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Ophthalmic Technology Assessment

Disinfection of Tonometers

A Report by the American Academy of Ophthalmology

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Objective: To examine the efficacy of various disinfection methods for reusable tonometer prisms in eye care and to highlight how disinfectants can damage tonometer tips and cause subsequent patient harm.

Methods: Literature searches were conducted last in October 2016 in the PubMed and the Cochrane Library databases for original research investigations. Reviews, non-English language articles, nonophthalmology articles, surveys, and case reports were excluded.

Results: The searches initially yielded 64 unique citations. After exclusion criteria were applied, 10 laboratory studies remained for this review. Nine of the 10 studies used tonometer prisms and 1 used steel discs. The infectious agents covered in this assessment include adenovirus 8 and 19, herpes simplex virus (HSV) 1 and 2, human immunodeficiency virus 1, hepatitis C virus, enterovirus 70, and variant Creutzfeldt-Jakob disease. All 4 studies of adenovirus 8 concluded that after sodium hypochlorite (dilute bleach) disinfection, the virus was undetectable, but only 2 of the 4 studies found that 70% isopropyl alcohol (e.g., alcohol wipes or soaks) eradicated all viable virus. All 3 HSV studies concluded that both sodium hypochlorite and 70% isopropyl alcohol eliminated HSV. Ethanol, 70% isopropyl alcohol, dilute bleach, and mechanical cleaning all lack the ability to remove cellular debris completely, which is necessary to prevent prion transmission. Therefore, single-use tonometer tips or disposable tonometer covers should be considered when treating patients with suspected prion disease. Damage to tonometer prisms can be caused by sodium hypochlorite, 70% isopropyl alcohol, 3% hydrogen peroxide, ethyl alcohol, water immersion, ultraviolet light, and heat exposure. Disinfectants can cause tonometer tips to swell and crack by dissolving the glue that holds the hollow tip together. The tonometer tip cracks can irritate the cornea, harbor microbes, or allow disinfectants to enter the interior of the tonometer tip.

Conclusions: Sodium hypochlorite (dilute bleach) offers effective disinfection against adenovirus and HSV, the viruses commonly associated with nosocomial outbreaks in eye care. Tonometer prisms should be examined regularly for signs of damage. *Ophthalmology 2017;■:1–9 © 2017 by the American Academy of Ophthalmology*

The American Academy of Ophthalmology prepares Ophthalmic Technology Assessments to evaluate new and existing procedures, drugs, and diagnostic and screening tests. The goal of an Ophthalmic Technology Assessment is to review systematically the available research for clinical efficacy and safety. After review by members of the Ophthalmic Technology Assessment Committee, other Academy committees, relevant subspecialty societies, and legal counsel, assessments are submitted to the Academy's Board of Trustees for consideration as official Academy statements. The purpose of this assessment by the Ophthalmic Technology Assessment Committee Glaucoma Panel is to investigate the disinfection methods for reusable tonometer prisms in eye care.

Background

Terminology

Cleaning, Disinfection, and Sterilization. Any procedure that involves contact of a medical device or surgical instrument with the patient's ocular surface may pose a risk for introducing infectious agents. Failure to disinfect or sterilize equipment may lead to the transmission of pathogens from either the environment or another person. Prevention of iatrogenic infection is based on a process of cleaning and then sterilizing or disinfecting reusable medical equipment. *Cleaning*, defined by the Centers for Disease Control and Prevention (CDC), is the removal of visible soil

http://dx.doi.org/10.1016/j.ophtha.2017.05.033
ISSN 0161-6420/17

using water with detergents or enzymatic products. This process is followed by *sterilization*, the complete removal or destruction of all forms of microbial life, or by disinfection. The *disinfection* process eliminates many or all micro-organisms except bacterial or fungal spores. The efficacy of both sterilization and disinfection is affected by many factors: prior cleaning methods; the nature of the instrument or device (e.g., material properties; presence of a lumen, crevices, or both); the presence of biofilm on the device; the temperature, pH, and exposure time used; and in some cases, the humidity of the agent used to disinfect or sterilize.[1,2]

