Understanding GLAUCOMA...

The Science Behind Current Testing and Therapy

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Objectives:
1) To understand that glaucoma is a disease process that affects the optic nerve
2) To understand the relationship between intraocular pressure and glaucoma
3) To become familiar with the tests used in glaucoma
4) To become familiar with the treatment options for glaucoma
5) To be aware that there are many classifications and types of glaucoma

What is Glaucoma?
• Disease process damaging the optic nerve
• NOT just a disease of eye pressure
• Slow, progressive damage & loss of nerve fibers that carry information from the eye (retina) to the brain
• Initially causes loss of side vision and eventually can lead to complete blindness

A multi-factorial disease
• Can be related to:
  ▪ Intraocular pressure
  ▪ Functioning of the eye’s drainage system
  ▪ Structure of the optic nerve
  ▪ Blood supply to optic nerve
  ▪ Underlying defects in eyes
  ▪ Genetics
  ▪ Previous trauma or inflammation
  ▪ Steroid use

Risk Factors for Glaucoma
• AGE
  ▪ greater risk as get older
  ▪ certain types of glaucoma may occur at younger ages
• RACE
• INTRAOCULAR PRESSURE
  ▪ the higher the pressure, the greater the risk
• FAMILY HISTORY of GLAUCOMA
  ▪ having a sibling, parent, grandparent with glaucoma is a greater risk, multiple family members is more risk

Visual Pathway
1) Light enters pupil & hits retina
2) Photoreceptors connect to nerve fibers
3) Nerve fibers travel from all parts of retina and merge to form optic nerve
4) Optic nerve carries image back to brain
  ▪ the “telephone cord”
5) Brain is what processes images
6) No optic nerve = no sight
Layout of Nerve Fibers in Retina
- 1.2 million nerve fibers per eye
- In peripheral retina, many photoreceptors connected to only one nerve fiber
- In macula, one photoreceptor to one nerve fiber
- Fibers never cross the horizontal midline

Optic Nerve Head (ONH)
- All of these fibers come together at the optic nerve head then dive back together toward the brain to form optic nerve
- Creates a doughnut-like structure with good wires around the edges and hole in the center

Cup-to-Disc Ratio (C/D ratio)
- Ratio of the size of hollow part to the overall size of the nerve
- Written as decimal which represents percentage
- 10% of nerve is cup = 0.1
- 50% of nerve is cup = 0.5
- Average nerve size is 0.4

Grow bigger or start out bigger?
- As nerve fibers die off around the edges, the cup (the hole in the center) gets larger so the C/D ratio increases
  - C/D Ratio of 0.4 grows to 0.7
- We all come with different sizes of nerves
  - 0.1, 0.4, 0.6, 0.8
  - Can a C/D ratio 0.8 be normal?

Physiological Cupping
- If canal that optic nerve exits out through sclera is large in diameter, then fibers can spread out more
- Creates larger appearing cup even though there is same number of nerve fibers
Possible changes to optic nerve due to glaucoma

- Concentric enlarging of the optic cup
- Asymmetric cupping between eyes
- Notching/thinning of the rim tissue (usually happens at superior or inferior rim)
- Baring of blood vessels
- Parapapillary atrophy
- Nerve fiber layer hemorrhage (Drance heme)

Enlarging Cup over time

Asymmetric Cupping OS > OD

Inferior Notching, Baring of Vessels
Inferior notch

Nerve Fiber Layer Hemorrhage, Inferior notching

Peripapillary Atrophy

Advanced cupping

Intraocular Pressure (IOP)

- Pressure of the aqueous humor that fills the anterior and posterior chambers of the eye
- Anterior Chamber = area between iris and cornea
- Posterior Chamber = area between back or iris and front of lens

Route of Aqueous Humor

- Aqueous is produced by ciliary body, located in posterior chamber
- Has to pass over lens, through pupil, and into anterior chamber
- Drained out through the trabecular meshwork in the "angle"
- Into venous system

Figure 6.39 End-stage glaucomatous cupping

Figure 6.47 Glaucomatous cupping with a splinter haemorrhage at 7 o'clock

Figure 5.40 Peripapillary changes with a peripapillary stump synech (a) and infranone bodies (b) associated with advanced atrophy

Figure 6.4 Glaucomatous oedema of the optic disc with anterior and posterior chambers of ney. The optic disc is elevated and the cupping is evident.
**Trabecular Meshwork**

... say what?

