COT/COMT REVIEW

TONOMETRY

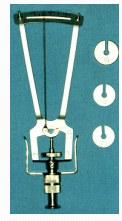
What is Tonometry?

- Tonometry is the measurement of the intraocular pressure of the eye
- Measured in millimeters of mercury (mmHg)
- It is not measured directly—it is measured noninvasively using either indentation or applanation

- Tonometry
  - Measures IOP in millimeters of mercury (mm Hg)
- 2 types of tonometry
  - Applanation
    - Goldmann
    - Flattens a small area of the central cornea and measures the force required to do this
  - Indentation
    - Schiotz
      - Weight presses plunger against cornea, indenting it
      - The amount of indentation produced by this weight is read from a scale with a needle indicator moved by the plunger

Indentation Tonometry

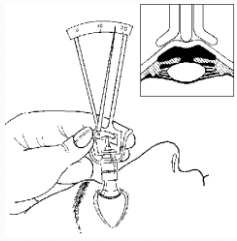
- Indentation
  - Deforms the cornea more than applanation
  - Schiotz
    - Raises pressure in the eye by indenting the surface with a given weight
    - The extent to which the plunger indents the cornea is the measure of IOP
    - Less accurate, especially if sclera is abnormally rigid or abnormally elastic
    - Portable



http://www.cnophol.com/eyes/UploadFiles_6369/200902/20090212103133619.gif

Schiotz

- Eye is measure with patient in a recumbent position
- Eye is anesthetized
- Weight is placed on tonometer
  - Standard weight is 5.5g
    - Additional weights of 2.0 and 4.5g may be used (total 7.5, 10)
- Tonometer rests on cornea while plunger indents cornea
- Reading produced on a scale on the top of unit
  - The more the indicator moves on the scale, the lower the IOP
  - So a higher reading actually means a lower IOP



http://www.lea-test.fi/en/eyes/images/pict13b.gif

Schiotz

- If scale reading is less than 3, add next weight and recheck
- Schiotz requires maintenance
  - Unit is disassembled to clean
  - The well may be cleaned with pipe cleaner moistened with alcohol
  - Plunger and other parts are cleaned with cotton cloth, alcohol

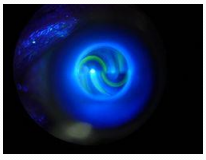
Applanation Tonometry

- Measures IOP by flattening small area of cornea
  - Goldmann applantation tonometer
    - Displaces very minimal amount of aqueous (less than .5mm volume)

http://www.pomonline.com/images/100pht2.jpg

Applanation Tonometry

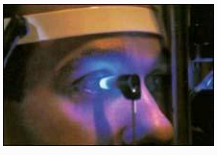
- Goldmann is less portable but more accurate than Schiotz
  - Plastic prism tip is attached to balance mounted on slit lamp
  - Tip measures 3.06 mm in diameter
  - When prism tip applanates cornea, a split circle, or **mires** are visible



http://wpcontent.answers.com/wikipedia/commons/thumb/3/3f/Goldmann_mires.jpg/250px-Goldmann_mires.jpg

Applanation Tonometry

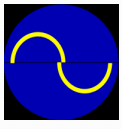
- Procedure
  - Patient is given fluress to anesthetize cornea and provide better visualization of mires
  - Blue filter is used to illuminate fluress
  - Blue light is angled at 45-60 degrees to side of tonometer and should be aimed at front of prism head
  - Slit lamp microscope is set at low power



http://www.alleyesonglaucoma.com/English/Images/About/Tonometry1.jpg

Applanation Tonometry

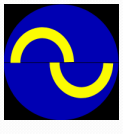
- As tonometer tip applanates cornea, mires become visible
  - An equal size semi-circle should be visible on top and bottom
    - If a larger circle is on top, the tip is set too low; if larger circle on bottom, the tip is set too high on cornea
  - Measurement drum is turned to the point where the insides of both semi-circles just touch

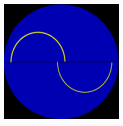


http://www.eyetec.net/Group8/M41Si.htm

Applanation Tonometry

- When mires are too thick (too much fluress) that means you will have to turn the drum more to separate them (false high pressure)
- When mires are too thin (too little fluress) you will not have to move the drum as much (false low pressure)

