and a deodorizer. It has a broad range of efficacy with a label claim contact time of two minutes at 20°. Both Babb and Alvarado et al. do not recommend chlorine-based compounds, such as the sodium hypochlorite contained in Dispatch, for disinfection of instruments and equipment. Robison et al. reported that a commercial disinfectant containing 0.55% sodium hypochlorite with a 2-minute contact time at room temperature displayed poor tuberculocidal activity. According to Robison's study, the average time required for a 6-log10 reduction was in excess of three hours. However, the CDC recommends that 5.25% sodium hypochlorite (household bleach) diluted to a concentration of 0.05% can be used for the decontamination of a blood spill.

Phenol-based
Wex-cide, ProSpray, and Birex are germicidal, fungicidal, virucidal, and tuberculocidal in 10 minutes at 20°. Birex is a cleaner and deodorizer. Birex is not sold at the use-dilution, and therefore, diluting Birex involves an extra step. Surface disinfectants that require dilution can result in preparation errors, and incomplete disinfection due to an inappropriate disinfectant concentration.

Quaternary amine-based
Envirosafe, Coverage HB, Coverage Spray, and Ascend are all low-level quaternary amine-based disinfectants, and have a more prominently restricted efficacy range than the other products discussed herein. These product spectrums do not include tuberculocidal activity. With the exception of Coverage HB concentrate, they do not kill HBV (Hepatitis B Virus). Additionally, Envirosafe, Coverage HB, and Ascend are not sold at the optimum concentration and dilution is required. Envirosafe, Coverage HB, Coverage Spray, and Ascend can be used for ultrasonic cleaning and as general cleaners. The four quaternary amine products can also be used for (limited) instrument immersion for the allotted time to kill microorganisms. However, surface disinfectants in general are not recommended as permanent holding solutions.

Quaternary amine / low concentration alcohol-based
The synergistic mechanism of quaternary amines in the presence of alcohols involves the breakdown of the lipoprotein complexes by the quaternary amines in the cell membrane of microorganisms. The opening of the membrane thereby allows the alcohol, which is a protein denaturant, to penetrate the cell membrane and cause irreversible damage inside the cell. Cavicide has a broad spectrum of antimicrobial activity with a recommended surface contact time of 10 minutes at 20°. It can be used as a cleaner, as an ultrasonic cleaning solution, and for instrument immersion.

Resistance to Organics (Soils)

Including blood in all active ingredient efficacy testing is important because clinicians rarely deal with pure cultures of microorganisms. Clinically, microorganisms are usually contained within proteinaceous material such as blood, plaque, saliva, etc. Inclusion of these proteins in tests is important since these proteins interfere with the antimicrobial activity of disinfectants. For this reason, it is a good clinical practice--and a mandated labeling requirement from the EPA--to clean surfaces of gross debris prior to disinfection.

Material and Instrument Compatibility

High concentration alcohol-based

The ideal surface disinfectant produces negligible changes in appearance or function of medical devices and surfaces with which it comes into contact. It is non-corrosive to metals, adhesives, plastics, gloves, etc. Prolonged exposure to alcohol has been known to disrupt adhesives, damage seals, cause certain plastics to swell and harden, which could make them more brittle and prone to break.

Chlorine-based

One of the most damaging disinfectants is sodium hypochlorite. Dispatch is not recommended for use on aluminum surfaces. A 0.53% solution of sodium hypochlorite caused significant corrosion of a Schiotz tonometer including the metal components just after 24 hours of soaking, and significant damage was seen after 11 days of soaking. Another study on acupuncture needle sterilization with 5.25% sodium hypochlorite showed that the solution completely dissolved the needle after 30 minutes of exposure. The pH of Dispatch is at 12.2, which may further contribute to the corrosive activity of sodium hypochlorite, particularly to soft metals such as brass as well as to rubber and polyurethane.

Phenol-based

Phenolic compounds are more difficult to rinse from equipment than other disinfectants. Kahn reported that equipment and devices treated with phenols, particularly para-tertiary amyl phenol, caused depigmentation of the skin and injury to mucous membranes.

Glove Compatibility Study Results

The permeation of disinfectants through gloves can be indicative of the skin exposure to bloodborne pathogens as some chemicals degrade or even increase permeability of the glove material.

Glove permeation was tested according to the American Society of Testing and Materials (ASTM) method F73913. The three glove types were exposed to each disinfectant for approximately six hours. The active components in each disinfectant (Table 1), for which standardized methods exist, were detected using an HPLC, with the exception of Envirosafe. For Envirosafe, a UV detectable chemical was added to facilitate the detection with the HPLC, and controls were also performed where the detectable chemical was mixed with deionized water and checked for permeation.

The breakthrough time is the time required for the liquid to be transported through the glove and be detected by the HPLC, and represents the potential usable time. No skin exposure occurs if the glove is removed prior to the breakthrough detection time. Nitrile gloves of 0.011 cm thickness can resist permeation for longer than five hours for all except two products including Ascend and Coverage HB Concentrate. Latex and PVC gloves did not perform as well as nitrile. PVC gloves of 0.017 cm thickness persisted permeation for longer than five hours for Lysol I.C. Spray, Cavicide, and Envirosafe. The PVC gloves provided less than 18 minutes of protection from ProSpray, Coverage™ HB Concentrate, Coverage™ Spray, and Ascend. Powdered latex of 0.011 cm thickness lasted for over five hours for four products including Lysol I.C. Spray, CaviCide, Coverage™ HB Concentrate and Envirosafe. The powdered latex lasted less than 18 minutes for ProSpray (under 10 minutes), Birex (15 minutes), Coverage Spray (less than 13 minutes), and Ascend (18 minutes).

