UNIT 10 AQUEOUS HUMOUR AND INTRA-OCULAR PRESSURE

Structure

10.0 OBJECTIVES

After studying this unit, you will be able to understand:

- the processes by which the aqueous humour is formed;
- the mechanisms of aqueous outflow; and
- intra-ocular pressure, its variations and estimation.

10.1 INTRODUCTION

In the previous unit you have studied and learnt the physiology of lids and lacrimal system. You also have learned about the layers, composition and drainage of tear film. In this unit you will study about the contents and physiology of anterior chamber. As you know anterior chamber contains aqueous humour, which is secreted by ciliary processes, and is drained through angle of anterior chamber through trabecular meshwork. It is important to learn its mechanism of production and drainage, as if it is not properly drained, it leads to raised intra-ocular pressure which is determental to anatomy and physiology of eye.

10.2 STRUCTURE AND FUNCTIONS OF AQUEOUS HUMOUR

Aqueous humour is a clear fluid that fills the anterior and posterior chambers of the eye and permeates the vitreous. It supplies the intra-ocular pressure required for the eye and provides nutrients and oxygen to the internal eye structures (e.g., lens, iris and cornea). In addition, the aqueous humour functions in eliminating metabolic waste. The aqueous provides a clear media which allows rays of light to pass through uninterrupted to the retina permitting clear vision.

Let us now understand are mechanism of formation, movement and outflow of aqueous homour.

10.2.1 Formation of Aqueous Humour

It is universally accepted that the aqueous is produced by the ciliary processes. Although a great deal of research has been done on the formation of aqueous humour we still have not determined the actual mechanism. The basic processes by which substances cross various cellular membranes are:

1) Ultrafiltration,
2) Diffusion,
3) Active Transport.

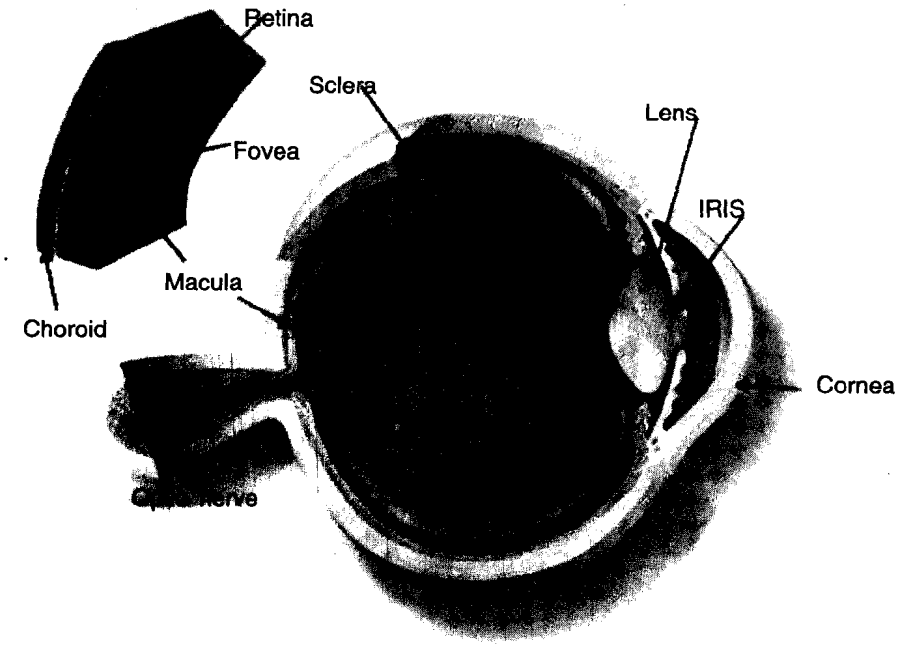

Fig. 10.1: Gross anatomy of the eyeball

1) Ultrafiltration

Ultrafiltration occurs when the flow of a substance across a cell membrane is increased by a hydrostatic pressure. This process was initially believed to be responsible for the majority of aqueous humour formation. The capillary wall is made up of tubes of flattened blood cells and plasma proteins of higher molecular weight. According to the ultrafiltration theory, the capillary wall behaves as a semi-permeable membrane. This membrane functions to block the entrance of small to medium sized particles that are dissolved in the plasma.

2) Diffusion

Diffusion occurs from the side of greater concentration to the side of lesser concentration. In aqueous humour this occurs from the plasma side in the blood to the side of aqueous humour in the posterior chamber of the eye.

3) Active Transport—Secretion

This method is now a well accepted process of aqueous formation. The rate of aqueous humour formation depends on the rate of active solute transport by the ciliary epithelium. This is an energy dependent reaction that involves ATP to move molecules from a lower concentration to a higher concentration.

