

GLAUCOMA DISEASE: AN INSIGHT VIEW

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Abstract - Glaucoma is an incurable disease that causes the sight degeneration, and it is the second leading cause of blindness in the World. Several techniques exist for the screening, detection, treatment, rehabilitation of glaucoma but still that are not sufficient to have control over this disease to prevent further for vision loss. Studies done on the prevalence of glaucoma have reported a high proportion of undiagnosed patients. Late diagnosis is related to increased risk of glaucoma associated with visual disability. Lack of awareness and non-availability of appropriate screening procedures are among the major reasons for non-diagnosis or late diagnosis of glaucoma. Importance of early diagnosis in glaucoma cannot be underestimated, for its effective management and prevention of blindness. This paper has been designed to evaluate the level of awareness and knowledge about glaucoma disease.

Keywords - Eye anatomy, Visual disorder, Glaucoma diagnosis, Treatment.

1. INTRODUCTION

Globally, both blindness and visual impairment are important public health problem. In recent times, World Health Organization (WHO) estimate on vision database shows that 36 million people are blind, and 217 million have moderate to severe visual impairment [1]. The World Report on Vision 2019, WHO shows that around 2.2 billion people, including near visual damage by addressed and unaddressed problem, have a visual impairment or blindness. Of this, nearly half of them are preventable [2]. Commonly, these

problems are due to non-communicable ophthalmic diseases, e.g. cataract, uncorrected refractive error, glaucoma, macular degeneration etc. Greater than two-third of visual problems are in low and middle-income countries. According to WHO, blindness is estimated to increase up to 38.5 million by 2020, and 117 million by 2050 due to the continuous increase of population aging across the globe [3].

2. EYE ANATOMY

The human eye represents the visual system and plays a vital role in determining the quality of life. The eye is a key organ that reacts to light and has several purposes. It has a number of components; some of them include cornea, iris, pupil, lens, retina, macula, optic nerve, choroid and vitreous etc. The eye has a cornea; smaller frontal unit, transparent and more curved and is linked to the larger white unit called the sclera. The eye is made up of three coats as shown in Figure 1 as- i) Outermost layer - The outermost layer, known as the fibrous tunic, is composed of the cornea and sclera. ii) Middle layer - The middle layer, consists of the choroid, ciliary body, and iris. It is also known as the vascular tunic or uvea. iii) Innermost layer - The innermost is the retina, which gets its circulation from the vessels of the choroid as well as the retinal vessels, which can be seen in an ophthalmoscope.

The clear fluid inside the eye is created by a small, circular structure found behind the iris or colored part of the eye, which is known as ciliary body.

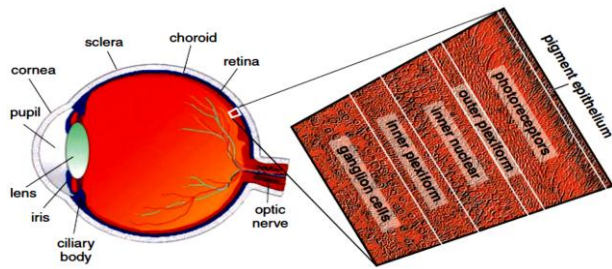


Figure 1. Structure of the Eye

This fluid, termed as the aqueous humor or aqueous, flows behind the iris and through the pupil or central opening in the middle of the iris. It is then fills the anterior chamber, termed as a space between the back of the clear cornea and the front of the iris. The aqueous exits the eye through a structure known as the drainage angle, is the angle formed inside the anterior chamber between the iris and the peripheral cornea. The aqueous filters through this angle and through the sclera or white part of the eye and then joins with the network of veins outside the eye. Any disturbance of this outflow of aqueous including from certain eye injuries can result in abnormality in the eye structure [5].

In numerous applications like disease diagnosis and human recognition, the retinal images play important role in this process. A number of things can go wrong in any of the structures of the eye, causing visual damage and blindness. In the past many decades, blindness and visual damage were addressed outside the scope of non-communicable diseases (NCDs). In the view of current considerable epidemiological transition, in the causation of blindness, i.e. a significant reduction of an infectious cause of blindness, for example, trachomatous blindness, measles, vitamin A deficiencies; however an increase in non-communicable causation like uncorrected refractive error, cataract, diabetic retinopathy, glaucoma etc.

Now, it is essential agenda that the prevention of blindness and visual impairment are also required to be addressed within the context of global public health improvement and development.