- Sieve-like structure
  - Drains 90% of aqueous humor
- Network of both loosely-organized and tightly-linked cells
  - Offers varying levels of resistance to outflow
- Varies in amount of pigmentation

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**Level of IOP**

Determined by balance between:

- Rate of aqueous production by ciliary body
- Rate of aqueous drainage by the trabecular meshwork

- Measured in mmHg

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**Fluctuation in IOP**

- Normal IOP varies with time of day, heart beat, blood pressure level, respiration
- Diurnal curve
- Range of fluctuation
  - Mean range is 5 mmHg for normal eyes
  - Greater variability can be indicative of glaucoma
- Single IOP measurement may be misleading

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**“What’s normal?”**

- Statistically,
  - Normal pressure is 10 to 22 mmHg
  - Mean is 16 mmHg
  - Bell curve & Standard deviation
    - 97.5% of population between 10 & 22
    - 2.5% will have pressures below 10 and above 21 just by statistics, not pathology
- What matters is what is normal and safe for that individual patient’s optic nerve!!!!!!

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**IOP is Risk Factor**

**The higher the pressure, the more likely glaucomatous damage is to occur**

- There are patients with IOP higher than “normal” but never develop glaucoma = Ocular Hypertension
- There are also patients with IOP in the normal range who do develop glaucoma = Normal Tension Glaucoma (NTG or LTG)

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**Ocular Hypertension**

- IOP consistently ≥ 21 mmHg **WITHOUT** damage to optic nerve
  - IOP 20-24 = approx 2.5% prevalence
  - IOP 25-29 = approx 10% prevalence
  - IOP 30+ = approx 40% prevalence (1 in 2.5 people)
- Monitor closely, but don’t always treat

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Measuring IOP

- **Non-Contact Tonometry (NCT)**
  - "air puff" test
  - easy to use, no anesthetic required, minimal training
  - only accurate in low to mid ranges of IOP

- **Tonopen**
  - hand-held, portable
  - good for irregular cornea, narrow lid apertures
  - overestimates low IOP, underestimates high IOP

- **Perkins**
  - hand-held applanation tonometer
  - does not require slit lamp
  - can be difficult to get reliable readings

- **Goldmann Applanation Tonometry**
  - gold standard, most accurate
  - requires anesthetic and trained staff

Goldmann Applanation Tonometry

- Correct endpoint is when inner edges just touch (c)

- Potential errors:
  1. Inappropriate Fluorescein Pattern
  2. Not being in the center of the cornea
  3. External pressure to the Globe (holding patient’s lids open)
  4. Patient not breathing, squeezing eyes shut, forcing themselves into slit lamp
  5. Corneal Pathology

Corneal thickness

- Goldmann Tonometry is calibrated for corneal thickness of 0.545 mm
  - If cornea is **thinner** than average = underestimates IOP
  - If cornea is **thicker** than average = overestimates IOP

Corneal Pachymetry

- Must check perpendicular to cornea
  - if measure at angle may measure thicker than should be
- Must check in center of cornea
  - cornea gets thicker as go to periphery

What is the “ANGLE”

- Location of the drainage apparatus
  - particularly, the **trabecular meshwork**
- Encircles 360 degrees
- Open, narrow, or closed
- Viewed by **gonioscopy**

Gonioscopy

- Procedure done to view the angle
- Determine if angle is open, narrow, or blocked in some way
- Classifies type of glaucoma
- Uses a mirrored lens that sits on cornea (3 mirror or 4 mirror)
- **MUST BE DONE BEFORE DILATION!!!!**
4-mirror Gonio Lens

How Gonio Lens Works

Why is the angle important?

- Need to determine if there is anything present in the drain that might block or impair fluid from draining out of the eye (blood vessels, pigment)

- Judge the likelihood that that patient’s angle might close ("occlude"), not letting aqueous drain out, therefore causing IOP to spike up suddenly (50+)
  - If occludable, DON’T DILATE!

Structures in the Angle

- Peripheral iris
- Ciliary Body
- Scleral Spur
- Trabecular Meshwork
- Schwalbe’s line – where cornea ends
  - The more structures you can visualize, the more accessible the drain is

What’s important to note about the angle?