10.2.2 Aqueous Movement and Outflow

There are two movements of the aqueous humour that occur—thermal flow and bulk flow. **Thermal flow** is an internal circulation of the aqueous fluid in the

anterior chamber. This occurs because of a difference in temperature between the cornea (cooler) and iris (warmer). In **bulk flow**, the aqueous humour moves from the ciliary epithelium in the posterior chamber and continues through the drainage channels at the anterior chamber angle and then through the episcleral veins. This can occur through a pressure dependent path or a pressure independent pathway. The pressure dependent pathway goes through the small pores (Canal of Schlemm) of the trabecular network (called the "Conventional Outflow"), which accounts for 80-90 per cent of the total outflow. In the independent pathway the aqueous humour drains through the uveoscleral outflow (also called the "Unconventional Outflow") channel. There is a **blood-aqueous barrier** which prevents the movement of substances from the plasma to the aqueous humour. If there is a breakdown of the blood-aqueous barrier the content of the aqueous humour can drastically change which will lead to an increase in intra-ocular pressure. Normal intra-ocular pressure is the pressure in the eye which does not cause damage. The range is from 15-20 mm Hg.

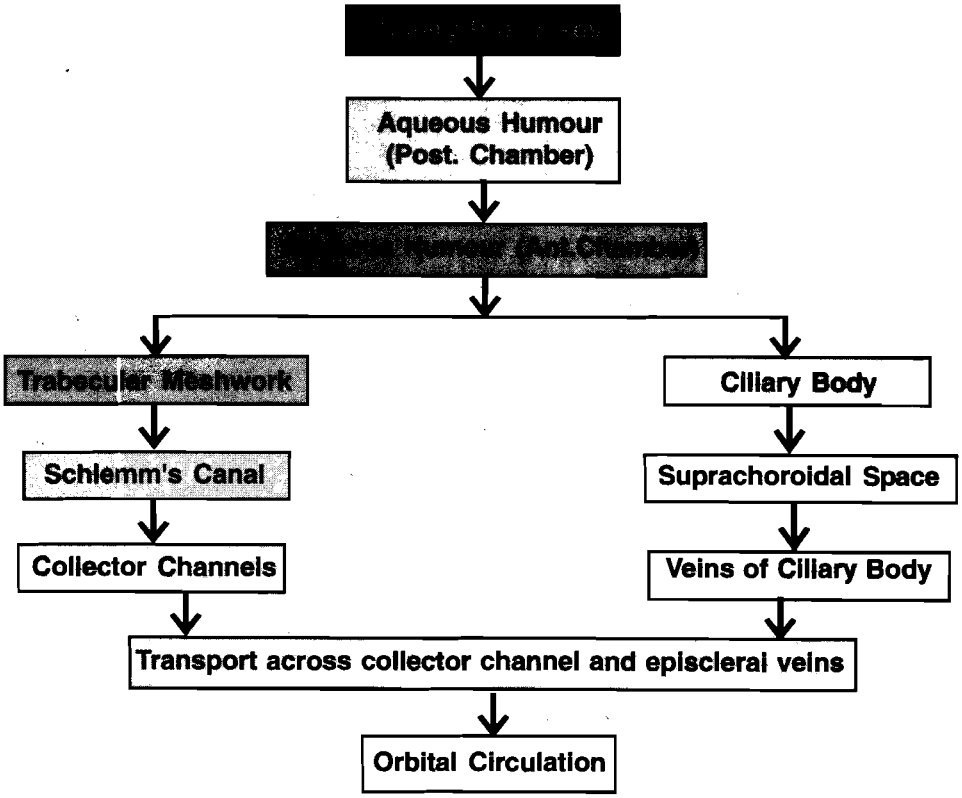

Fig. 10.2: Path of aqueous flow

10.2.3 Aqueous Composition

The aqueous humour contains:

- Water: 99 per cent
- Electrolytes
- Glucose and lactate
- Oxygen
- Ascorbate
- Amino acids
- Proteins
- Immunoglobulins
- Certain inhibitors
- Lens proteins
- Lactic dehydrogenases
- Lipids
- Other substances

10.2.4 Physio-chemical Properties of Aqueous

1) Volume : 0.3 to 0.4 ml

2) Refractive index : 1.336

3) Density : 1.025 to 1.040

4) Osmotic pressure : hyperosmotic (3-5 m.osmol/L)

5) pH : 7.2 acidic

6) Rate of formation : 2.3 microL/min

Check Your Progress 1

1) What is the function of the aqueous humour?

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2) What is the normal intra-ocular pressure range?