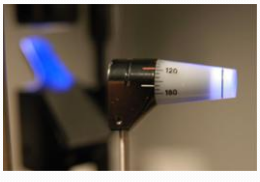




http://www.eyetec.net/Group8/M41Si.htm

Applanation Tonometry

- Tonometer tip has axis readings
  - Corneal astigmatism greater than 3 diopters can cause false IOP measurements
  - Tonometer tip is rotated where red line corresponds with axis of **minus** cylinder



http://www.eyetec.net/Group8/M41Si.htm

Applanation Tonometry

- Errors in readings
  - Pressing on the globe while holding lids can elevated IOP
  - Coughing, holding breath will elevate IOP
- Corneal thickness affects IOP readings
  - Normal CCT (central corneal thickness) is 555
    - Thinner corneas will give false LOW readings
    - Thicker corneas will give false HIGH readings

Applanation Tonometry

- Goldmann should be calibrated periodically
  - A short rod of measured weight is attached to balancing arm
  - Rod is set at 0, 2, and 6 and measuring drum should be placed at corresponding stop
- The tonometer head can be removed for cleaning
  - Can be soaked in 3% hydrogen peroxide or a 1:10 dilution of household bleach for 10 minutes
  - Rinse w/ water and dry thoroughly

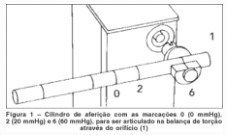


Figura 1 – Cilindro de aferição com as marcações 0 (0 mmHg), 2 (20 mmHg) e 6 (60 mmHg), para ser articulado na balança de torção através do orifício (1).

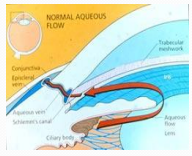
http://www.scielo.br/img/revistas/abo/v67n2/1975fi.gif

Serial Tonometry

- Because IOP can vary throughout the day, serial tonometry may be performed to show IOP fluctuations
  - Tonometry readings are taken at multiple times throughout the day
  - Wide fluctuations in IOP can be a risk factor for glaucoma progression

Aqueous Humor

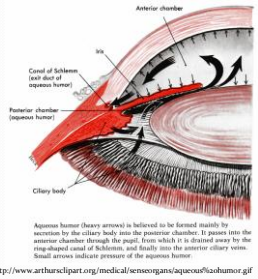
- Intraocular pressure (IOP)
  - Fluid pressure in the eye
- Aqueous humor is produced by ciliary processes which are located behind the iris
- Aqueous composition is similar to that of blood plasma
  - 99% water with proteins, amino acids, glucose, etc.



http://www.ueseyecare.com/images/photos/normal_aqueous_flow.jpg

Aqueous Humor

- Once aqueous is produced, it flows into anterior chamber through pupil, exits through trabecular meshwork, Schlemm's canal and episcleral veins

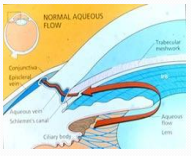


Aqueous humor (heavy arrows) is believed to be formed mainly by secretion by the ciliary body into the posterior chamber. It passes into the anterior chamber through the pupil, from which it is drained away by the ring-shaped canal of Schlemm, and finally into the anterior ciliary veins. Small arrows indicate pressure of the aqueous humor.

http://www.arthursclipart.org/medical/senseorgans/aqueous%20humor.gif

Aqueous Humor

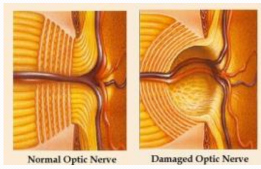
- Consider IOP process as basic plumbing!
  - Aqueous is continually produced by ciliary body (faucet)
  - Pressure is controlled through adequate drainage through TM/Schlemm's canal (drain)
  - Inadequate drainage causes increase in IOP
  - Insufficient aqueous production causes low IOP (hypotony)



http://www.ueseyecare.com/images/photos/normal_aqueous_flow.jpg

Anatomy of Optic Nerve Head

- Retinal nerve fibers collect in a bundle at the optic nerve head, then exit the eye as the optic nerve
- The part of the optic nerve head through which nerve fibers exit the eye is called the lamina cribrosa
  - This is a layer of approx. 10 stacked plates
  - Prolonged elevated IOP causes these plates to collapse, resulting in ONH cupping and VF loss