The main visual disorders are described below-

Cataract – It is nothing but clouding of the lens, resulting in a blurred image. The lens is comprised of mostly water and protein which is arranged in a way that retains the lens clear and allows light to pass through. Because of ageing, some of the protein may clump together and start to cloud a small area of the lens, resulting in a cataract that diminishes the amount of light reaching the retina. The cataract may slowly grow and makes the vision gradually duller or more blurred. Nuclear cataract, cortical cataract, and subcapsular cataracts are the main types of cataract.

Glaucoma - Glaucoma is related to the optic nerve that results in loss of vision or blindness. The optic nerve is progressively damaged, usually due to raised intraocular pressure, known as ocular hypertension (OHT).

Age-related Macular Degeneration (AMD) - In this, bunch of yellowish material (known as drusen) gradually accumulate within and below the Retinal Pigment Epithelium (RPE). The RPE cells may die and therefore no longer support the photoreceptors, which then cannot function. Resulting in the loss of vision in that part of the retina. If the photoreceptors in the macula are affected, this can seriously impair fine visual skills; this condition is sometimes named as ‘dry’ macular degeneration (or central, geographic atrophy) and it is the most common form of AMD.

Diabetic Retinopathy - Diabetic retinopathy is a common impairment of diabetes. Poor glucose control during diabetes disturbs and may damage the tiny blood vessels of the retina. New, fragile, vessels develop; however, these are prone to bleeding and the blood may leak into the retina and vitreous, causing spots or floaters, along with the decreased vision. If anomalous blood vessel growth continues, scar tissue formation may cause retinal detachment and glaucoma may also develop.

Hemorrhage - In this type of disorder of the eye in which bleeding takes place in the light sensitive tissue on the back wall of the eye. This disease can be caused due to hypertension, retinal vein occlusion, or diabetes mellitus. Result of this, small fragile blood vessels to form, which can damage easily.

Retinitis Pigmentosa - Retinitis pigmentosa bring up to the group of genetic eye diseases that causes

deterioration of photoreceptor cells in the retina. Patients experience progressive vision loss, as these cells degenerate and die. This condition is identified by using electroretinography to show progressive loss in photoreceptor function.

Pterygium – In this, noncancerous growth of the clear, thin tissue that overlies the conjunctiva. This condition may affect one or both eyes. Even though the cause of pterygia is unknown, people who work outdoors and are excessively exposed to sunlight and wind more frequently develop pterygia than who work indoors. Pterygia exist as a painless, raised area of white tissues, with blood vessels on the inner or outer edge of the cornea. No treatment is usually required unless the pterygium begins to obstruct vision, and surgical removal of the pterygium usually has good results.

Ocular Surface Neoplasia - Ocular surface neoplasia is a term used to describe various dysplasias, carcinoma in situ and squamous cell carcinoma of the ocular surface epithelium (conjunctiva and cornea).

3. GLAUCOMA HISTORY AND IT'S CAUSES

In the 17th century, glaucoma was probably documented as a disease. The term was derived from the Greek term '*glaucoma*' meaning "cataract or opacity of the lens" implying the lack of understanding of this disease process as cataracts and glaucoma are not distinguished at that time [6]. Today, glaucoma is recognized as a group of diseases with collective endpoint characteristics affecting the optic nerve. It is defined as an optic neuropathy characterized by specific structural findings in the optic disc as depicted in Figure 2. The particular functional deficits will appear in automated visual field test [7].

In glaucoma disorder, the optic nerve at the back of the eye is slowly destroyed. In most people this damage is due to an increased pressure inside the eye which is a result of blockage of the circulation of aqueous, or its drainage. While in other patients, it may be caused by the poor blood supply to the vital optic nerve fibers, a weakness in the structure of the nerve, and/or a problem in the health of the nerve fibers.