1. Number of structures seen
   - Grade 4 (IV) - Wide open - incapable of closure

2. Shape & contour of peripheral iris
   - Grade 3 (III) - Open - incapable of closure

3. Trabecular pigment

4. +/- Peripheral Anterior Synechiae (PAS)
   - Grade 2 (II) - Moderately narrow - angle closure unlikely

5. +/- Neovascularization

6. +/- Angle recession
   - Grade 1 (I) - Very narrow - high risk of angle closure

Grading the Angle
Types of Glaucoma

- **Primary Open Angle (POAG)**
  - IOP > 21
  - Drain is open

- **Normal Tension (NTG/LTG)**
  - IOP < 21
  - Drain is open

- **Primary Angle Closure**
  - Drain narrow or completely closed
  - Born narrow (small eye, hyperopia)
  - Cataract squishing it shut
  - Symptomatic – IOP goes up really high really fast

- **SECONDARY GLAUCOMAS**
  - Drain is technically “open” but there is something blocking fluid from draining out as well
    - Pigmentary
    - Pseudoexfoliative
    - Neovascular
    - Traumatic (Angle Recession)
    - Inflammatory
    - Structural

- **Congenital**
  - Drain born with malformation that blocks fluid from even getting to the drain

Gonioscopy of Closed Angle

- **Phacomorphic Glaucoma**
  - Advancing cataract causes shallow anterior chamber

- **Pupillary Block**
  - Secondary angle closure glaucoma caused by pupillary block

- **Pseudoexfoliation on Anterior Lens Capsule**
  - Figure 6.64 Central disc of pseudoexfoliative material

- **Trabecular Meshwork Pigment**
  - Figure 6.80 Secondary angle-closure glaucoma caused by pupillary block
Neovascularization of the Angle (NVA)

Figure 6.76 Early angle neovascularization.

Angle Recession

Figure 6.91 Gonioscopic view of angle recession showing irregular reflection of the ciliary body band.

Peripheral Anterior Synchiae

- Bad adhesions between iris and drain that stop fluid from getting out of the eye
- Due to inflammation in eye (uveitis/iritis), trauma, previous high eye pressures, laser treatments

Figure 6.82 Partial angle closure by peripheral anterior synchiae.

So what are the Symptoms of Glaucoma? ...

- NONE initially!!
- Have to lose enough nerve fibers that central vision becomes affected or a large enough portion of side vision has been lost
- Not reversible - cannot replace fibers that have been lost
- Key is early diagnosis !!

Visual Field

- Superior Retina = inferior visual field
- Inferior Retina = superior visual field
- As Superior Nerve dies off, an inferior visual field defect will occur
- Have to lose about 50% of wires before defect shows up on VF testing

Figure 6.23 Patterns of retinal nerve fibers.

Ways to test Visual Field

- Confrontation Visual Fields
- Automated Perimetry
  - Frequency Doubling Perimeter
  - Humphrey Perimeter (gold standard)
    - 24-2 tests 48 degrees of field
    - 30-2 tests 60 degrees of field
- Goldmann Perimeter
  - Done by hand – not automated
  - Tests side vision with different sizes and brightnesses of light
Humphrey Visual Fields
(a whole lecture on its own)
- Threshold test
- Age-matched normals
- Reliability tests (fixation testing)
- “Learning Curve”
- Mean Deviation vs Pattern Deviation
- Glaucoma Hemifield Test (GHT)
- Physiological Blind Spot
- Used for diagnosis as well as to monitor for stability or progression while on treatment

Types of VF defects
- Early Defects
  - Nasal Step
    - See above or below horizontal midline
    - Superior nasal step means inferior nerve damage
  - Extension of Blind Spot inferiorly or superiorly

Arcuate Defects

Inferior nasal step

Normal Humphrey VF

Altitudinal Defect, Constricted
**Advanced loss**

- **Nerve Fiber Layer Analysis**
  - Computerized method for documenting thickness of nerve fiber layer around the circumference of the nerve
  - Can do serial analysis to catch subtle changes in thickness over time
  - Catch earlier loss than VF
  - Different Brands: OCT, GDx, HRT

**Normal OCT**
- Bimodal curve (2 humps - superior and inferior)
- Colors represent demographics
  - Green = normal
  - Yellow = caution
  - Red = bad
- Nerve thickest superior and inferior

**Abnormal OCT**
- Line is flat
- Loss of normal bimodal curve
- Lots of Red
- Thinnest sup and inf
  - Advance nerve fiber thinning
  - Advanced Glaucoma

**Inferior notch in Glaucoma**
- Patient with low tension glaucoma in OD only with inferior notch

**Glaucoma...**
- Treatment
**Treating Glaucoma**

**MANAGE IOP**

- Goal: reduce IOP to a level that will slow down damage from glaucoma enough so that patient will remain asymptomatic during their life span
  - Set "target" pressure for each patient and each eye!
  - Glaucoma is slowly progressive disease, don't always have to get pressure to 10 – the more advanced, the lower the target
  - May need to change target IOP if disease progressing too quickly