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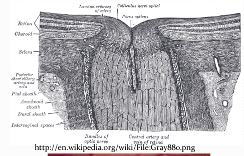
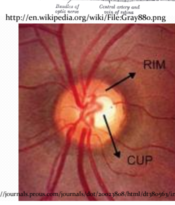
Anatomy of Optic Nerve Head

- In the center of the optic disc is the optic cup, which is a small depression
- Cup-to-disc ratio refers to the size of this depression relative to the overall disc size
  - Optic cupping greater than .6 can be indicative of glaucoma



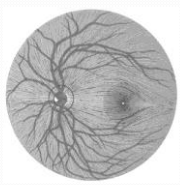
http://en.wikipedia.org/wiki/File:Gray880.png



http://journals.prous.com/journals/dot/20023808/html/dt380563/images/Weinreb_f2.jpg

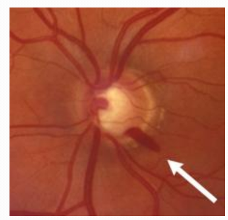
Optic Nerve Head

- The nerve fiber layer is arranged in a specific pattern
- Nerve fibers that enter the ONH at the superior and inferior poles appear to be more susceptible to glaucomatous damage
  - The damaged area of the nerve will cause a specific VF defect



Optic Nerve Head

- In addition to general enlargement of the cup/disc ratio, there are several ONH changes that can be indicative of glaucoma
  - Focal enlargement (notching of nerve)
  - Disc hemorrhages
  - C/D asymmetry between the two eyes



http://www.medrounds.org/glaucoma-guide/uploaded_images/3-6-782879.jpg

What is Glaucoma?

- Glaucoma is damage to the optic nerve with associated visual field loss, with elevated intraocular pressure as one of the primary risk factors
- Usually *painless* and *progressive*; always *permanent* loss of vision
- There are several forms of glaucoma
  - Primary Open Angle (MOST COMMON)
  - Primary Angle Closure (10% of all glaucomas)
  - Secondary Glaucoma
  - Congenital glaucoma

- “Normal” IOP is generally between 10-22 mm/Hg
  - IOP is usually highest in the morning
- Patient can have cupping of optic nerve and/or elevated IOP without VF loss
- Elevated IOP without VF loss is called Ocular Hypertension
  - Often watched without treatment
- A large cup to disc ratio without other signs of glaucoma is termed physiological cupping
  - Myopes tend to have larger C/D ratios

Primary Open Angle Glaucoma (POAG)

- Also called chronic open-angle glaucoma (most common form of glaucoma)
- Affects more than 2 million Americans
- Gradual onset, usually mid- to later in life
- Ocular anatomy appears normal, but outflow of aqueous at TM is obstructed
- No symptoms, usually diagnosed at routine visits
  - 3 signs help make the diagnosis of POAG
    - Elevated IOP
    - Cupping of optic nerve
    - Visual field loss

Primary Open Angle Glaucoma

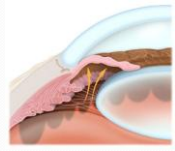
- Risk factors
  - Age
    - Risk increases with age
  - Race
    - African Americans are 4-5 times more likely to develop POAG
  - Positive family history
    - Having a sibling with POAG increases chance of glaucoma 3.7-fold
  - Myopia may be risk factor

Primary Open Angle Glaucoma

- POAG is typically treated with topical medications
  - Beta blockers are very effective in reducing the production of aqueous
- Laser treatment may be used for POAG
  - SLT= selective laser trabeculoplasty
  - ALT =argon laser trabeculoplasty
    - Argon laser beam is directed at junction of anterior unpigmented and the posterior pigmented edge of TM
- Trabeculectomy
  - Block of tissue is removed beneath a scleral flap
  - Fluid is able to flow out this opening to collect in conjunctiva (bleb)