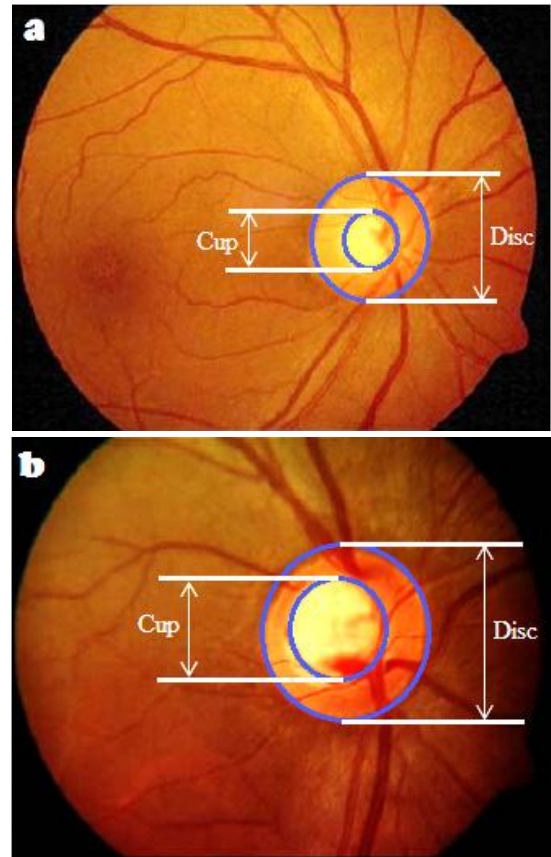


Figure 2. Eye Fundus Images
a) Normal Eye Fundus Image b) Glaucomatous Eye Fundus Image

General causes leading to Glaucoma -

- Ageing - People above 60 years of age are more prone to develop glaucoma.
- Other eye disorders - People with diabetes have a higher chance of developing glaucoma.
- Eye Injuries - Eye injuries are linked to a higher glaucoma risk. Retinal detachment, eye tumors and inflammations can also lead to glaucoma.
- Eye Surgery - Patients who go through eye surgery have a higher risk of glaucoma.
- Myopia (Nearsightedness) - People with myopia (ability to see close objects more clearly than distant objects) also have a risk of glaucoma.
- Corticosteroids - This constitutes the steroid hormones. People who use extensively corticosteroids have a higher risk of developing glaucoma. Migraine and peripheral vasospasm have also been identified as risk factors for glaucomatous optic nerve damage.

4. CLASSIFICATION OF GLAUCOMA WITH SIGNS AND SYMPTOMS

The categories of glaucoma can be as follows –

1. Open-Angle Glaucoma and Closed-Angle Glaucoma

Open-angle glaucoma is the most common type of Glaucoma and it covers about 90% of all the cases [8]. When the fluid in the anterior chamber reaches the angle between the cornea and iris, and passes too slowly through the meshwork drain. The pressure inside the eye rises to a level that may damage the optic nerve when the fluid builds up. It develops for a long period as it is less painful and unnoticeable. With different levels of intraocular pressure in various patients, during the diagnosis of glaucoma damage to the optic nerve rather than OHT alone.

Closed-angle glaucoma occurs when the eye's drainage canal gets blocked due to an excessive amount of liquid. The iris develops less wide and open, as compared to the normal eye. In this case, the pupil rapidly gets enlarged to a great extent [9]. This type is painful and needs major surgery. It is also called angle-closure glaucoma.

2. Normal-Tension Glaucoma or Low-Tension Glaucoma

In this, the IOP is normal but still, the optic nerve gets damaged somehow and therefore loss of visual field occurs.

3. Congenital Glaucoma

This is also called children glaucoma, which is common in infants. It has two types, i.e., primary congenital glaucoma, which is occurring due to incomplete or improper development of eye's drainage canal and secondary congenital glaucoma, resulting from disorders in the eye or body, which may or may not be inborn.

4. Secondary Glaucoma

It occurs from some other disease. Secondary glaucoma can be categorized as Pigmentary and Neovascular glaucoma.

• Pigmentary Glaucoma

It occurs due to the presence of pigmented granules present on the backside of the iris, into the aqueous

humor. These granules move toward the drainage canals and clog them over a period of time, leading to an increase in intraocular pressure.

• Neovascular Glaucoma

This type of glaucoma results when there is inadequate development of blood vessels on the iris and also over the drainage canals. This type mostly has its association with some other diseases like diabetes.

5. DIAGNOSIS OF GLAUCOMA

Generally, accurate diagnosis of glaucoma requires three different sets of inspections: (i) evaluation of the intraocular pressure (IOP), (ii) evaluation of the visual field, and (iii) evaluation of the Optic Nerve Head (ONH). While checking the causes of glaucoma also could be with more attention given to sex, race, history of drug use, refraction, inheritance and family history.

Glaucoma leads to (1) structural changes of the optic nerve head (ONH) and the nerve fiber layer and (2) a simultaneous functional failure of the visual field. By slowly fading of neuroretinal rim indicating degeneration of axons and astrocytes of the optic nerve results in the structural changes. As lost capabilities of the optic nerve cannot be recovered, early detection and subsequent treatment is essential for affected patients to preserve their vision [10].