Critical, Semicritical, and Noncritical Devices. A classification system first devised by Spaulding in 1968[3] divides instruments for patient care into critical, semicritical, and noncritical categories, based on the risk of infection. *Critical* devices carry a high risk of infection if contaminated with any micro-organism. This category includes surgical instruments, implants, and needles for venipuncture or intravitreal injection. Instruments in this category either should be steam sterilized or purchased sterile. *Semicritical* instruments are defined as devices that come in contact with intact mucous membranes or nonintact skin. Intact mucous membranes generally are resistant to infection by common bacterial spores, but are susceptible to more virulent infectious agents. The CDC considers applanation tonometers to be semicritical devices.[1] Cleaning, followed by high-level disinfection, should eliminate enough pathogens to prevent transmission of infection as recommended by the CDC.[1] The CDC defines germicides as chemicals that inactivate all microbial pathogens, except large numbers of bacterial and fungal spores, as high-level disinfectants provided they are used according to the label. High-level disinfectants can be considered sterilants when used under the same contact conditions except for a shorter contact time.[2] The CDC considers high-level disinfection with a sterilant cleared by the United States Food and Drug Administration as the minimum requirement for the reuse of semicritical instruments. *Noncritical* items come in contact with intact skin, but not mucous membranes.[3]

Commonly Used Chemical Disinfectants in Eye Care

Ideally, the tonometer disinfection process should cover a broad antimicrobial spectrum; should act rapidly; should not damage the tonometer tip; and should be nontoxic to the user, patient, and environment. Three groups of commonly used disinfectants in eye care include alcohols, chlorine, and hydrogen peroxide.

Alcohols. Seventy percent isopropyl alcohol and 70% ethyl alcohol can be rapidly germicidal against bacteria, fungi, and viruses by denaturating proteins, but these disinfectants do not destroy bacterial spores. Both 70% isopropyl and 70% ethyl alcohol can inactivate human immunodeficiency virus (HIV), and 70% isopropyl alcohol kills *Acanthamoeba* cysts effectively. The CDC does not recommend alcohols for sterilizing medical and surgical materials because alcohols lack sporicidal action and they are not able to penetrate protein-rich materials.[1] The Food and Drug Administration does not consider alcohols or dilute bleach to be high-level disinfectants.[2]

Chlorine and Chlorine Compounds. Dilute bleach is a ubiquitous disinfectant. Dilute bleach is used in 1:10 and 1:20 concentrations for disinfection. Bleach has a broad spectrum of antimicrobial activity, does not leave toxic residues, is not affected by water hardness, and acts fast. Bleach oxidizes cell membranes and denatures proteins, which leads to loss of structure and cell lysis. Dilute bleach is biocidal against HIV, bacteria, bacterial spores, mycoplasma, mycobacterium tuberculosis, and fungi.[1]

Hydrogen Peroxide. Hydrogen peroxide's germicidal effect is attributed to destructive hydroxyl free radicals that oxidize membrane lipids, DNA, and other essential cell components.[1] Anaerobic and facultative anaerobes may be resistant to hydrogen peroxide in low concentrations.[1] Ten percent hydrogen peroxide deactivates a wide range of micro-organisms, including *Acanthamoeba* cysts, bacteria, yeasts, fungi, viruses, and spores.[1]

Damage to Tonometer Tips Caused by Disinfectants

All disinfectants, including dilute bleach, hydrogen peroxide, isopropyl alcohol (wipes or soaks), ethyl alcohol, prolonged soaking, heat (temperatures of more than 60°C), and ultraviolet light, have been identified as causing tonometer prism damage and may result in patient injury.[4–10]

Lingel and Coffey[7] conducted laboratory experiments studying damage to tonometers caused by disinfection using 1:10 dilute bleach, 3% hydrogen peroxide, and 70% isopropyl alcohol soaks. Three tonometer prisms each were soaked for 2 hours at a time, 4 times daily, 5 days weekly, for a total of 3 weeks. After each disinfecting soak, tonometers were rinsed with distilled water, dried with cotton, and inspected at a biomicroscope to grade for visual appearance and clarity. Tonometer damage by these 3 disinfectant soaks was compared with tonometer damage by 70% isopropyl alcohol wipes followed by a saline rinse. The tonometer prisms were noted to swell after disinfectant soaks. The increased diameter made it difficult to reinsert the tonometer prism into the holder. However, this did not affect intraocular pressure measurements. Seventy percent isopropyl alcohol soaks caused the most severe damage to the prisms, both to the glued parts and the prism surface, rendering them unusable for applanation after 4 days. Seventy percent isopropyl alcohol wipes caused damage to the glued ring structure of the prism, but did not affect accuracy. Soaking in both dilute bleach and 3% hydrogen peroxide left a hazy film over the prism surface. The film could be removed mechanically with a hard contact lens cleaner, but prisms soaked in dilute bleach retained a blue glow that diminished only after 3 weeks of air drying.

In summary, all disinfectants inevitably affect the glue that holds the hollow tip together and cause cracks in the rim of the tonometer tips. These cracks can irritate the cornea, harbor microbes, or allow disinfectants to get into the interior of the tonometer tip. The disinfectants then can leak