**Treatment Options**

- **Eye drops**
  - decrease aqueous production and/or increase aqueous outflow
- **Oral pills**
  - decrease amount of aqueous produced
- **Laser treatments**
  - increase outflow through angle
- **Surgery**
  - increase outflow by bipassing angle and draining aqueous out under conjunctiva

**Pressure Drops**

- **Prostaglandin Analogs**
  - **Brands**
    - Xalatan (latanoprost) – only generic
    - Travatan Z
    - Lumigan
    - Zioptan (preservative-free vials)
    - Rescula (only one that is BID)
  - **Dosing** – 1 gtt QHS
  - **Turquoise cap**
  - Increase outflow
  - "First line" therapy, 25-30% IOP reduction
  - **Side effects**: darkening of iris and skin around eye, thickening/lengthening of lashes, red eye, inflammation in eye

- **ß- Blockers**
  - **Names**
    - Timolol (0.25%, 0.5%), Ista, Timoptic XE (gel)
    - Timoptic in Ocudose (preservative-free vials)
    - Betagan, Betoptic S
  - **Dosing** – either QAM or BID
  - **Yellow Cap**
  - Decrease production of aqueous
  - "First Line" therapy, 25-30% IOP reduction
  - **Side effects**: difficulty breathing, decreased heart rate (don't give if COPD, emphysema, asthma, bradycardia)

- **Alpha Agonists**
  - **Names**
    - Alphagan P (0.1%)
    - Brimonidine (generic – 0.15%, 0.2%)
  - **Dosing** – BID or TID
  - **Purple cap**
  - Decrease production of aqueous
  - Usually second or third med, 15-20% IOP reduction
  - **Side effects**: red irritated eyes, itching, follicular conjunctivitis (worse in generic)

- **Carbonic Anhydrase Inhibitors (CAIs)**
  - **Names**
    - Azopt
    - Trusopt
  - **Dosing** – BID or TID
  - **Orange Cap/sticker**
  - Decreases production of aqueous
  - 15-20% IOP reduction
  - Additional med, not usually mono therapy
  - **Side Effects**: red irritated eyes, unpleasant taste
Combination Pressure Drops

- Improve compliance when multiple meds needed
  - **Cosopt**
    - Combination of timolol and trusopt – now has generic and can get in preservative-free vials
    - Dosing – BID
    - Large bottle with dark blue sticker
    - Side effects: red irritated eye, avoid breathing problems
  - **Combigan**
    - Combination of timolol and alphagan
    - Dosing – BID
    - Dark blue cap
    - Side effects: avoid breathing problems

Pressure Drops

- **Sympathomimetics**
  - Names
    - Pilocarpine (1, 2 and 4%)
    - Carbachol
  - Dosing – BID to QID
  - Increase outflow by pulling open pillars of drain
  - Green cap
  - Side Effects: miosis of pupil, peripheral retina pathology (tear, RD), accommodative spasm, headache

Oral Pills to reduce IOP

- **Carbonic Anhydrase Inhibitors**
  - Decreases aqueous (and CSF) production
  - Used mostly for sudden IOP decrease in angle closure glaucoma (IOP 50+)
  - Side Effects: tingling of skin, metallic taste, don’t give if kidney disease
  - **Diamox tablets**
    - 250 mg QID or 500 mg Sequel BID

Laser Treatments

- **Argon Laser Trabeculoplasty (ALT)**
- **Selective Laser Trabeculoplasty (SLT)**
  - Laser the drain to make it work better
  - Do when drops not enough or poor compliance
  - Do ½ of the drain at a time (180 degrees)
  - May still need drops, particularly after several years
  - Works better when more pigment in angle and for certain types of glaucoma
  - ? Repeatability

Laser Trabeculoplasty
Peripheral Iridotomy (LPI)

- **Ultimate fix for narrow angle glaucoma**
- Use laser to make small opening in iris
- This offers alternate passage (other than just through pupil)
- Equalizes pressure between space in front of and behind iris so pressure cannot push forward the iris and close the angle

Laser Peripheral Iridectomy

Trabeculectomy

- **Surgery** – done under anesthesia in surgery center
  - Make a new drain for fluid to get out of anterior chamber (skipping trabecular meshwork)
  - Incision made like a trap door at edge of iris (usually superior)
  - Creates a “bleb” – or elevation where aqueous is draining out under conjunctiva
  - Done when maximum medical therapy not getting IOP low enough – more advanced glaucoma

“Bleb” after trabeculectomy
“Bleb” and Superior Iridotomy

- Used for advanced glaucoma when blebs fail/scar
- Plastic tube placed in anterior chamber and sewn into place under conjunctiva

Shunt Tubes

The end...

Questions?

Thank you!