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10.3 INTRA-OCULAR PRESSURE

Intra-ocular pressure is the pressure maintained inside the eye above the atmospheric pressure. It is higher than fluid pressure in any other tissue (2-3 mm of Hg) or even cerebropenal fluid (7 mm of Hg). Its normal value, as you know, is 15-20 mm of Hg. This higher intra-ocular pressure is necessary for maintenance of the optical properties of the eye.

10.3.1 Diurnal Variation of Intra-ocular Pressure

Intra-ocular pressure demonstrates diurnal fluctuation and is maintained by the equilibrium between the mechanisms driving fluid in and out of the eye. Due to this, there may be a diurnal fluctuation of aqueous humour outflow.

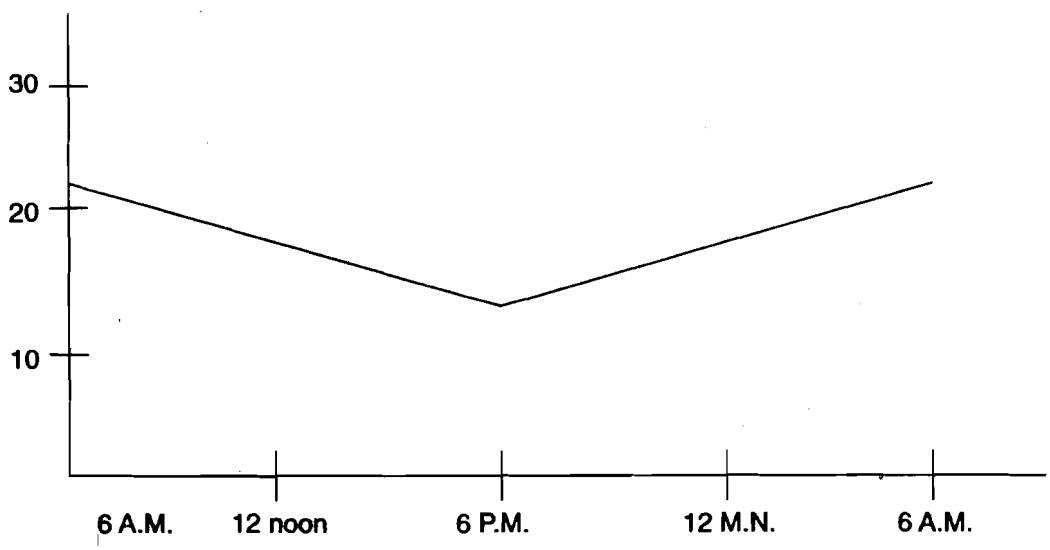
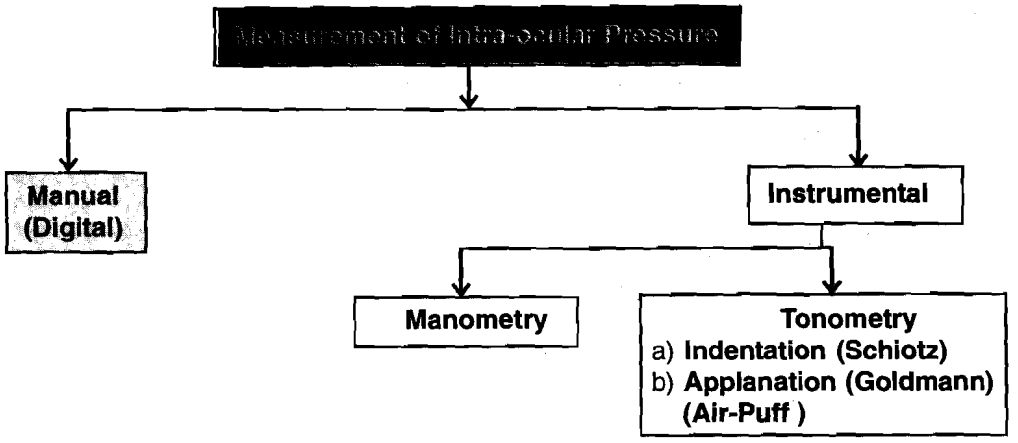


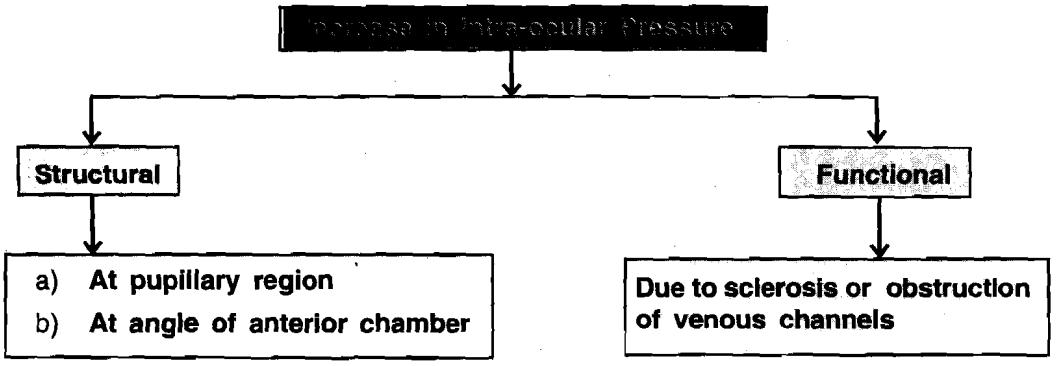
Fig. 10.3: Diurnal variation of intra-ocular pressure

