
UNIT 29 OPHTHALMIC DYES, IRRIGATING SOLUTIONS, ARTIFICIAL TEARS AND VISCOELASTICS

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29.0 OBJECTIVES

After completing this unit, you should be able to understand:

- different types of ophthalmic dyes;
- viscoelastics and irrigating solutions used in ophthalmology;
- indications and uses of irrigating solutions, dyes and viscoelastic with their side effects; and
- the role of artificial tears in ophthalmology.

29.1 INTRODUCTION

Ophthalmic dyes are used mainly for diagnostic purposes particularly when any damage occurs to any part of the eyeball. These agents, because of their inherent property, either adhere to the **damaged** tissue or because of their colouring effect, give the extent of damage.

Irrigating solutions are aqueous solutions and the primary purpose of an intraocular irrigating solution is to maintain both the anatomic and physiologic integrity of intra-ocular tissues. They provide cellular nutrients that are required for intercellular and intracellular function during prolonged intra-ocular surgery. These components help to maintain a thin cornea by avoiding corneal clouding.

Artificial tears are preparations that produce a stable preocular tear film. An ideal artificial tear drop should be soothing and comfortable, a proper wetting agent, a buffer and a preservative, pH ranging between 7-8.5, osmolality around 300 mosm and it should not produce epithelial toxicity.

Viscoelastics are vital component for any type for intra-ocular surgery and help to protect the delicate ocular tissues from damage during any ocular surgery.

29.2 OPHTHALMIC DYES

These agents are used for various diagnostic purposes in ophthalmology. They are either retained in particular tissues or stain some particular tissues, and because of these properties have various diagnostic and therapeutic implications.

Commonly used ophthalmic dyes:

- 1) Fluorescein Sodium
- 2) Rose Bengal
- 3) Lissamine Green
- 4) Trypan Blue
- 5) Indocyanine Green
- 6) Verteporfin

29.2.1 Fluorescein Sodium

It is a water soluble dye. It is yellowish in colour and it turns greenish on higher dilution. The intact corneal epithelium has high lipid content and resists the penetration of water soluble substances. Thus any break in the epithelium will stain the stroma and the epithelial irregularity can be visualised.

Uses in Ophthalmology

- 1) Detection of Corneal Epithelial Defects
- 2) Detection of Intra-ocular Pressure by Applanation Tonometry
- 3) Contact Lens fitting: To know the exact fitting of contact lens
- 4) Detection of any wound leak particularly after glaucoma and cataract surgery
- 5) Detection of potency of Lacrimal drainage
- 6) Measurement of tear film break up time
- 7) Fundus fluorescein angiography: It is a highly useful diagnostic tool in retinal vascular disorders like neovascularisation, leakage, ischaemia, obstruction etc.

Fluorescein absorbs shorter wavelength rays and emits longer wavelength rays in a characteristic spectral range. The following conditions can be diagnosed:

Disorders of the Retinal Vascular System:

In diabetic retinopathy, hypertensive retinopathy, vascular blocks, vascular inflammatory conditions.

- Intra-ocular tumors:

To know the vascular pattern of malignant and non-malignant tumors.

- Determination of normal and dead retinal tissue
- Evaluation of Iris vasculature

Adverse Reaction

Topical - Irritation/burning sensation

Injectable - Nausea, vomiting, syncopal attack

Hypersensitivity Reactions

Skin discolouration

Discolouration of hair and urine

29.2.2 Rose Bengal

Rose Bengal stains dead and degenerated epithelial cells of the cornea and conjunctiva. In case of dry eye conditions, there occurs a triangular shaped conjunctival staining in the interpalpebral area (part of the conjunctiva exposed when the eye is open).

Routes of Drug Administration

Topical as 1 per cent ophthalmic solution.

Dosage

1-2 drops into the conjunctival sac before any examination.

Indication

- 1) Dry Eye
- 2) Corneal Epithelial Defect
- 3) Viral keratitis like herpes simplex and herpes zoster

Adverse Reaction

Irritation/Burning sensation

Staining of Eye Lid

29.2.3 Lissamine Green

This is a green coloured dye, used in concentration of 1 per cent. The indications and the actions are similar to Rose Bengal dye. It has the advantage of being non irritating on instillation in the conjunctival sac.

29.2.4 Indocyanine Green

It is water stable tricarboyanine dye. It has a high protein binding capacity and near infrared fluorescence.

Indication

Indocyanine green Angiography (ICG) for evaluation of posterior segment disorders particularly for choroidal neovascularisation.

Dosage

Available as powder for injection in 25 mg and 50 mg strength. Generally 40 mg dye dissolved in water is given.

