THE DENTAL ADVISOR
Improving Patient Care Through Research & Education

TRANSLATING THE SCIENCE
Number 27 - January 2016
www.dentaladvisor.com

Environmental Surface Cleaning and Disinfection: Effects of Alcohol Concentration

John A. Molinari, Ph.D. and Peri Nelson, B.S. | Dental Consultants, Inc., Ann Arbor, Michigan

INTRODUCTION

Infection prevention programs for health care facilities include environmental surface cleaning and disinfection as fundamental components. The use of chemical disinfectants is warranted in certain instances because it is neither necessary nor possible to sterilize all contaminated items and surfaces after provision of patient care. The importance of environmental asepsis is evident as reported clinical outbreaks have been increasing involving microbial transmissions from environmental surfaces in hospital settings.[1] As examples, recent investigations indicated that contaminated surfaces played important roles in epidemic and endemic transmission of Clostridium difficile, methicillin-resistant Staphylococcus aureus, norovirus, vancomycin-resistant enterococci (VRE) infections, and multidrug-resistant (MDR) gram-negative rods.[2,3]

Many types of treatment surfaces in dental settings typically become contaminated with blood, saliva, and exudate during patient care. While at the present time there are no data confirming cross-infection from dental environmental surfaces, a number of bacteria, viruses, and fungi are able to survive on counter tops, trays, hoses, tubing, handles, and other inanimate items for extended intervals. Included are two bloodborne viruses of major importance in dentistry and medicine, hepatitis B virus (HBV) and hepatitis C virus (HCV). Both are able to remain infectious for prolonged periods on inanimate surfaces (HBV for 1 week; HCV up to 6 weeks). In addition, readily transmissible respiratory viruses such as influenza and rhinoviruses are also able to survive for hours or even days after cross-contamination from nasal secretions on countertops, door handles, and other surfaces.[4,5]

. . . high-alcohol disinfectants were unable to consistently and effectively remove debris from surfaces . . .

Since multiple types of inanimate surfaces in dental and medical treatment areas become coated and contaminated with saliva, blood, exudate, and other secretions, the need for effective surface asepsis either by use of surface barrier covers or chemical disinfectants cannot be minimized. A variety of EPA-regulated and registered products are available to accomplish surface disinfection, with more formulations appearing each year. Selection of an acceptable chemical disinfectant should involve comparing clinical application and limitations to properties of an "ideal" disinfectant **(Table 1).**[6]

Table 1. Properties of an Ideal Disinfectant

BROAD SPECTRUM:
- Should always have the widest possible antimicrobial spectrum

FAST-ACTING:
- Should always have rapid lethal action on all vegetative forms of bacteria, fungi, viruses.

NOT AFFECTED BY PHYSICAL FACTORS

NONTOXIC:
- Active in the presence of organic matter such as blood, sputum, and feces.

NON-ALLERGENIC

SURFACE COMPATIBILITY:
- Should not compromise integrity of dental equipment and metallic surfaces
- Should not cause the disintegration of cloth, rubber, plastics, or other materials

RESIDUAL EFFECT ON TREATED SURFACES

EASY TO USE

ODORLESS:
- An inoffensive odor would facilitate its routine use

ECONOMICAL

It is important to note here that instructions for surface disinfectants include a recommendation that products be used on clean surfaces. Cleaning is defined as the removal of visible soil or debris that results in the reduction in the number of microorganisms and removal of organic matter. It is an important first step in any sterilization or disinfection process. A number of chemical classes are available for disinfection, including quaternary ammoniums, alcohols, hydrogen peroxide, phenols, chlorine-containing agents, and iodophors. Many formulations contain a specific concentration of either isopropyl or ethyl alcohol, in addition to other antimicrobials. Although alcohols have historically been demonstrated to act as effective broad-spectrum antimicrobial agents, they have also been shown to be poor cleaning agents in the presence of bioburden. Examination of the labels on alcohol-containing surface disinfectants also indicates a wide range of available concentrations.

. . . residual bioburden limits alcohol effectiveness by protecting protein-coated bacteria from the destructive effects of the chemical . . .

A logical question arises. What effect does alcohol composition play in accomplishing environmental asepsis? The present study therefore investigated the effect that a disinfectant's alcohol concentration could have on cleaning and antimicrobial activity in a controlled contaminated environment.

