Re-Visiting Disinfectants for the Ophthalmologist

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Abstract :

When Joseph lister used carbolic acid in the treatment of surgical wounds & reported remarkably lower incidence of infections, he ushered in the era of disinfectants and asepsis. Subsequently, use of alcohols, bleach was discovered. Since then, having come a long way in the use of disinfectants & now we have good number of disinfectants in the health industry. Most new commercial brands introduced have combinations of these disinfectants.

Their use in the clinics has been pushed to the fore by the current Covid-19 epidemic. This article attempts to revise the various steps used in the journey to asepsis, list different disinfectants used in health care, the rationale behind their use & advantages & disadvantages of each.

Prevention of cross infection from patients to the physician, from one patient to another and from physician to patient is of utmost importance in clinics, hospitals & health care setups. Disinfection even in the clinic, though always a standard of care, has never been pushed to the forefront of medical discussion as much as it has been during the current pandemic of Covid -19. Transmissibility from asymptomatic patients, ability of the virus to remain alive on fomites for prolonged periods of time and rapid spread of the disease are reasons why clinicians all over the globe are looking closely at disinfection in the OPD. Different brands have suddenly sprouted in the market with claims of killing Corona Virus. Do we need anything different from what we have always done? Through this article, different chemical disinfectants which are currently used, their microbicidal activity & use in ophthalmic setting is analysed.

What is the difference between cleaning, disinfection & sterilisation?

Cleaning: It is removal of organic & inorganic debris from clinical instruments, areas & surfaces.

Disinfection: It is the process of eliminating microbes except spores from inanimate objects.

Sterilisation: It is the process of complete elimination of all forms of microbial life including spores.

Cleaning:

Cleaning is usually achieved with mechanical processes with/ without detergent effect, & removes organic/inorganic matter persistence of which, helps proliferation of bacteria. Cleaning decreases the load on disinfectants.

Also, efficacy of certain disinfectants is decreased in the presence of organic matter. Cleaning before disinfecting/ sterilising increases efficiency.

Water, soap/detergents are common cleaning agents.

Some agents perform both, cleaning & disinfection, at specific concentrations. (Sodium hypochlorite @0.1% & above, isopropyl alcohol & Ethyl alcohol @ 70% & above).

Some other cleaning agents are:

Bleaching powder (Calcium Hypochlorite)
Ammonia solution
Tetrachloroethylene (drycleaning)

Disinfection:

Antimicrobials used on inanimate surfaces – usually liquids – are called "disinfectants".

Antimicrobials used in living tissue like skin or mucous membrane are called "antiseptics".

The order of resistance of microorganisms to disinfectants from most resistant to least resistant is:

Prions>Cryptosporidium oocysts>Bacterial spores> Mycobacteria>Parasite cysts> Small non enveloped viruses> Trophozoites>Gram negative bacteria>Fungii>Large non–enveloped viruses >Gram positive bacteria> Enveloped viruses.

Depending on the extent & type of microbicidal activity involved, three levels of disinfection are recognised.

Table 1- Classification of Disinfectants.

level of disinfectant	Bacterial & Fungal spores	Mycobacteria	Nonenveloped virus	Fungii	Enveloped Viruses	Vegetative Bacteria	Examples
Low level	No	No	No	+/-	Yes	Yes	Quaternary ammonium compounds
Intermedia-te level	No	Yes	+/-	Yes	Yes	Yes	Isopropyl alcohol
High level	Maybe	Yes	Yes	Yes	Yes	Yes	Glutaraldehyde
Chemical Sterilant	Yes	Yes	Yes	Yes	Yes	Yes	Glutaraldehyde

Some high level disinfectants, on prolonged exposure, are sporicidal & are also called chemical sterilants.

Factors affecting disinfection:

Type & size of microbial load, exposure time, concentration & microbicidal range of disinfectant, nature of the object (material, lumen, crevices etc), pH, presence of organic matter are some factors which affect efficacy of the disinfectant.

In 1968, Earle H. Spaulding[1] proposed that based on the risk of transmitting infection, reusable instruments & objects of patient care could be categorised into critical, semi critical & non-critical & then matched to methods of sterilisation& disinfection.