Side Effects

Allergic reaction

Avoid in pregnancy

29.2.5 Trypan Blue

Trypan Blue stains anterior lens capsule, so it is mainly used during extraction of cataractous lens. The stained capsule is easy to visualise and hence the performance of anterior capsulotomy is simplified.

Recently it has also been used to stain the internal limiting membrane for performance of ILM peeling in macular hole surgeries.

Dosage

Available as 1 ml single use ampoule containing 0.6 mg trypan blue.

Adverse Reaction

- May cause damage to corneal endothelium so dye has to be washed out immediately.
- May increase the chance of post-operative inflammatory reactions.

29.2.6 Verteporfin (Visudyne)

This is a newer dye, which is used in photodynamic therapy for treatment of choroidal neo vascular membranes.

Check Your Progress 1

1) Name the commonly used dyes in ophthalmology.

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2) Mention the common uses of fluorescein in ophthalmology.

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29.3 IRRIGATING SOLUTIONS

Irrigating solutions are aqueous solutions and the primary purpose of an intra-ocular irrigating solution is to maintain both the anatomic and physiologic integrity of intraocular tissues, especially the corneal endothelium. They provide cellular nutrients that are required for intercellular and intracellular function during prolonged intraocular surgery. They are also useful to maintain the globe inflated and keep up normal pressure volume relationship.

Ideal intra-ocular irrigating solution should:

- contain concentrations of inorganic and organic constituents similar to those present in aqueous humor and vitreous cavity.
- not cause corneal oedema, corneal endothelium cell loss, crystalline lens opacification, damage to trabecular meshwork and retinal oedema.
- keep the globe inflated.
- contribute in keeping a normal pressure-volume relationship intra operatively.
- be tissue-compatible to minimize stress to the intraocular tissues during the surgery.

Indications

- cataract surgery including phacoemulsification and extra-capsular cataract extraction.
- vitrectomy and posterior segment surgeries.
- anterior segment reconstruction.

29.3.1 Balanced Salt Solution (BSS)

Advantage

Better tolerated irrigant than ringer lactate and normal saline.

Disadvantages

- Lacks the bicarbonate, glucose and glutathione present in aqueous humor.
- Causes a significant increase in the co-efficient of variation of cell area (polymegathism).
- Causes a significant decrease in the percentage of hexagonal cells (pleomorphism) in longer irrigation.
- Results in stressed endothelial mono-layer which may be more susceptible to additional surgical trauma.

29.3.2 Balanced Salt Solution Plus (BSS Plus)

Advantages

- It is iso-osmotic with the intra-ocular tissues.
- Maintains corneal thickness (bicarbonate in BSS PLUS allows normal corneal endothelial pump function).
- Causes minimal changes in endothelial morphologic characteristics regardless of the irrigation time.
- Addition of glucose provides energy source to the Na/K ATPase pump.
- Maintain lens clarity in posterior segment surgeries.
- No retinal oedema.
- Glutathione helps to protect cell against oxidative stress and maintain integrity of blood aqueous barrier to minimise inflammation.

Disadvantages

It contains unstable compounds like adenosine and glutathione, so it has to be prepared fresh every time and hence becomes expensive.

29.3.3 Normal Saline (0.9 per cent NaCl)

Disadvantages

- Not an ideal solution to be used in ophthalmology because causes complete destruction of endothelial cells of cornea within one hour of instillation.
- Fails to maintain endothelial pump and barrier function resulting in corneal swelling.

29.3.4 Plasma Lyte 148

Disadvantage

- Lacks the critical ion calcium.
- Causes the junction between the endothelial cells to breakdown.
- Corneal oedema.

29.3.5 Lactated Ringer's Solution

Advantage

Contains most of the essential ions to maintain the integrity of intraocular tissue.

Disadvantages

- Contains 28mM lactate, a much higher concentration than that present in intra-ocular fluids.
- Causes various degrees of endothelial cell breakdown and corneal swelling on prolonged perfusion.

29.3.6 S-MA2

Advantages

- Said to protect corneal endothelium.
- Prevents corneal oedema when infused into the anterior chamber for extended time period.
- Prevents corneal decompensation after pars plana vitrectomy.

29.3.7 Dextran Containing Irrigation Solution (DPS)

Advantages

- It is stable for more than two years.
- It prevents fluid uptake by the cornea.

29.3.8 Glucose Fortified BSS Plus

Advantage

It has four times more glucose than BSS PLUS. It is useful in diabetic patients to prevent intraoperative lens opacification.

Check Your Progress 2

- 1) Name the various intra-ocular irrigating solutions.

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- 2) Mention the advantages of KSS Plus.