10.3.2 Measurement of Intra-ocular Pressure



10.3.3 Increase in Intra-ocular Pressure

A prolonged alteration in the intra-ocular pressure occurs due to an alteration in the inflow of aqueous or resistance to its outflow. The outflow resistance is because of an increase in the episcleral venous pressure. There are certain factors that cause a temporary rise in intra-ocular pressure. These include variations in the hydrostatic pressure of blood, a change in the osmotic pressure of blood, volumetric globe changes, and/or blockage in the circulation of aqueous.



10.3.4 Lowering Intra-ocular Pressure

The following drugs can help in lowering intra-ocular pressure:

- IV Mannitol: mainly reduces vitreous volume.
- Acetazolamide: a Carbonic Anhydrase inhibitor that acts by decreasing aqueous production.
- Timolol Eye drops: decreases aqueous production.
- Pilocarpine Eye drops: increases aqueous outflow through trabecular meshwork.
- Latanoprost: increases uveoscleral outflow.

10.3.5 Factors Affecting Intra-ocular Pressure

a) Factors causing long term changes in intra-ocular pressure:

1) Heredity: Family history of glaucoma is high risk
2) Age: After 40 yrs of age, there is a slight increase in intra-ocular pressure.
3) Sex : Females > Male (after 40 yrs.)
4) Race: Negro — more resistant glaucomas.
5) Refractive error: Myopes have more IOP but falsely recorded as normal due to low scleral rigidity.

b) Factors causing short-term changes in intra-ocular pressure:

1) Arterial blood pressure

2) Systemic venous pressure (SVP)

3) Mechanical pressure

4) Plasma osmolarity: Hyper-osmolarity due to mannitol makes intra-ocular pressure lower.

5) Blood pH : Metabolic acidosis by carbonic anhydrase inhibitors like acetazolamode reduces intra-ocular pressure.

6) Diurnal variation in intra-ocular pressure:

- Normal 5 mm Hg
- >8 mm of Hg – glaucoma
- 5 to 8 mm of Hg – glaucoma suspect

Normal peak in early morning and lowest in evening.

7) Seasonal variation

8) Systemic hyperthermia

9) Effect of general anaesthesia on intra-ocular pressure: Type of anaesthesia has role, so must be kept in mind while measuring intra-ocular pressure under G.A. specially in children with congenital glaucoma.

In general, once the patient is under the effect of general anaesthesia: intra-ocular pressure is reduced.

10) Effects of drugs on intra-ocular pressure:

a) alcohol, morphine products, lower etc.: intra-ocular pressure,

b) steroids, caffeine, tobacco, LSD, etc.: increase intra-ocular pressure.

11) Blockage of the circulation of the aqueous —at pupil or at angle of anterior chamber: increase intra-ocular pressure.

Check Your Progress 2

1) What is the function of Acetazolamide?

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2) How does a temporary rise in intra-ocular pressure occur?

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10.4 LET US SUM UP

In this unit you have learnt that aqueous humour is a clear fluid that fills the anterior and posterior chambers of the eye and permeates the vitreous. Aqueous humour is formed through ultra-filtration, diffusion, and active transport. Movement of aqueous occurs through bulk flow and thermal flow. There is a blood-aqueous barrier which prevents the movement of substances from the plasma to the aqueous humour. A prolonged alteration in the IOP occurs due to

an alteration in the inflow of aqueous and resistance to its outflow. Intra-ocular pressure demonstrates diurnal fluctuation and is maintained by the equilibrium between the mechanisms driving fluid in and out of the eye. In next unit you will learn about pupil and pupillary reflexes.

10.5 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) It provides intra-ocular pressure which is required for normal optical function of the eye. Also, if provides nutritions to and eliminates waste products from the intra-ocular structures like lens, iris and cornea.

2) 15-20 mm Hg

Check Your Progress 2

1) It decreases aqueous formation thereby reduces intra-ocular pressure.

2) Due to variations in hydrostatic pressure of blood, change in osmotic pressure of blood, valumetric globe changes, and/or blockage in circulation of aqueous.