GLAUCOMA: INTRODUCTION AND EPIDEMIOLOGY

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INTRODUCTION AND EPIDEMIOLOGY

WHAT IS GLAUCOMA?

Glaucoma is a commonly diagnosed neuro-degenerative ophthalmic condition. There are a number of other such systemic, neuro-degenerative diseases such as Alzheimer's, Parkinson's, Huntington's, and Amyotrophic Lateral Sclerosis, however glaucoma is seen in twice as many people as the others combined (WHO 2010). In 2010 the World Health Organization (WHO) estimated that glaucoma accounted for 2% of global visual impairment and 8% of global blindness. Disability adjusted life years attributable to glaucoma more than doubled between 1990 and 2010 (Murray, 2012). Therefore, glaucoma is a disease of great public health importance.

EPIDEMIOLOGY OF GLAUCOMA

The impact of glaucoma, based on epidemiological studies, is seen in estimates made by the World Health Organization (WHO) for 2010.

- Estimates indicate that there were 60.5 million people worldwide with glaucoma in 2010, increasing to 79.6 million by 2020; of these, 8.4 million bilaterally blind by 2010, increasing to 11.2 million by 2020.
- 74% will have open angle glaucoma (OAG).
- Women comprised 55% of OAG, 70% of angle closure glaucoma (ACG), and 59% of all glaucoma in 2010.
- Asians represent 47% of those with glaucoma and 87% of those with ACG.
- The cost of treating glaucoma is approximately $1.9 billion annually in the US.
- It has been estimated that treatment saves approximately 65,000 eyes per year from blindness in the USA alone.

DEFINITION

Glaucoma refers to a group of conditions with multiple causes that result in damage to the optic nerve head and loss of visual field. Historically the disease was defined by a significant increase in intra-ocular pressure (IOP) above the normal value. The normal mean value for IOP is 15.5 mm Hg with ± 2 standard deviation giving a range of 10-21 mm Hg. However, we now know that glaucoma can develop without a rise in IOP and therefore this is no longer a defining characteristic (EMGT).

Primary open angle glaucoma is the most common type accounting for over 70% of cases. However, it is believed that 20-52% of patients with glaucoma have their IOP within the normal range and are thus said to have low (or normal) tension glaucoma (King, 2013).

CHARACTERISTICS OF GLAUCOMA

- Bilateral
- Chronic
- Slowly progressive

"In the early stages of glaucoma, the only reliable compass is usually the observation of change, particularly of an objective phenomenon such as narrowing of the neuroretinal rim or thinning of the retinal nerve fiber layer" (Spaeth, 2011).

'OUTDATED' DEFINITIONS OF GLAUCOMA

The definition of glaucoma has changed over time. First, consider the 'outdated' definition of glaucoma, which is no longer accepted.

- "Glaucoma is the name given to a group of ocular conditions characterized by":
  - Elevation of intraocular pressure (IOP)
  - Cupping of the optic nerve head
  - Visual field loss."
    (Kanski and McAllister*, Glaucoma. Butterworths.1989.)*

- Glaucoma is a distinctive optic neuropathy associated with visual field loss and raised IOP.
  - Up until the 1990's if IOP was measured a greater than 21 mm Hg, the patient was automatically diagnosed with glaucoma and IOP lowering strategies were employed.

MORE RECENT GLAUCOMA DEFINITION

Glaucoma is a progressive, chronic optic neuropathy in which intraocular pressure (IOP) and other currently unknown factors contribute to damage from which, there is a characteristic acquired atrophy of the optic nerve and loss of retinal ganglion cells and their axons.

- Glaucoma refers to a group of diseases that have in common a characteristic ***optic neuropathy, retinal ganglion cell loss*** *and, eventually,* an associated ***visual field defect.***

- Presence or absence of elevated intraocular pressure no longer plays a role in the definition of glaucoma

PATHOPHYSIOLOGY OF GLAUCOMA

Glaucoma is a pathophysiological change of the optic nerve resulting in loss of vision. There are many theories to support the pathophysiological nature of glaucoma but, in large part, the exact etiology in most cases is relatively unknown.

The role of the optic nerve is to transmit visual signals to the brain. The optic nerve changes that occur in glaucoma, not only affect the nerve appearance, but the function as well. Glaucomatous change results in a loss of nerve fibers, which ultimately leads to visual field changes. As stated above, the nature of glaucomatous change is slow and progressive in most cases.