Primary Angle Closure Glaucoma

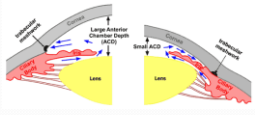
- Peripheral iris comes in contact with trabecular meshwork, blocking the drain
- Pupillary block is the most common form
  - Aqueous cannot flow through pupil
  - Pressure pushes peripheral iris into angle



http://c1-preview.prosites.com/34042/wy/images/angle_closure.jpg

Primary Angle Closure Glaucoma

- Risks associated with angle closure glaucoma
  - Narrow anterior chamber angles
    - Carefully evaluate before dilating!
    - For patients with critically narrow anterior chamber angles, some systemic sympathomimetic drugs can cause mild dilation, resulting in ACG
  - Hyperopia
    - Smaller anterior chambers
  - Age
    - Lens size increases with age, may increase risk for pupillary block



http://webeye.ophth.uiowa.edu/dept/service/glaucoma/images/fig-5-2.gif

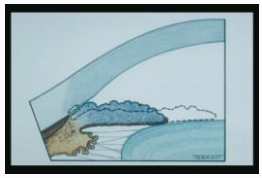
Primary Angle Closure Glaucoma

- Angle closure attack can be brought on by pupillary dilation
- Signs/symptoms of ACG include
  - High IOP
  - Mid-dilated pupil
  - Corneal edema
  - Conjunctival injection
  - Pain
  - Photophobia
  - Rainbow-colored halos
  - Blurry VA
  - Nausea/vomiting

http://retinasurgeon.tripod.com/sitebuildercontent/sitebuilderpictures/aacg.jpg

Primary Angle Closure Glaucoma

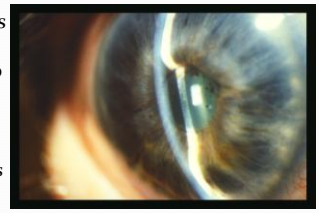
- Plateau iris is a special form of ACG
  - Anteriorly positioned ciliary processes push peripheral iris forward
  - Component of pupillary block may also be present
  - Following dilation, peripheral iris bunches up and blocks TM
  - Central anterior chamber is often fairly deep, while peripheral A/C is very narrow



http://arapaho.nsuok.edu/~fulk/Images/Img0029.JPG

Iris Bombe

- Anterior bowing of iris stroma caused by inability of aqueous to flow through pupil
  - Associated with posterior synechiae, pupillary membranes



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Secondary Glaucoma

- Pseudoexfoliation
- Pigmentary glaucoma
- Phacolytic glaucoma
- Phacomorphic
- Inflammatory glaucoma
- Traumatic glaucoma
- Steroid-induced
- Neovascular

PEX Glaucoma

- Fibrillar material is deposited in the anterior segment
  - On lens surface, zonules, pupillary margin, iris stroma, ciliary processes, inferior anterior chamber angle
  - Exfoliative material can clog TM, causing increased IOP
  - Often causes zonular weakness, so lens can move forward, causing the anterior chamber to shallow
  - Can limit pupil dilation

Pigmentary Glaucoma

- Pigment dispersion syndrome (PDS)
  - Pigment is found on corneal endothelium (Krukenberg spindle) in TM and on the lens periphery
  - Iris transillumination defects are noted
  - Pigment is released from iris and collects in TM, causing IOP spikes

Phacolytic Glaucoma

- A mature or hypermature lens may leak protein
  - Causes inflammatory glaucoma as lens proteins and inflammatory debris clog TM
  - Anterior capsule is often wrinkled, demonstrating loss of lens volume as the proteins leak out
  - Cataract surgery is required to treat condition

Phacomorphic Glaucoma

- Lens causes anterior chamber to shallow (often abruptly) in an eye not otherwise disposed to angle closure
  - Often caused by intumescent lens
    - An intumescent lens is a mature cataract which has become swollen as the lens takes up fluid
  - Causes rapid IOP rise, pain, corneal edema, etc.