MATERIALS AND METHODS

Disinfectants used in this investigation contained different concentrations of alcohol as the main antimicrobial component **(Table 2)**. These products were selected in order to study possible differences in cleaning and disinfection efficacy between low- and high alcohol-containing formulations. Bacterial suspensions of stock methicillin-resistant *Staphylococcus aureus* (MRSA) ATCC #33591 were prepared aerobically by culturing bacteria in trypticase soy broth at 37C for 48 hours. Freshly collected heparinized human blood was diluted using sterile saline to yield 10% and 50 % preparations. Whole blood served as the 100% blood suspension. Experimental contaminated soil was subsequently prepared by adding 0.5 mL of bacterial culture into each blood suspension (10, 50, and 100%). These 3 bioburden samples were then used to coat experimental environmental surfaces by adding 0.2 mL of fluid onto 2x2 in. laminated countertop tiles. The material was spread over the surface using sterile cotton swabs, and allowed 1 hour to dry at room temperature **(Figure 1).**

Disinfectant wipes were applied onto tiles with consistent mechanical force and wiped 3-5 times. The experimental spray disinfectant, Lysol IC III Disinfectant Spray, was sprayed 2-3 times onto test surfaces before wiping 3-5 times with sterile 4x4 in. gauze. Tiles treated with disinfectants were then allowed to remain in contact with applied liquid for the manufacturers' recommended intermediate-level disinfection (i.e. tuberculocidal) interval. They were subsequently replica plated onto trypticase soy agar plates containing 5% sheep blood and incubated at 37C for 24 hours. Positive, control blood tiles (no cleaning or disinfection procedures) were also replica plated.

Table 2. Disinfectants tested with corresponding alcohol contents and recommended intermediate-level disinfection exposure times

- ***Caviwipes*** *(Total Care)*
  – 17.2% isopropyl alcohol – 3 minutes
- ***Super Sani-Cloth*** *(Professional Disposables)*
  – 55.0% isopropyl alcohol – 2 minutes
- ***Lysol III Disinfectant Spray*** *(Reckitt Benckiser)*
  – 58% ethyl alcohol – 10 minutes
- ***Discide*** *(Palmero)*
  – 63.25% isopropyl alcohol – 1 minute

RESULTS

The first property evaluated for the 4 disinfectant preparations was their ability to clean visibly soiled, hard surfaces. Cleaning of tiles coated with 10%, 50%, and 100% bacteria/blood contaminated surfaces was found to be best accomplished when *Caviwipes* were used. Virtually all visible soil was removed on tiles wiped with this low-alcohol containing disinfectant **(Figure 2).** In contrast, while cleaning was noted on tiles coated with 10% bacteria/blood suspensions after wiping with *Discide, Super Sani-Cloth, and Lysol III Disinfectant Spray,* the high-alcohol disinfectants were unable to consistently and effectively remove debris from surfaces coated with 50% and 100% contaminated bioburden. Most of the debris remained after wiping procedures **(Figure 3).**

Growth patterns of MRSA were also studied after applied disinfectants were allowed to remain in contact with tile surfaces for the tuberculocidal contact times. Data from these cultures were compared to replica plate controls. The latter yielded confluent microbial growth from untreated bacteria/blood tiles after 24 hour incubation **(Figure 4).** When contaminated tiles were treated and subsequently cultured on blood agar media, detectable MRSA levels were found to vary greatly between those specimens exposed to the low-alcohol formulation and treated with high-alcohol disinfectants. Few, if any bacteria were found on surfaces after cleaning and disinfection using *Caviwipes,* a low-level alcohol disinfectant **(Table 3; Figure 5).** In contrast, higher microbial counts were noted following treatment with the 3 disinfectants containing high concentrations of alcohol *(Super Sani-Cloth, Discide, Lysol III Disinfectant Spray)* **(Table 3; Figure 6).**

DISCUSSION

A predominant mode of action for the historical antibacterial effectiveness noted for ethyl and isopropyl alcohols is their interaction with microbial proteins to cause dehydration and denaturation. These effects in turn lead to associated disruption of bacterial cytoplasmic integrity, cell lysis, and interference with microbial metabolism. Unfortunately, these positive chemical properties present problems for alcohol applications on soiled environmental surfaces. Alcohols are poor cleaning agents in the presence of bioburden.[7] Following exposure to alcohol, denatured bioburden becomes more insoluble and tenaciously adherent onto most surfaces. As a result, initial cleaning prior to disinfection is not accomplished. In addition, the residual bioburden limits alcohol effectiveness by protecting protein-coated bacteria from the destructive effects of the chemical.

The present study evaluated the ability of 4 surface disinfectants containing alcohol to clean environmental surfaces coated with organic debris and kill vegetative bacteria in 10, 50, and 100% blood suspensions. The findings showed that *Caviwipes,* which contains 17.2% isopropyl alcohol, was able to both clean visibly soiled tiles and effectively kill MRSA on those surfaces. In contrast, the overwhelming majority of debris remained adherent on bioburden-laden tiles after exposure to the 3 disinfectants with a high alcohol component (55.0-63.25%). Replica plate cultures from those treated tiles also yielded bacterial counts that were substantially higher than those detected with *Caviwipes.* The differences were especially noteworthy when surfaces coated with 50% and 100% MRSA-contaminated blood were sampled after disinfectant exposure.