There are two main competing theories used to explain the pathophysiology of glaucoma. The mechanical theory best explains damage occurring from mechanical forces such as increased intraocular pressure. The vascular theory contributes blood flow abnormalities to the development of glaucoma and best describes normal tension glaucoma. There are also a host of secondary forms of glaucoma that arise for various reasons.

OPTIC NERVE CHANGES IN GLAUCOMA

- Ganglion cell axons travel superficially within the nerve fiber layer then make a 90-degree turn to traverse the optic nerve
- This becomes the neuro-retinal rim tissue of the optic nerve (Figure 8.1). Therefore, the neuro-retinal rim tissue is comprised mostly of ganglion cell axons
- The neuro-retinal rim tissue also contains capillaries and connective tissue support.

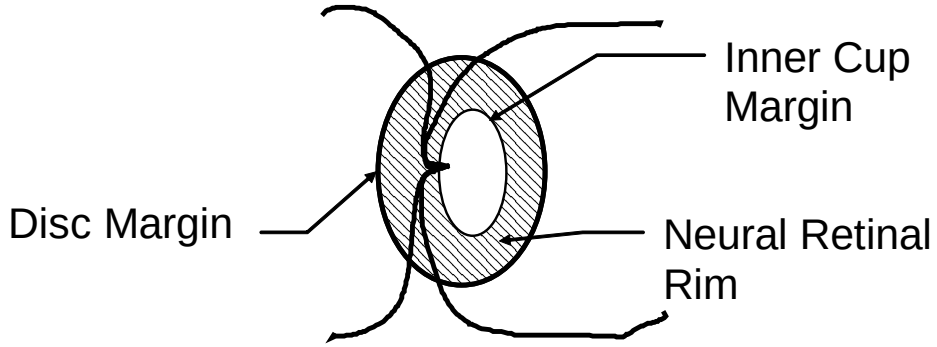

Figure 8.1: *Physiological optic nerve head landmarks*

- In the center of the optic disc, there is an area that has an absence of tissue called the optic cup (Figure 8.2)
- In glaucoma, ganglion cells axons die which then corresponds to a loss of the neuro-retinal rim tissue. Subsequently, the size of the optic cup increases.
- Most notably the changes to the neuro-retinal rim appear along the superior and inferior bundles due in part to their anatomical arrangement.

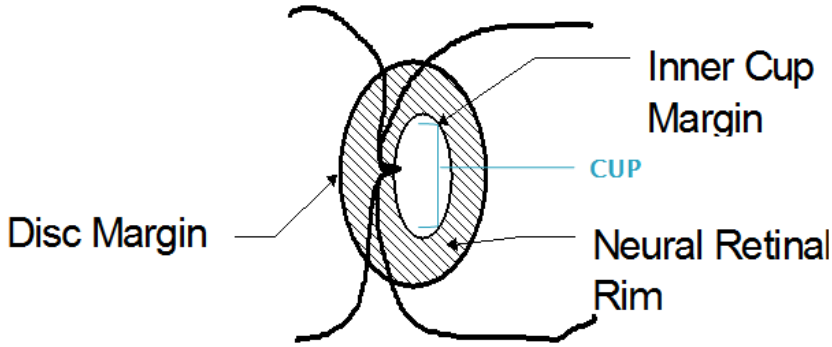

Figure 8.2: *Optic nerve cup*

Figure 8.3 shows photos of the optic nerve head as it changes through the development of advanced glaucoma. Darker orange regions correspond to the nerve fibers that come from the periphery, bend and go out of the eye. When these fibers are missing, the tissue looks more yellowish. We can see that, as glaucoma progresses, in images to the right - the nerves are less abundant and the paler yellow area increases in size and becomes more visible.