Inflammatory Glaucoma

- May be caused by a variety of mechanisms
  - Edema of TM
  - Endothelial cell dysfunction
  - Blockage of TM by fibrin and inflammatory cells
- Generally treated with corticosteroids

Traumatic Glaucoma

- Angle recession glaucoma
  - Can occur months to years following ocular trauma
    - Caused by a tear in the ciliary body , tears are often present in the TM as well
    - Results in deepened or recessed anterior chamber angle
      - The deeper the recession, the greater the likelihood of developing glaucoma

Steroid Induced Glaucoma

- Prolonged use of topical, inhaled, or systemic corticosteroids can cause this glaucoma
- IOP elevation is the result of increased resistance to aqueous outflow through the TM

Neovascular Glaucoma

- Retinal or ocular ischemia leads to the formation of fine blood vessels on the iris surface and TM
  - Abnormal vessels begin at pupillary margin, eventually progress radially to angle
  - These blood vessels have fibrous membrane which contracts, leading to peripheral anterior synechiae (PAS)
    - PAS closes off anterior chamber angle, leading to increased IOP
  - Treatment generally consists of PRP

Normal-tension Glaucoma

- Glaucomatous damage occurs despite “normal” IOP
  - Exact mechanism of disease is unknown, possibly due to vascular cause
  - Can be very difficult to treat
    - Aggressively lowering IOP has been shown to be helpful in reducing VF loss

Study Questions

Ledford, J.K. (1997) Certified Ophthalmic Technician Exam Review Manual

Ledford, J.K. (2000) Certified Ophthalmic Medical Technologist Exam Review Manual

- The flow of aqueous in the eye follows this pattern:
  a) Angle, posterior chamber, pupil, anterior chamber
  b) Angle, anterior chamber, pupil, posterior chamber
  c) Pupil, posterior chamber, anterior chamber, angle
  d) Posterior chamber, pupil, anterior chamber, angle

- As it exits the eye, aqueous humor flows in this pattern:
  a) Canal of Schlemm, trab. meshwork, episcleral veins
  b) Trab meshwork, Canal of Schlemm, episcleral veins
  c) Trab meshwork, nasolacrimal duct, episcleral arteries
  d) Canal of Schlemm, episcleral veins, trab meshwork

- The most common type of glaucoma is:
  a) Congenital
  b) Secondary
  c) Open Angle
  d) Angle closure

- Reduction and control of elevated IOP is based on:
  a) Lowering the blood pressure
  b) Lowering cranial pressure
  c) Increasing aqueous production and/or decreasing outflow
  d) Decreasing aqueous production and/or increasing outflow

- Glaucoma is classically characterized by the triad of increased IOP, visual field damage and:
  a) Pigment in trabecular meshwork
  b) Decreased facility outflow
  c) Fluctuating visual acuity
  d) Optic nerve head damage

- Symptoms and signs for acute angle closure glaucoma include all of the following *except*:
  a) Severe pain
  b) Decreased vision
  c) Vomiting/nausea
  d) Miotic pupil

- In addition to tonometry, the diagnosis of glaucoma may be based on all of the following tests *except*
  a) Ophthalmoscopy
  b) Gonioscopy
  c) Retinoscopy
  d) Perimetry

- Gonioscopy is used to evaluate:
  a) The angle structures
  b) The optic nerve
  c) Peripheral vision
  d) Corneal edema

- In angle closure glaucoma:
  a) The iris closes off the anterior chamber angle
  b) There is a sudden surge of aqueous production
  c) The pupil closes, preventing aqueous passage from posterior to anterior chamber
  d) Corneal edema closes off the anterior chamber angle

- Emergency treatment during an angle closure attack includes pressure lowering medications and:
  a) Miotics
  b) Mydriatics
  c) Antibiotics
  d) Corticosteroids

- All of the following may trigger an angle closure attack except:
  a) Being dilated in the office
  b) Being in a dark room
  c) Sudden exposure to bright light
  d) Sitting in a movie theater

- Which of the following conditions gives a higher risk for developing angle closure glaucoma attack?
  a) High hyperope
  b) High myope
  c) Aphake
  d) Keratoconus

- The appearance of halos around lights during an attack of angle closure glaucoma is due to:
  a) Lens edema
  b) Corneal edema
  c) Vitreous hemorrhage
  d) Optic nerve damage

- In open angle glaucoma
  a) The iris blocks off the angle structures
  b) The pressure damages the ciliary body
  c) The open angle allows too much aqueous to drain out
  d) The angle looks normal