CONCLUSION

The data reported from the present study suggest that the concentration of alcohol in a disinfectant has an important impact on the product's ability to clean soiled environmental surfaces. The formulations with high alcohol concentrations were unable to achieve the initial cleaning step in the process when challenged with organic debris on the tiles. This was not unexpected. Manufacturers' instructions specifically recommend that soiled surfaces be cleaned before application of a disinfectant. Cleaning solutions should include a water-based formulation, such as that found with *Caviwipes*.

Table 3. Detectable MRSA remaining on treated surfaces allowed to remain wet for product intermediate-level disinfection periods.

Disinfectant/Contact Time	Specimen Type	10% Blood (cfu)*	50% Blood (cfu)*	100% Blood (cfu)*
Caviwipes (3 min.)	Untreated Controls	4,704	3,504	3,172
	Treated	0.4 (0-1)	0.2 (0-1)	0.2 (0-1)
Discide (1 min.)	Untreated Controls	5,096	3,964	3,416
	Treated	5 (0-12)	68 (1-138)	268 (104-395)
Super SaniCloth (2 mins.)	Untreated Controls	4,136	3,604	3,120
	Treated	0.6 (0-2)	98.6 (15-256)	69 (18-180)
Lysol III Spray (10 mins.)	Untreated Controls	4,612	3,736	3,816
	Treated	17 (5-28)	76.6 (25-162)	427.2 (276-637)

*cfu (colony forming units)

Figure 1. Positive control tiles coated with suspensions of blood and MRSA: A) 10% dilution, B) 50% dilution, C) 100% whole blood

Figure 2. Cleaned tiles after removal of bacteria-blood soil with *Caviwipes*: A) 10% dilution, B) 50% dilution, C) 100% whole blood

Figure 3. Remaining surface bioburden contamination from tile surfaces representative of treatment after use with tested high alcohol disinfectants: A) 10% dilution, B) 50% dilution, C) 100% whole blood

Figure 4. Representative MRSA replica plate culture from an untreated bacteria/blood bioburden-contaminated tile.

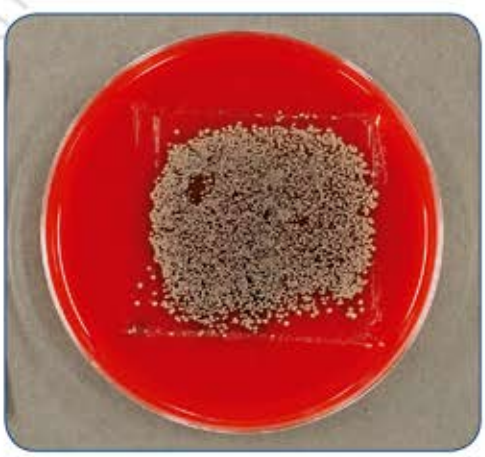

Figure 5. Detectable MRSA on representative replica plate cultures after cleaning procedures and 3 minute intermediate-level disinfection exposure interval using Caviwipes. Note that only a single bacterial colony was found after treatment of a tile originally coated with bacteria mixed with: a) 10%; b) 50%; and c) 100% blood.

Figure 6. Detectable MRSA on representative replica plate cultures after cleaning procedures and 10 minute intermediate-level disinfection exposure interval using Lysol III Disinfectant Spray on tiles originally coated with bacteria mixed with: a) 10%; b) 50%; and c) 100% blood.

REFERENCES:

1. Otter, JA, Yezli, S, Salkeld, JAG, et al. Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings. *Am J Infect Control* 2013; 41:S7-S11.

2. Otter, JA, Yezli, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hosp Epidemiol* 2011:32:687-699.

3. Nseir S, Blazejewski C, Lubret R, et al. Risk of acquiring multidrug-resistant gram negative bacilli from prior room occupants in the ICU. *Clin Microbiol Infect* 2011; 17:1201-1208.

4. Bean B, Moore BM, Sterner B, et al. Survival of influenza viruses on environmental surfaces. *J Infect Dis* 1982; 146:47-51.

5. Gwaltney JM, Hendley JO. Transmission of experimental rhinovirus infection by contaminated surfaces. *Am J Epidemiol* 1982; 116:828-833.

6. Molinari JA, Campbell MD, York J. Minimizing potential infections in dental practice. *J Michigan Dent. Assoc* 1982; 64:411–416.

7. Ali YA, Dolan MJ, Fendler, EJ, et al. Alcohols. In Block SS, ed. Disinfection, Sterilization, and Preseervation (5th Edition). Philadelphia, PA. Lippincott Williams & Wilkins; 2001: 229-253.