Glaucoma can be detected by applying intelligent algorithms for extracting diagnostic features from different imaging modalities like Fundus, Optical Coherence Tomography (OCT), Ultrasound and Heidelberg Retina Tomogram (HRT) etc.

There are some conventional diagnostic techniques such as Tonometry, Ophthalmoscopy, Perimetry, Gonioscopy, Pachymetry and Nerve fiber analysis for glaucoma detection. These diagnostic methods are tiresome, time consuming and costly.

▪ **Tonometry** – In this, the examiner needs to measure the inner pressure of the eye through pressure applied by a puff of warm air or a tiny tool. While doing so, the examiner uses a tonometer, as we know that the eye may numb due to eye drops.

- **Ophthalmoscopy** - The pupil is dilated via the application of eye drops. Using a small magnification device with a light on the end, the examiner can examine the magnified optic nerve.
- **Perimetry (Visual Field Test)** - The patient looks straight ahead and is asked to indicate when light passes the patient's peripheral field of vision.
- **Gonioscopy** - Eye drops are used to numb the eye. A contact lens with a mirror is positioned gently on the eye to allow the examiner to get the angle between the cornea and the iris.
- **Pachymetry** – In this, to measure the thickness, the pachymeter gently placed on the front of the eye.
- **Nerve Fiber Analysis** - The retinal nerve fiber layer can be assessed with imaging techniques such as Optical Coherence Tomography (OCT), Scanning Laser Polarimetry, Scanning Laser Ophthalmoscopy (Heidelberg Retinal Tomogram) etc.

Over past years, digital image processing techniques are preferred in the detection of eye diseases. Digital image processing supports the ophthalmologist in glaucoma detection. Glaucoma detection through computer-aided diagnostics plays an important role in medical science and supports an ophthalmologist to diagnosis glaucoma through digital image processing. The several public and private databases of retinal fundus images which can be used for research related to glaucoma as DRIONS-DB dataset, HRF data set, STARE data set, VEP data set, IPN data set, ORIGA data set, ORIGA-light data set, DRIVE data set, Local or Private data set etc. [11].

One serious threat and cause of concern for glaucoma is unlike many other diseases the signs and symptoms of glaucoma are not immediately felt and experienced by the patient [12]. By the time the patient experiences the signs and symptoms of glaucoma, the damage in the retina is done. So, New diagnostic approaches should be developed that would enable early detection of glaucoma as it prevents the development of the disease and progression of the condition.

6. GLAUCOMA TREATMENT

Glaucoma has been called the ‘silent thief of sight’ because the loss of vision usually occurs slowly over a long period of time. Glaucoma is not curable and the loss of vision cannot be regained but with early diagnosis it is possible to avoid further loss of vision by proper treatment. Glaucoma treatment includes medical management, trabeculectomy, laser surgery, and drainage implants, etc.

Commonly, surgical treatments for glaucoma involve bypassing trabecular meshwork resistance by routing aqueous humor directly to the subconjunctival space. In recent years, trabeculectomy is the most common penetrating surgery for glaucoma. Lately, Rho Kinase (ROCK) inhibitors Ripasudil, K-115 and Netarsudil, AR-13503 have been permitted for ophthalmological use in therapy of glaucoma [13].

One major problem to present techniques is the lack of standardization. Safety and better efficiency can be achieved with improved standardization and reproducibility in glaucoma surgery. Fortunately, glaucoma surgery is moving toward safer, more reproducible and micro-invasive options comparable to what was seen with cataract surgery with the advent of phacoemulsification [14].

7. OPEN RESEARCH ISSUES

Researches related with automatic and early detection of glaucoma have been done, but the open research issues are still potential in this field. Some potential research concerns that can still be developed are mentioned below -

- Use a combination of different features for automatic glaucoma detection.
- Use a combination of different feature extraction technique: non-morphology (image based feature) and morphology (need segmentation process).
- The classification of glaucoma using different feature or type of feature extraction technique, which the result is not only distinguish normal or glaucoma but several stage of glaucoma (early, mild and advance).
- Several publications have already been done in the glaucoma field. The conclusions from this will be useful for the design of glaucoma

database, screening, early detection, treatment, rehabilitation, and related public health strategies. However, working on a summary of the findings is currently lacking.

8. CONCLUSION

The main determination of this research paper is to highlight the severity of glaucoma across the globe. Glaucoma is encompassed as one of the priorities among the avoidable blinding condition. Elimination of glaucoma blindness is feasible only when sufficient measures will be taken at all levels of services. There is a lot of research going on and novel detection techniques, treatments may become available for glaucoma in the near future.

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