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29.4 ARTIFICIAL TEARS/OCULAR LUBRICANTS

Under normal circumstances corneal and conjunctival surfaces are covered by a thin layer of fluid called tear film. Tear film layer is essential for the normal functioning of cornea and conjunctiva.

Normal Functions of Tear Film

- 1) A protective layer: It washes out any debris, dust particle that comes in contact with conjunctiva and cornea.
- 2) Tear film contains some chemical agents that have antibacterial action. When any bacteria comes in contact with eye, these chemical agents destroy these bacterial agents.
- 3) Optical function: Tear film gives a smooth surface to the cornea by which cornea acts as a perfect optical surface,

Layers of the Tear Film: From outer to inner

- 1) Lipid layer : Secreted by the glands situated in the lid (Meibomian gland).
- 2) Aqueous layer: Secreted by the lacrimal glands.
- 3) Mucinous layer: Secreted by the goblet cells of the conjunctiva,

Whenever there is dysfunction of Meibomian glands, Lacrimal glands and/or goblet cells of the conjunctiva, quantitative and qualitative deficiency of the tear film occurs. This condition is known as Dry Eye. The main treatment of these conditions is tear supplementation (Ocular Lubricants).

Ocular Lubricants

- 1) Methyl cellulose
- 2) Hydroxy propyl methyl cellulose
- 3) Hydroxy methyl cellulose
- 4) Polyvinyl alcohol
- 5) Sodium hyaluronate

Ocular lubricants usually contain inorganic electrolytes, preservatives and water soluble polymeric system.

Dosage

Usual dosage is to instill 1-2 drops at a frequency of 4-6 hours. However depending upon the severity of the disease, frequency of drug administration may be increased.

Given in Two Forms

- Ophthalmic Teas Solutions
- Ophthalmic Tear Ointments: Ointments are generally given preferably at bed time.

Indications

- Dry Eye
- Keratoconjunctivitis Sicca
- Recurrent corneal erosions
- Following eye surgery
- Decreased corneal sensation

Adverse Reaction

Ocular lubricants are usually safe drugs. In some cases ocular side effects reported are:

- Redness
- Stinging/Burning sensation
- Ocular discomfort
- Hypersensitivity reactions

Check Your Progress 3

1) What are the commonly used ocular lubricants?

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2) Mention the common indications of their usage.

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29.5 VISCOELASTICS AND OTHER SURGICAL ADJUNCTS

Viscoelastics are vital component for any type for intraocular surgery. They help to maintain an anatomical situation created by surgeon and maintenance of anterior chamber. They protect corneal endothelium during intra-ocular surgery from mechanical trauma. They are used to coat implants, instruments and corneal epithelial surface during surgery. They are used to mechanically break synechiae and tamponade bleeding vessels.

29.5.1 Sodium Hyaluronate

Sodium Hyaluronate 1 per cent is a large polysaccharide molecule, that is present in all connective tissue matrices of vertebrates. It is highly viscous and elastic. Its viscosity is 100,000-300,000 centi poise and molecular weight is about 4 million Daltons. It is obtained from dermis of rooster coombs.

Advantages

- Non-allergic and clear.
- It inhibits phagocytic activity, synthesis and release of prostaglandin by macrophages during phagocytosis.
- It is non-antigenic.
- It reduces endothelial loss greatly, when used in intra-ocular surgery.

Indications

- Phacoemulsification with IOL implantation.
Corneal transplant surgery.
- Glaucoma surgery.
- Posterior segment surgeries.

Dosage

Available as preloaded syringe with 27 G or 30 G cannula containing sodium hyaluronate 10 mg/ml or 14mg/ml strength (in 0.25, 0.50, 0.80, 2 ml and 4 ml syringes).

Adverse Reaction

- Transient post-operative increases in intra-ocular pressure.
- Corneal edema.
- Rarely inflammatory reactions.

Precautions

- Do not over fill the anterior chamber.
- Ensure total removal before surgery.
- Monitor IOP in post-operative phase.

29.5.2 Chondroitin Sulphate

It is a biological polymer and is a proteoglycan. It is obtained from shark cartilage. The molecular size is 5×10^5 centistokes. It has low viscosity therefore it can not maintain space. It is a much smaller molecule than sodium hyaluronate. In combination with another biological polymer like sodium hyaluronate, it forms a good viscoelastic.

29.5.3 Sodium Hyaluronate and Chondroitin Sulphate

Composition

3 per cent sodium hyaluronate and 4 per cent chondroitin sulphate with 0.45 mg sodium dihydrogen phosphate hydrate, 2.65 mg disodium hydrogen phosphate and 4.5 ml NaCl (0.5ml Pack).