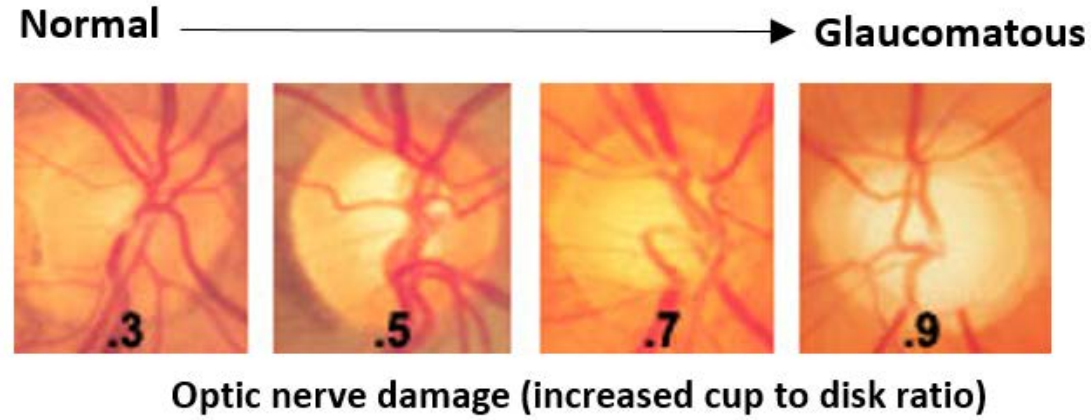

Figure 8.3: *Progression of glaucoma and simulated vision loss*

The effect of this reduction in nerve fibers can be appreciated through the simulated image shown on the right in Figure 8.3. There is loss of vision, initially in the periphery but there is potential for loss of central vision later in the disease

resulting in blindness. There are usually no symptoms in earlier stages of the disease. Therefore it is estimated that half the people affected with glaucoma are unaware until late in the disease when central vision is affected. At this stage there is nothing that can be done to repair the damage because the nerve fibers are dead. This has contributed to making glaucoma the second leading cause of blindness in the world.

Figure 8.4: *Glaucomatous optic nerve cupping*

TYPES OF GLAUCOMA

CLASSIFICATION OF GLAUCOMA – ANGLE STRUCTURE

Correct classification of glaucoma is important when establishing the optimum treatment plan. The two major classification used for glaucoma are as follows:

