CONTACT LENS SOLUTIONS

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CONTENTS

This chapter includes a review of:

- Purpose
- Ideal properties
- Contact lens wear
- Contact lens deposits
- Contact lens care

PURPOSE

- To facilitate contact lens wear
    - The patient must be able to wear the contact lens successfully without any discomfort or irritation to the eye
- To maintain the optical and physical properties of the contact lens
    - The solution must not alter the refractive state of the eye or the material of the contact lens
- To reduce the risk of infection
    - Any infection, however mild will limit or prevent contact lens wear.

IDEAL PROPERTIES

- Sterile
  - Sterility is important both when the solution is first manufactured and during the useful life
  - Most contact lens solutions are packaged in multi-use containers
- Will not discolour the lens or change its properties or parameters
  - The solutionn must not react with or cause any changes to the actual contact lens material
- Not toxic or irritative to the eye
  - Must not be dangerous to the eye by causing a toxic or irritating reaction
- The mode of use must encourage patient compliance
- CE marked ("European conformity" mandatory for products sold in European Economic Area)
  - Solution must contain a CE mark to show that it meets the required European standards
- Isotonic with tears and buffered
  - It must be the same concentration as tears to prevent stinging

If all of the above are properties of the contact lens solution, then this will encourage greater patient compliance.

CONTACT LENS WEAR

Lenses become contaminated due to:

- Protein and lipid from tear film
  - Build up of proteins is greatest on high water content, ionic soft lenses
- Desquamated epithelial cells
- Environmental pollutants
- Cosmetics
- Nicotine

> Rigid Gas Permeable (RGP) lens wear stimulates the immune system and the contact lens is continually bathed in lipids secreted from meibomian glands.

CONTACT LENS DEPOSITS

Results of Deposits

Deposits can cause many problems for contact lens wearers from uncomfortable lenses to serious infections.

- Deposits reduce visibility and comfort, for wearers of RGP and soft contact lenses
- RGPs: Deposits reduce wetting of lens material
- Bound protein causes allergic and inflammatory reactions
  - Allergic reactions to the protein deposits on the lens
  - E.g. giant papillary conjunctivitis
- Microbial contamination: serious infection of cornea (keratitis)
  - Keratitis eventually may lead to perforation of the cornea with very serious implications
- Reduced wearing time
  - Cleaning increases wearing time
- Reduced visibility will lead to poorer visual acuity and reduced wearing time

- Surface problems with RGP lenses also reduce wearing time

Main contact lens care solutions can be divided into these four areas.

- Cleaning
- Disinfecting
- Protein deposit removal
- Wetting and rinsing

CLEANING

- Surfactant agent and manual rubbing of lens aim to remove surface debris such as
    - Lipid and mucous
    - Proteins
    - Oil from cosmetics
    - Environmental pollutants

    > - >95% of contaminates are removed by manual rubbing of the lens
    > - It is easier and more effective to disinfect a clean lens
    > - May or may not contain a preservative agent to prevent infection

- The cleaning process emulsifies or solubilises contaminates.
    - Mixes contaminate with a liquid making it easier to remove.
- It reduces microbial contamination and surface deposits.
    - Boston Advance Cleaner (RGP)
    - Total Care Daily Cleaner (AMO) (RGP)
    - Optifree Daily Cleaner (Alcon)
    - Elite Cleaner (Bausch and Lomb)

Surfactants

A list of various agents used in cleaning solutions:

- Poloxamer
- Alkyl ether sulphate
- Sodium tridecylether sulphate
- Amphoteric imidazoline derivative
- Citate
- Poloxamine
- Isopropyl alcohol
- Pluronic 174R
- Pluronic F127
- RML 100 (PEG-11 lauryl ethercarboxylic acid)

> Check various solutions to identify the cleaning agents used. Surfactants lower the surface tension and allows easier spreading of liquid.

DISINFECTING SOLUTIONS

- Prevents growth of potentially pathogenic organisms.
- May involve soaking the contact lens in solution, heating method or utilising the oxidative action of hydrogen peroxide (SCL – soft contact lenses).
- RGP wetting (or soaking solutions) also known as conditioning solutions.

> Disinfecting solutions are sometimes known as soaking solutions. Disinfecting solutions should be effective against a wide range of bacteria including staphylococcus aureus, pseudomonas aeurogisosa, escherichia coli and acanthamoeba.