Indication

- Cataract extraction with intra-ocular lens implantation with poor endothelial count.

Advantage

- Effective in protecting endothelium.

Disadvantages

- Does not maintain anterior chamber.
- Difficult to aspirate.
- Tends to trap small air bubbles.
- Less cohesive.
- Requires refrigeration.

29.5.4 Hydroxypropyl Methylcellulose

HPMC is an artificial compound in the eye. Its viscosity is 3000-4000 centipoise approximately and an average molecular weight of 86000, an Osmolarity of 285 mosm and a pH of 7.2.

Advantages

- Cheap, water soluble, inert, transparent, non-pyrogenic and non-toxic to corneal endothelium.
- Post operative increase in TOP is seen less frequently.

Indications

Same as sodium hyaluronate.

Adverse Reaction

Same as sodium hyaluronate.

Disadvantage

Due to low viscosity it is not able to maintain anterior chamber during surgery.

Check Your Progress 4

- 1) Name the common viscoelastic agents.

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- 2) What are the common indications for their use?

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29.6 LET US SUM UP

In this unit you have studied about ophthalmic dyes. Fluorescein is the most commonly used dye in ophthalmology. Verteporfin is a newer dye, used in photodynamic therapy for treatment of choroidal neovascular membranes.

You have also studied that use of an ideal irrigating solution is a must to prevent toxicity to delicate intra-ocular structures. The most commonly used irrigating solutions are Ringer lactate and BSS Plus. Glucose fortified BSS plus has a definite advantage in diabetics.

Further you have studied that the normal tear film may be damaged in dysfunction of the meibomian glands, lacrimal glands or the goblet cells of the conjunctiva. Besides ocular lubricants, other methods of treatment in these conditions include anti-inflammatory drops, preservation of existing tears (with punctal occlusion) and decrease tear evaporation (by using occlusive glasses).

Also, you have studied that viscoelastic agents are an essential part of intra-ocular surgeries to protect the corneal endothelium during intra-ocular manipulation:..

The viscoelastic agent must be completely aspirated from the anterior chamber at the end of the procedure.

In next unit you will study about chelating agents, immunosuppressants, enzymes, antiseptics and disinfection.

29.7 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Commonly used ophthalmic dyes:

- Fluorescein Sodium
- Rosé Bengal
- Lissamine green
- Trypan Blue
- Indocyanine Green
- Verteporfin

2) The common uses of fluorescein sodium are:

- Detection of corneal epithelial defects
- Detection of intra-ocular pressure by applanation tonometry
- Contact lens fitting: to know the exact fitting of contact lens
- Detection of any wound leak particularly after glaucoma and cataract surgery
- Detection of potency of lacrimal drainage
- Measurement of tear film break up time
- Fundus fluorescein angiography: It is a highly useful diagnostic tool in retinal vascular disorders like neovascularisation, leakage, ischaemia, obstruction etc.

Check Your Progress 2

1) The various intra-ocular irrigating solutions are:

- Normal saline
- Ringer lactate
- BSS
- BSS PLUS

- Glucose fortified BSS Plus
 - Dextran containing irrigating solution
 - S-MA2
 - Plasmalyte 148
- 2) The advantages of BSS Plus are:
- It is iso-osmotic with the intra-ocular tissues
 - Maintains corneal thickness (bicarbonate in BSS Plus allows normal corneal endothelial pump function)
 - Causes minimal changes in endothelial morphologic characteristics regardless of the irrigation time.
 - Addition of glucose provides energy source to the Na/K ATPase pump.
 - Maintain lens clarity in posterior segment surgeries.
 - No retinal oedema.
 - Glutathione helps to protect cell against oxidative stress and maintain integrity of blood aqueous barrier to minimise inflammation.

Check Your Progress 3

- 1) The commonly used ocular lubricants are:
- Methyl cellulose
 - Hydroxy propyl methyl cellulose
 - Hydroxy methyl cellulose
 - Polyvinyl alcohol
 - Sodium hyaluronate
- 2) The common indications of ocular lubricants use are:
- Dry eye
 - Keratoconjunctivitis Sicca
 - Recurrent corneal erosions
 - Following eye surgery
 - Decreased corneal sensation

Check Your Progress 4

- 1) The common viscoelastic agents are:
- Sodium hyaluronate
 - Chondrotin sulphate
 - Hydroxy propyl methyl cellulose
- 2) The common indications for the use of viscoelastic agents are:
- Phacoemulsification with IOL implantation.
 - Corneal transplant surgery.
 - Glaucoma surgery.
 - Posterior segment surgeries.