- Open angle
- Closed angle

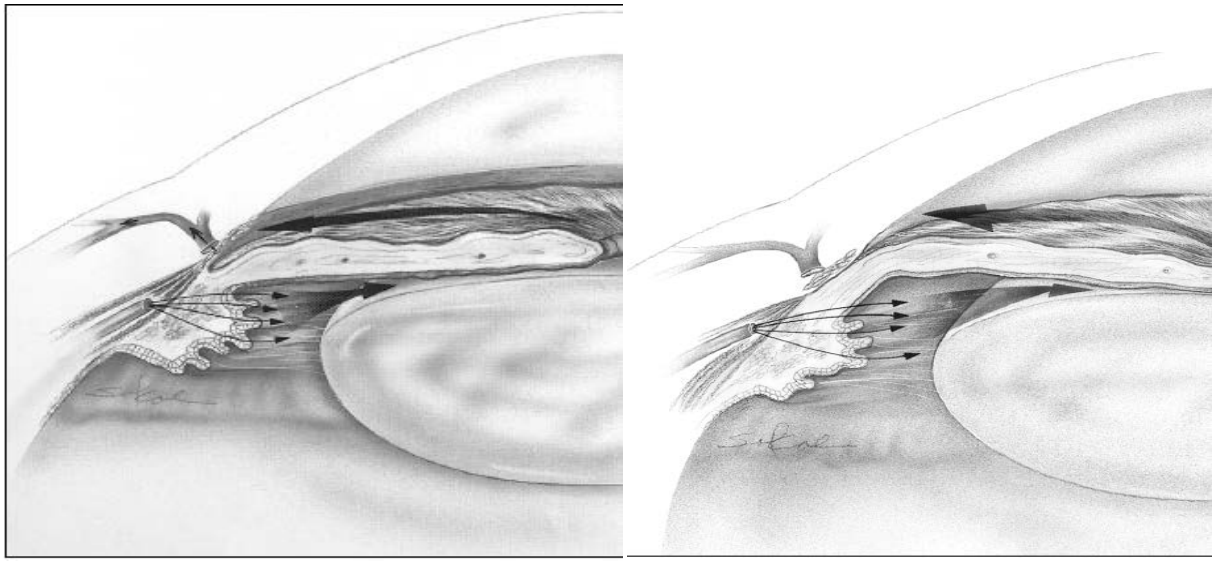

Figure 8.5: *Left: Open angle glaucoma and Right: Closed angle glaucoma*

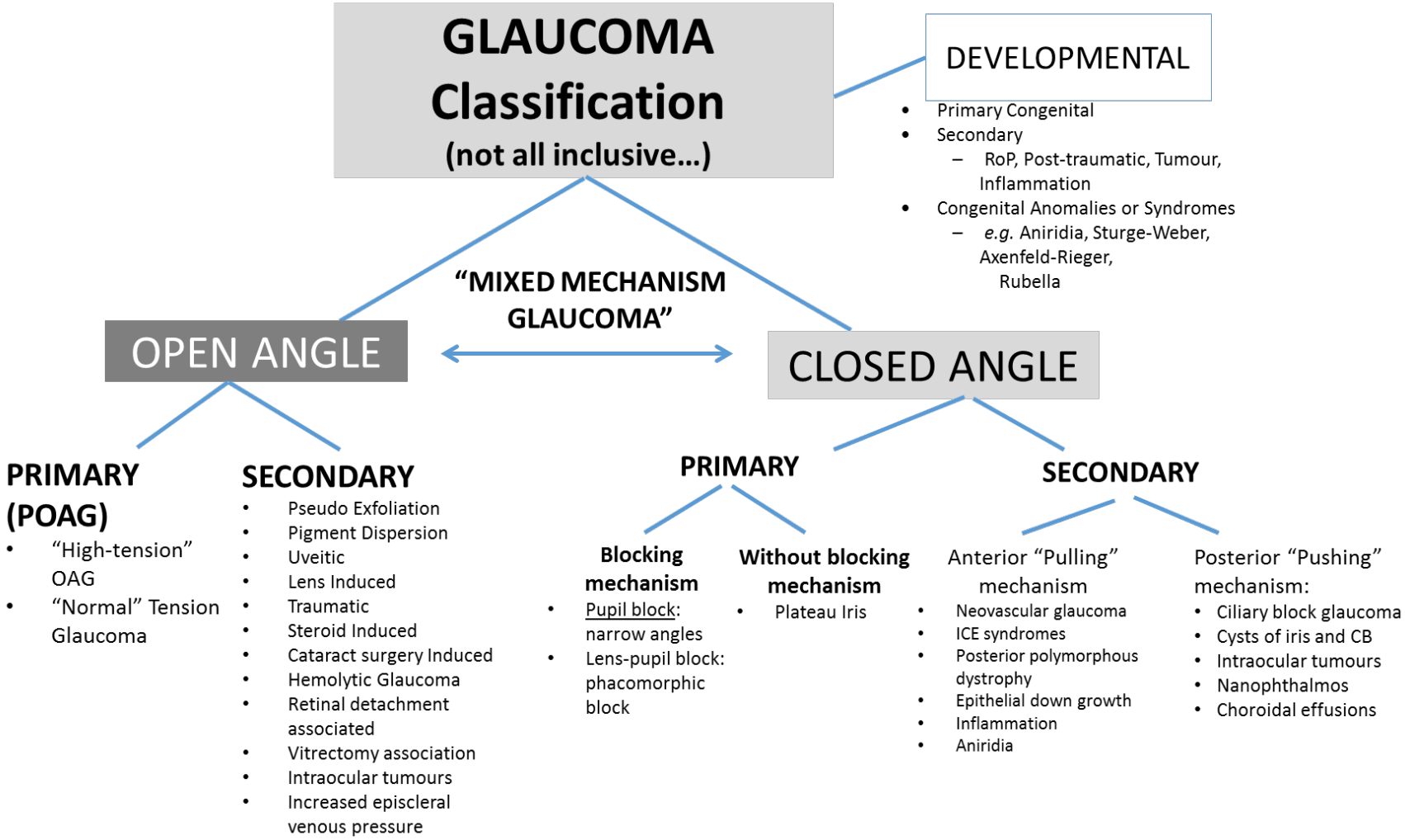

Figure 8.6: *Classification of glaucoma (McIver)*

PRIMARY FORMS OF GLAUCOMA (IDIOPATHIC)

i. **Primary open angle glaucoma (POAG)**: this is the most common form of glaucoma. The definition refers to the fact that the anatomical angle of the anterior chamber of the eye is open. There are several theories to describe the pathophysiology of the disease process.
    1. One theory suggests that the drainage angle of the eye loses its ability to maintain the intraocular pressure adequately. This can be due to inadequate draining of the aqueous fluid or elevated aqueous fluid production.
    2. Other theories suggest there is a change in blood flow to the optic nerve, thus causing damage to the nerves.

ii. **Normal tension glaucoma (NTG)**: the etiology behind this type of glaucoma is largely unknown. The intraocular pressure is typically lower than 21 mm Hg, but optic nerve damage continues despite this fact.

iii. **Angle closure glaucoma (ACG):** is caused by an anatomically narrow angle. When and if the angle closes, it causes a significant increase in the intraocular pressure. The nerve damage can happen relatively quickly if the intraocular pressure is not lowered.

iv. **Congenital glaucoma:** is associated with developmental anomalies which are present at birth or early childhood. These types of glaucoma are often related to systemic malformations as well.