Antimicrobial Agents

- Sterilization
  - Removal or killing of all viable organisms
- Disinfection
  - Elimination of the possibility of infection from a material
- Physical Agents
  - Subject organisms to sufficient energy to produce lethal protein denaturation and cell changes.
- Chemical Agents
  - Non-specific or specific bactericical agents

Properties

- Minimise microbial spoilage of multi-use formulations
- Disinfection of contact lens in past: many preservatives in RGP conditioning solutions and soft lens disinfecting solution produced a hypersensitivity reaction.
- Stand alone disinfectant products for both soft and RGP lenses are no longer used
  - Used traditional preservatives such as benzalkonium chloride, thiomersal, chlorhexidine.

Thiomersal (or Thimerosal)

- Mercurial derivative
- Not widely used now
- Required long periods of disinfection (i.e. overnight) and caused hypersensitivity reactions
- Marked antifungal activity
- Thimerosal 0.004% required 24 hours to kill an innoculum of Pseudomonas aeruginosa
- Toxic or irritative reactions
- Can get saline preserved with thimerosal

Benzalonium chloride

- Concentrations (0.004-0.01%)
- Used in wetting solutions (0.004%) and soaking solutions (0.01%)
- Cationic detergent
- Bactericidal in low concentrations

- Irritative in higher concentrations (>0.01%)
- Interferes with lens wetting
- Hypersensitivity reactions
- Found as preservative in many ocular drugs

Chlorohexidine

- Better antibacterial properties than thimerosal
- Less allergic effects
- Effective against a range of microorganisms

MULTIPURPOSE SOLUTIONS

Multipurpose solutions were introduced in 1995 and by 2005 represented 91% of contact lens care systems. In addition to disinfecting, they perform the following functions:

- Cushioning of the lens/cornea interface
- Mechanical protection – reduce friction
- Render surface of RGP lens hydrophilic
- Render lens surface compatible

The main advantage of multipurpose solutions is that there is improved patient compliance, which decreases risk of contamination. Often practitioners come across patients who will omit one step of the cleaning regime due to problems with time or expense.

- RGP and Soft Lenses
- One step agents
- Improved compliance
- Possible higher risk of infection
- Used to clean, rinse and disinfect lens
- Vary in surfactant cleaner, preservative concentration and buffering agent.
- Cleaner may be a traditional surfactant cleaner or via the release of citrate.
- Disadvantage is loss of dedicated surfactant to remove deposits.
- Newer agents marketed as 'no rub'.
    - It is however, still better to encourage the patients to manually clean the lens also.

LIST OF MULTIPURPOSE SOLUTIONS FOR SOFT AND RGP LENSES

There is a wide range of multi-purpose solutions available for both RGP and soft lenses.

- Soft Lenses
    - Focus Aqua (Ciba)
    - Optifree Express (Alcon)
    - Solo Care (Ciba)
    - Complete (AMO)
    - Renu (Bausch and Lomb)
    - All in One Light (Sauflon)
- RGP Lenses

- Elite Conditioning Solution (Bausch and Lomb)
- Solo Care (Ciba)
- Total Care (AMO)

One study showed that not all no-rub contact lens solutions were shown capable of removing the protein deposit from soft contact lenses.

DISINFECTANTS/PRESERVATIVES

Below is a list of the most commonly encountered disinfectants/preservatives. There is a large range of disinfectants previously and currently used in CL solutions.

- Polyhexanide
- Polyquad
- Sorbic Acid
- Perobate
- Aldrox
- Chlrohexidine
- Hydrogen Peroxide
- Benzalkonium chloride
- Thiomersal
- Cetrimide

Disinfecting Agents

- Polyquad (polidronium chloride) and Polyhexanide (polyhexamethylene biguanide PHMB or DYMED)
  - Polyquad is found in Optifree Express
  - Large molecular size
  - Lower concentrations therefore less toxic
  - Less toxic to ocular tissues
  - Bind to negatively charged phospholipids found in bacterial membranes causing disruption and cell lysis
  - Large molecules cannot bind to ocular tissues
  - Large molecular weight resists diffusion into the lens matrix reducing the toxic or hypersensitivity reaction
- Aldrox (myristamidopoppyl dimethylamine or MAPD)
  - Interaction with cell wall components allowing penetration of fungal cells.
  - Aldrox is used in Optifree multipurpose solution.

DISINFECTIVE AGENTS/TRANSIENT OR OXIDATIVE AGENTS

Hydrogen Peroxide (3%)

Hydrogen peroxide was the first method of chemical disinfection. Broad antibacterial spectrum and is effective in killing pathogens very quickly. It was thought that two step systems were more effective but they are not used widely now. Oxysept 1 and 2, a two step system, was discontinued in 2006.

- Very effective
- Soft Lens Care Systems
- Toxic to eye causing discomfort and conjunctival hyperaemia

Two Step System

The two step system is gold standard which everything else is compared to. In 2005 it was used by 10% of contact lens wearers (Morgan and Effron 2005).