Table 2- Spaulding's Classification of Medical Devices

Medical Devices	Definition	Recommended Sterilisation/ Disinfection	examples
Critical	Very high risk of transmitting infection if contaminated	Sterilisation	Surgical Instruments, IOLs, Glaucoma Implants
Semi-Critical	Comes into contact with mucous membrane &/or Non-intact skin	High Level Disinfection	Tonometer tips, Tips of Ultra sound Pachymeter probes, Gonioscopes, Contact laser lenses
Non-critical	Comes into contact with intact skin.	Intermediate or low level disinfection	Trial frames, trial lenses, BP cuffs, slit lamps,
Non critical surfaces	Very little direct contact with patient	low level disinfection	switches, tables, patient chairs, OPD floors

Abbreviations : IOL-Intraocular lens, BP-blood pressure

Chemical Disinfectants commonly used are :

- Alcohol.
- Chlorine and chlorine compounds.
- Formaldehyde.
- Glutaraldehyde.
- Ortho-phthalaldehyde (OPA)
- Hydrogen peroxide.
- Phenols
- Iodophors.
- Peracetic acid.

Alcohols:

Ethyl & Isopropyl alcohol are commonly used alcohol disinfectants.

Alcohols are anti microbials because of their ability to cause denaturation of protein. Water enhances the efficacy of alcohols by causing quicker denaturation of proteins and increasing the contact time by delaying evaporation. [2,3] Hence, absolute ethyl alcohol is less bactericidal than a mixture of alcohol and water. Their efficacy decreases in presence of protein rich material. The optimum concentrations of ethyl & isopropyl alcohol are 60-90% diluted in water. [3,4] They are not sporicidal.[5] Ethyl alcohol does not inactivate hepatitis A virus[6] or the polio virus. [7] Alcohols are very effective against lipophillic viruses but not all hydrophillic viruses.[8]

Alcohol disinfectants & tonometer tips:

Of the studies which evaluated tonometer disinfection against adenovirus, all studies that tested 1:10 dilute bleach concluded that it was effective against adenovirus.[9,10,11,12] Four studies tested 70% isopropyl alcohol as a disinfectant for adenovirus.[8] Two of these studies [9,10] found that 70% isopropyl alcohol and 3% hydrogen peroxide were effective against adenovirus,[8] but these used lower virus concentrations & immediately wiped adenovirus [8] from the tip. Two other adenovirus studies demonstrated that 70% isopropyl alcohol and 3% hydrogen peroxide were not effective in eliminating adenovirus. In summary, studies suggest that elimination of adenovirus is best achieved by using 1:10 dilution sodium hypochlorite. Use of 70% isopropyl alcohol (e.g., alcohol wipes) is not sufficient to eliminate adenovirus (especially in desiccated form or at high concentrations)

Ethyl alcohol 60% & isopropyl alcohol 75% formulations inactivate SARS-CoV-2. [13,14]

Table 3- Overview of Commonly used Disinfectants:

Disinfectant	Concentration	Level of disinfectant	Recommended exposure time	used for	Advantages	Disadvantages
Glutaraldehyde	2%	High / CS	-20 min 3-12 hours for spores	-Surgical instruments used for septic cases. -Surface disinfection in OT. Gonioscope disinfection -Disinfecting fiberoptic scopes	-Relatively inexpensive. -Excellent material compatibility including optical instruments like endoscopes.	-Requires activation. -Odour. -Irritant to the eyes. -Slow mycobacteri -cidal activity
Orthopthaldehyde OPA	0.55%	High / CS	12min but longer for spores.	same as glutaraldehyde	-No odour. -Faster mycobactericidal activity. -Excellent material compatibility.	-Slow sporicidal. -Stains skin & mucous membranes. -More expensive -Irritant to the eyes
sodium Hypochlorite	1% 500 ppm.	High		tonometer tips, Gonioscopes Laser lenses Surface disinfection	Cheap. Easily available. Fast acting.	-Corrodes metals. -Has to be freshly made.
Hydrogen Peroxide	3-25%	High	5 min-few hours (for sporicidal effect)	Contact lenses. Tonometer tips. Surface disinfection.	-Easily available -Decompose into harmless products	Incompatible with certain metals. -Corneal toxicity if not rinsed off.
Quaternary ammonium compounds	0.1-2	Low	few seconds to minutes.	Disinfecting floor, furniture, walls	-No functional or cosmetic damage to surfaces.	-
Isopropyl alcohol	60-75%	interme-diate	few seconds to minutes	Hand rubs. Wiping surfaces of equipments like slit lamp. Alcohol wipes for Pachymeter probes, tonometer tips. (not FDA recommended)	-Easily available. -Non corrosive.	Does not inactivate Polio, hepatitis A virus. Rapid evaporation.
Peracetic acid	0.2%	High	30-45 min for disinfection 6 hours for sterilisation	-Surgical instruments used for septic cases. -Disinfecting fiberoptic	-Faster -Sporicidal at low temperatures	-More expensive -Corrosive towards metals. -Eye irritant

Chlorine & Chlorine Compounds:

Hypochlorites& among them ,sodium hypochlorite (NaOCl), is

the most widely used chlorine disinfectant. Sodium hypochlorite is bactericidal, virucidal, fungicidal, mycobactericidal.