SECONDARY FORMS OF GLAUCOMA (ASSOCIATED WITH COMORBIDITY)

v. **Traumatic glaucoma:** arises due to trauma to the eye. The nature of the trauma can cause an anatomical change in the drainage angle. The anatomical changes result in a reduction in the outflow of aqueous fluid.

vi. **Pigment dispersion glaucoma:** is characterized by excessive pigment within the drainage angle of the eye. The pigment accumulates and causes a blockage in the outflow of aqueous fluid. It is characteristic of this type of glaucoma to observe pigment on the corneal endothelium (known as a Kruckenberg spindle), iris transillumination, and pigment in the trabecular meshwork.

vii. **Neovascular glaucoma:** is caused by the growth of new blood vessels in the drainage angle of the eye. The underlying etiology is based upon a decrease in oxygen to the eye. Neovascular glaucoma is related to systemic and ocular vascular disease. Such events include, but are not limited to, sickle cell anaemia, carotid occlusive events, and diabetic retinopathy.

viii. **Pseudo-exfoliative glaucoma:** is a result of a systemic condition. A basement membrane disorder results in production and deposition of material in various locations in the body. In the eye, the material deposits at the pupillary margin, on the crystalline lens, on the lens zonules, and in the trabecular meshwork. The material in the trabecular meshwork causes a reduction in the outflow of aqueous fluid and a consequent rise in IOP.

ix. **Steroid induced glaucoma:** arises in response to the use of ocular steroids. Steroids are used routinely to control inflammation in the eye. Approximately 20-30% of the population responds adversely to steroid use with a rise in IOP.

x. **Inflammatory glaucoma:** is related to ocular inflammation in the form of uveitis. The inflammatory cells will invade the trabecular meshwork of the eye and impede the outflow of aqueous fluid. This ultimately causes an elevation in the intraocular pressure.

RISK FACTORS ASSOCIATED WITH GLAUCOMA

The chronic forms of glaucoma can destroy vision before any signs or symptoms are apparent. It is critically important that the eye care practitioner is aware of the major risk factors for glaucoma and takes the appropriate steps to evaluate all of their patients who may present with one or more of the following (Coleman, 2008):

- Intraocular pressure elevation
- Older age
- Family history of glaucoma
- African ancestry or Hispanic ethnicity
- Thin central cornea
- Low ocular perfusion pressure
- Type 2 diabetes mellitus
- Myopia
- Steroid use

RACIAL DIFFERENCES IN GLAUCOMA

A meta-analysis showed a substantial variation in glaucoma prevalence rates in adults according to ethnicity (Rudnicka, 2006).

- African descent
  - 4 times greater risk of OAG than any other race
  - 2% over the age of 40 years
  - Earlier age of onset compared with Caucasians
- Hispanic descent
  - OAG > Europeans
  - Rises rapidly with age
  - > 75 years, similar to Africans
- Chinese descent
  - 5 times greater risk of ACG (Angle Closure Glaucoma) than Europeans or Africans
  - ACG ≈ OAG (5 times greater in all other ethnicities)

EPIDEMIOLOGY OF ANGLE CLOSURE GLAUCOMA (ACG)

- Among Caucasians, open angle glaucoma accounts for 85-90% of cases
- Among Asians, particularly Chinese, ACG is more common than previously assumed
- ACG accounts for 26% of all glaucoma cases
- Despite greater prevalence of OAG, ACG accounts for > 50% of all blindness caused by glaucoma

- China
  - 21% of world's population
  - 30% of world's glaucoma

- S.E. Asia, India, Africa, Europe/N. America
  - 16-20% of world's population each
  - 16-20% of world's glaucoma each

However,

- Uniformity is in spite of different demographics and prevalence e.g. median age for OAG in:

- Africa: is 57 years of age
- Europe: is 77 years of age

GLAUCOMA AS AN INCREASING PUBLIC HEALTH CONCERN

The social and economic burden, due to the prevalence of glaucoma in the community, is likely to increase in the future because of a longer life expectancy and an ageing population. Some key issues when considering the public health impacts include the following:

- Baby boom increase in the older population is happening
  - There will be a 50% increase in the prevalence of glaucoma by 2020 (compared to 2000)
- People are living longer
  - By the year 2040, the number of patients with glaucoma over the age of 85 will triple
  - In the year 2000 people aged 65 and older made up 12.4% of the US population but by 2040 this will almost double to 20.4% of the population (Goldberg, 2000)
- Glaucoma is a chronic disease therefore there is a high cost of POAG on the health care system
  - Cost of treatment
    - Estimated cost of treatment in the USA is $1.6 billion
  - Burden of blindness
    - USA federal government provides over $1 billion dollars to assist persons who are blind from glaucoma

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