- Contact Lens placed in hydrogen peroxide for a minimum of 4 hours.
- Catalyst added to neutralise peroxide
- After 10 minutes contact lens can be removed from neutraliser and placed on eye
- Preservative free
- The two steps make it less convenient
- Excellent disinfection (highly effective against acanthamoeba)
- Catalyst breaks H_2O_2 down into water and oxygen

One Step Solution

- Improves patient compliance
    - Always an advantage in contact lens wear.
- Platinum disc or a catalase tablet
- Gradual neutralisation of hydrogen peroxide
- Less effective against resistant organisms
- Peroxide systems recommended if preservative hypersensitivity is a problem

Peroxide Systems

- One Step Peroxide Solutions
    - AO Sept Plus (Ciba)
    - Oxysept One Step (Allergen)
    - Easy Sept (Bausch and Lomb)
- Two Step Peroxide Solutions
    - Oxysept 1 and 2 (AMO) – no longer available (2006)

PROTEIN REMOVAL

- Should be carried out weekly for RGP and SCL wearers
- Protein removal uses enzymes
    - Biochemical catalysts that cleave protein molecules into shorter chains which can be easily removed with a surfactant cleaner
- Bound protein can cause allergic and inflammatory reactions.
- Lens immersed in a sterile solution for between 15 minutes to 4 hours.
- Protein removal agents:
    - Pancreatin
    - Subtilisin A
    - Protease
    - Lipase
    - Pronase
- Very important for atopic patient especially during the hayfever season

- Various agents used to remove protein from the lens
- Good to familiarise yourself with the different protein removers in the clinic and identify the active enzymatic ingredient.
    - Total Care (AMO) Protein remover tablets
    - Ultrazyme (AMO)
    - Unizyme (Ciba)

ACCESSORY AGENTS

SALINE

- Most contact lens solution manufacturers will produce saline.
- Cleaning and Rinsing remove over 99% microorganisms from contact lens.
- Saline solution should be:
    - Compatible with tears, lens and container
    - Cause no discomfort or tissue disruption
    - Stable and free from contamination
    - Preservatives added to multidose saline
- Can also be used in unpreserved form

TONICITY AGENTS

- Eye can tolerate solutions with osmotic pressures 0.5-2.0% sodium chloride (0.9% is isotonic)
- Add salt concentration to tear compatibility

  E.g. sodium chloride
- Eye drops with increased osmotic pressures, e.g. phenylepherine, will cause stinging

WETTING SOLUTION

- Stand alone wetting solutions no longer available
    - Incorporated into multipurpose solutions
- Important for RGPs
- Produces a film to convert hydrophobic lens surface into hydrophilic surface
- Improves comfort
    - Cushioning minimises discomfort during initial insertion and lens wear
    - Encourages prolonged wearing of the lens
- Prevents contamination on insertion
- Mechanical buffer
- Optical performance is enhanced by the even distribution of the tears over the lens

BUFFERING AGENTS

- Maintain the pH within a narrow range (pH 6-8)
    - Sodium phosphate
    - Borate
    - Tormethamine

The pH of a solution can affect its therapeutic effect, comfort, stability, sterility and viscosity. Ophthalmic drugs are in most instances alkaloid salts, salts of weak bases and strong acids.

Tears contain buffer systems which keep the pH between 7.2 and 7.6. The corneal epithelium is a cellular layer with very few intracellular spaces and so to pass through the epithelium, drugs must be lipid soluble. Alkalis become soluble in lipids and therefore a high pH will facilitate passage through the epithelium. However, the stroma favours water soluble molecules. Thus for a drug to pass through the cornea its solubility must swing from lipid soluble to water soluble to lipid soluble and back to water soluble to dissolve in the aqueous.

CHELATING AGENTS

- Enhance the action of the preservative
  - Sodium edetate
  - Ethylenediamine tetra acetic acid (EDTA)
- Produce their effect by removing calcium ions from the solution and disrupting the cell wall.

CONCLUSIONS

Type of Solutions Required

- Daily cleaning and disinfection are required for all types of lenses except daily disposables.
- Enzymatic cleaning essential for soft non-disposable lenses and recommended for rigid lenses.
- Comfort solutions optional for all types of CL's
- Enzymatic cleaner (or protein removal)
- Comfort solutions are dependent on the patient
- Usually not prescribed initially but given to patients who find their lenses becoming slightly uncomfortable at certain times e.g. for environmental reasons

Case Contamination

- Case cleaning regime should be ascertained at each aftercare visit
- Light coloured case
- Regularly replaced
- Case must be cleaned, disinfected and have protein removed
- Weekly cleaning with boiled water

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