Since latex is one of the more commonly used types of gloves, the tear strength was tested to determine the force per unit required to pull the glove apart. After six hours of soaking at 30° C in each disinfectant, the tear test was measured using an automated machine, the Instron model 4467. The tests were performed according to the ASTM method D624 on the same powdered latex gloves that were tested for permeation above. Four glove specimens per disinfectant were cut and tested using the Die C shape, as described in the method. The glove samples were soaked in deionized water as a negative control, emulating the best-case scenario, and in mineral oil, which is known to deteriorate latex for the positive control.

From the tests, it could be seen that other than water, ProSpray performed the best, followed by Dispatch, Cavicide and Envirosafe. The product formulations that appear to most alter the tear strength of powdered latex gloves include Birex, Coverage™ Spray, and Wex-Cide.

Toxicity

All chemical substances will eventually permeate gloves given enough time, and therefore the toxicity of the surface disinfectant should also be considered. The following descriptions discuss toxicity based upon the category of disinfectant being evaluated.

Ethanol-Based
Ethanol can increase the volume of the polar pathway of the skin, thereby creating new pores, or expand the existing ones to result in increased permeability of the strateum corneum layer. Thus, ethanol-based products may be suspect to problems wherein the ethanol expands the pores allowing bacteria or dangerous chemicals to seep into the skin. Additionally, ethanol can dry the skin. Appropriate gloves should be worn and changed frequently enough to inhibit harmful chemicals or bacteria from penetrating into the skin via an ethanol medium.

Chlorine-Based
In 1994, the Clinton Administration announced a Clean Water Plan that could eventually eliminate chlorine and chlorine-based products due to the many hazards they entail. Sodium hypochlorite is an oxidizer that has been implicated in many household accidents and/or deaths, according to the American Association of Poison Control Center's annual reports. Additionally, special hazards exist when using sodium hypochlorite on surfaces previously treated with other germicides. Improper use may result in cross-contamination with acid-containing products such as toilet bowl cleaners or ammonia to create dangerous or fatal by-products. Furthermore, concentrations of sodium hypochlorite as small as .04% have been shown to elicit positive skin contact sensitivity responses in a clinically sensitized individual.

Phenol-Based
In 1994, the OEHHA (Office of Environmental Heath Hazard Association), which is a division of the US EPA, classified ortho-phenylphenol (OPP) as a carcinogen, and many studies have shown the cytotoxicity and genotoxicity of OPP19-23. OPP has been labeled by the EEC with risk phrase R36/38, indicating that it is irritating to the skin and eyes. There have been reported cases of allergic contact dermatitis, contact urticaria (hives) or of depigmentation of the skin. The phenol-based residue contamination on non-critical items after using a surface disinfectant can cause hazardous injury to tissue or mucous membranes with which they contact. Moreover, phenol-based products are limited in that they can not be used in the proximity of neonatal areas, particularly isolettes, or other infant contact surfaces.

Quaternary Amine or Quaternary Amine/low concentration alcohol-based
Quaternary amines such as benzalkonium chloride and benzethonium chloride are commonly used in small concentrations in after-dinner skin wipes, skin disinfectants as well as in ophthalmic, cosmetic and food preservatives. Alfredson et al. demonstrated that alkyldimethylbenzyl ammonium chloride (benzalkonium chloride) at .25% in the diet of rats over a two-year feeding period did not demonstrably affect the treated animals. The final report on the safety assessment of benzethonium chloride (diisobutylphenoxyethoxyethyl dimethylbenzyl ammonium chloride) and benzalkonium chloride has been issued by the CTFA (Cosmetic, Toiletry and Fragrance Association) and concluded that the compound is safe at concentrations of .5% and below in cosmetics applied to the skin, and safe at .02% for cosmetics used in the eye area. The quaternary amine products including Envirosafe, Coverage HB Concentrate, and Ascend are therefore safe at the use dilution. Cavicide and Coverage Spray are also safe if exposed to the skin since the quaternary amine levels are below the CTFA guidelines. Although quaternary amines are not as toxic as the previously mentioned active components, the glove pores may still be opened by the product components to allow permeation of bacteria.

Conclusion

Significant differences exist between the ten surface disinfectants examined including antimicrobial activity, toxicity, instrument corrosion and material and glove compatibility. The maintenance of a good barrier function of gloves requires regular changing and the proper selection of glove material for the surface disinfectant being used. Universal precautions, such as changing gloves after each patient contact and thorough handwashing after using gloves, should be carefully observed. No-touch techniques and choosing the right glove for the particular surface disinfectant decrease the possibility of microorganisms in blood or toxic chemical contact during surface disinfection.

Lauren Crawford, BS is a research chemist with over three years of infection control experience at Sybron Dental Specialties (Orange City, CA).

Zhi-Jian Yu, PhD is a senior scientist at SDS who is a surface science expert with over 25 publications in top surface science journals and over five years of industrial experience in infection control.

Tina Yu, MS is a research chemist at SDS.

Erin Keegan, BS is a technical representative at SDS who oversees the correct use of infection control products.