In water, NaOCl forms hypochlorous acid (HOCl) & hypochlorite ion. The microbicidal activity, however, is mainly due to Cl–in hypochlorous acid. [17,18.]

Other compounds that release chlorine and are used in the health-care are demand-release chlorine dioxide, sodium dichloroisocyanurate, and chloramine-T. The advantage of these compounds over the hypochlorites is that because chlorine is retained longer they exert a prolonged bactericidal effect.

Use

Sodium Hypochlorite solution is used for disinfecting tonometer heads[20] and for disinfection of countertops and floors. Its role in disinfection has been brought to the fore in the current pandemic. 1% solution of sodium hypochlorite is recommended for disinfection of health care facilities particularly for surface cleaning. The prepared solution can be used for 24 hours. For small spills of blood on noncritical surfaces, the area can be disinfected directly with sodium hypochlorite. Because hypochlorites and other germicides are less effective in the presence of organic matter, [21, 22,23,24,] for large spills of blood the surface should be cleaned before disinfecting with 1:10 solution of Sodium Hypochlorite .[25]

However Sodium Hypochlorite is corrosive to metals & releases chlorine gas when mixed with ammonia or acids.

Formaldehyde

It is an aldehyde and used in healthcare as a 100% saturated solution of formaldehyde in water which is 37% formaldehyde by weight. It has to be diluted to 2-8% solution for disinfection and 2% for air fumigation.

The aqueous solution is bactericidal, tuberculocidal, fungicidal, virucidal and sporicidal. [26, 27, 28] and is a high level disinfectant.

Though formaldehyde is cheap, easily available & a high-level disinfectant, because of its irritating fumes, odour, dermatitis & asthma like respiratory symptoms caused by long term exposure & its role as a suspected human carcinogen in nasal cancer and lung cancer, its use is now restricted [29]

Glutaraldehyde

Glutaraldehyde is bactericidal, tuberculocidal, fungicidal, virucidal and sporicidal. It is a chemical sterilant & high level disinfectant . Aqueous solutions of glutaraldehyde are acidic & not sporicidal. Alkalinating agents which increase the pH to 7.5-8.5 make the solution sporicidal. This process is called "activation". However, the biocidal effectiveness of activated glutaraldehyde diminishes because of polymerization of active sites at alkaline pH.

Glutaraldehyde has good compatibility with surfaces, is noncorrosive to metal and does not damage optical instruments, rubber or plastics. It can however cause respiratory irritation & contact dermatitis. It also fixes organic tissue to surfaces.

Ortho-phthalaldehyde

Ortho-phthalaldehyde (OPA 0.55%) is also an aldehyde & is bactericidal, tuberculocidal, fungicidal, virucidal. Sporicidal effect is improved if pH is increased to 8. It is a high-level disinfectant.

OPA has superior mycobactericidal activity to glutaraldehyde but inferior sporicidal effect.

Uses are similar to glutaraldehyde but OPA has some advantages over glutaraldehyde. It does not require activation & is stable over a wide range of pH(3–9). OPA, like glutaraldehyde, has excellent material compatibility & does not damage optical instruments. But it stains skin & mucus membranes gray and should be handled carefully.

Hydrogen Peroxide:

Hydrogen peroxide is active against bacteria, yeasts, fungi, viruses, and spores .[31,32]

7% stabilized hydrogen peroxide proved to be sporicidal (6 hours of exposure), mycobactericidal (20 minutes), fungicidal (5 minutes) at full strength, virucidal (5 minutes) and bactericidal (3 minutes) at a 1:16 dilution. [33]

Commercially available 3% hydrogen peroxide is a stable and effective disinfectant when used on surfaces. It has been used in concentrations from 3% to 6% for disinfecting soft contact lenses (3% for 2–3 hrs) & tonometer biprisms. [34]

Iodophors

Iodophors are a combination of iodine and an agent, providing a sustained-release reservoir of iodine and release small amounts of free microbicidal iodine.

Povidone-iodine (polyvinylpyrrolidone with iodine) is the most commonly used Iodophor.

Iodophors are bactericidal, mycobactericidal, and virucidal but can require prolonged contact times to kill certain fungi and bacterial spores. They are used as antiseptics & disinfectants.

Dilution of Povidone-iodine, weakens the iodine linkage & increases availability of free iodine in solution causing more rapid bactericidal action than a full-strength solution 680. Therefore, iodophors must be diluted in water according to the manufacturers' directions. Most PVP-I used for medicine is standardized to deliver between 0.5 percent and 1.0 percent free molecular iodine on dissolution. Thus the common pre–surgical 10 percent Betadine actually delivers about 1 percent of biocidal, free molecular iodine.

It is non toxic, stable & non irritating to the skin.

Phenols.

Phenol & its derivatives have been used for surface disinfection. Manufacturers' data demonstrate that commercial phenolics are not sporicidal but are tuberculocidal, fungicidal, virucidal, and bactericidal at their recommended use-dilution. Published reports show variable microbicidal activity. Many phenolic germicides are used as disinfectants on environmental surfaces (e.g., bedside tables, bedrails, and laboratory surfaces) and noncritical medical devices. Phenolics are not FDA-cleared as high-level disinfectants for use with semicritical items.

Peracetic Acid

Peracetic acid is a strong oxidising agent & is bactericidal, viricidal, fungicidal & sporicidal. Advantages of peracetic acid are that it lacks harmful decomposition products (i.e., acetic acid, water, oxygen, hydrogen peroxide), enhances removal of organic material, and leaves no residue. It remains effective in the presence of organic matter and is sporicidal even at low temperatures Peracetic acid can corrode copper, brass, bronze, plain steel, and galvanized iron. It is considered unstable, particularly when diluted; a 1% solution loses half its strength through hydrolysis in 6 days [42]

Quaternary Ammonium Compounds.

These compounds are widely used in the health industry. Some of them are benzalkonium chloride, cetrimonium, cetrimide.

They are bactericidal, fungicidal, and viricidal against enveloped virus but not mycobactericidal, sporicidal. They do not destroy non-enveloped viruses. Hard water decreases their effectiveness. Quaternary ammonium compounds, 70% isopropyl alcohol, phenolic, and a chlorine-containing wipe [80 ppm]) effectively (>95%) remove and/or inactivated multidrug-resistant S. aureus, vancomycin-resistant Entercoccus, P. aeruginosa from computer keyboards with a 5-second application time. [43]

Hence they are used for disinfection of noncritical surfaces & items such as floors, furniture, walls, blood pressure cuffs.

Disinfection of Diagnostic & Laser lenses:

Glutaraldehyde, Peracetic acid, OPA, sodium hypochlorite can all be used for disinfecting diagnostic, contact &non contact lenses.

Table 4 : VOLK OPTICAL - CLEANING & CARE GUIDE

Product Type ✓ OK to Use	Alkacide / Alkazyme	**Bleach Solutions (Sodium Hypochlorite)	Bode Mikorbac Tissues	CaviWipes	*Cidex OPA	*Glutaraldehyde	Perasafe	*Revital-Ox™ Resert XL® HLD	Tristel Duo
BIO Lenses (Black & All Colors)		✓	✓	✓	✓	✓	✓		✓
BIO Lenses (ACS)		✓	✓	✓	✓	✓	✓		✓
Classic Series Lenses (Black & All Colors)		✓	✓	✓	✓	✓	✓		✓
Super & Digital Series Lenses (Black & All Colors)		✓	✓	✓	✓	✓	✓		✓
Mirrored Lenses (3-Mirror Lenses, Mini 4-Mirror Lens, & SLT)	✓	✓	✓	✓	✓	✓		✓	✓
G-Series Gonio Lenses		✓	✓	✓	✓	✓		✓	✓

Disinfection & SARS-CoV-2:

It is sensitive to UV &heat.It can be inactivated at 56°C & also by liquid solvents like ether, 75% ethanol, chlorine disinfectant, peracetic acid & chloroform.

Slit lamp, auto refractor, OCT, Fundus camera, perimeter (not the bowl) should be cleaned with 75% ethanol or 3% hydrogen Peroxide.

Appliances directly touching the ocular surface such as tonometer tip, gonioscopes, ultrasound pachymeter probe should be soaked in 2% glutaraldehyde, washed with distilled water & then cleaned with 75% ethanol.[44]

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