- A patient in the end stages of open angle glaucoma:
  a) May have a small island of vision temporally
  b) May have a small island of vision centrally
  c) May have a small island of vision nasally
  d) Still has enough peripheral vision to get around

- The physiologic cup of the optic nerve
  a) Is an abnormal finding in glaucoma
  b) Represents the normal opening in the sclera through which the optic fibers pass
  c) Is the area of finest central vision
  d) Is a normal depression in the macular area

- The first area of the optic nerve to be damaged by elevated IOP is often:
  a) The center of the disc
  b) The interior of the disc
  c) The nasal side of the disc
  d) The upper and lower portions of the rim

- All of the following are employed in reducing IOP except:
  a) Carbonic anhydrase inhibitors (CAIs)
  b) Steroids
  c) Beta blockers
  d) Miotics

- The topical medication of first choice in treating open angle glaucoma is often:
  a) Epinephrine derivatives
  b) Osmotics
  c) Beta blockers
  d) CAIs

- In angle closure glaucoma, a laser is used to create a (an):
  a) Iridotomy
  b) Peripheral iridectomy
  c) Sector iridectomy
  d) Iris ablation

- The surgical procedure which creates an external drainage area via a pathway to the anterior chamber is a (an):
  a) Trabeculectomy
  b) Cycloablation
  c) Iridotomy
  d) Iridectomy

- In some aqeous draining procedures, aqueous is drained from the anterior chamber to an area under the conjunctiva. This area is known as a/an:
  a) Subconjunctival canal
  b) Bleb
  c) Pinguecula
  d) Iris cyst

- The theory of nerve death (caused by glaucoma) that states that the axons die due to inadequate blood flow is the:
  a) Indirect mechanical theory
  b) Direct ischemic theory
  c) Direct mechanical theory
  d) Indirect ischemic theory

- The theory of nerve fiber damage (caused by glaucoma) that states that the axons die due to compression of the nerve fibers is the:
  a) Direct ischemic theory
  b) Direct mechanical theory
  c) Indirect mechanical theory
  d) Indirect ischemic theory

- In an adult, if IOP is elevated over a long period of time (as in chronic glaucoma) the following change may be seen:
  a) Enlarged cornea
  b) Buphthalmos
  c) Scleral thinning
  d) Ciliary flush

- The retinal damage of chronic glaucoma is manifest by damage to:
  a) The nerve fiber layer and ganglion cell layer
  b) The macula
  c) The retinal vascular system
  d) The photoreceptor cells

- The focal point of optic nerve damage in glaucoma is the:
  a) Lamina cribrosa
  b) Myelin sheath
  c) Hyaloid membrane
  d) Embryonic layer

- The type of early glaucoma field loss that occurs most often is:
  a) Nasal steps
  b) Temporal wedges
  c) Paracentral scotomas in the Bjerrum area
  d) Concentric contraction

- Visual acuity in a glaucoma patient with a 10 degree island of central vision and a detached, large temporal island (in the absence of other ocular disease) might be expected to be:
  a) 20/20
  b) 20/100
  c) 20/200
  d) <20/400

- It is thought by some that, preceding changes in the visual field, the glaucoma patient might exhibit changes in:
  a) Color vision and contrast sensitivity
  b) Central vision
  c) Amsler grid testing
  d) Stereopsis and motility function

- A hypermature cataract may cause secondary glaucoma by:
  a) Leaking proteins that clog the trabeculum
  b) Dislocating and drifting into the anterior chamber
  c) Dislocating and drifting into the vitreous
  d) exfoliating

- Neovascular glaucoma would most likely be seen in a patient with:
  a) Diabetes
  b) Contact lens over-wear
  c) High blood pressure
  d) Carotid artery disease

- Patients who experience an increase in IOP while using corticosteroids are called:
  a) Ocular hypertensives
  b) Glaucoma suspects
  c) Steroid regulators
  d) Steroid responders

- Malignant glaucoma is a postoperative complication that occurs when:
  a) Aqueous leaks into the vitreous
  b) Vitreous strands are present in the anterior chamber
  c) Conjunctival epithelium invades the angle structures
  d) There is a hemorrhage in the anterior chamber

- Slit lamp signs that often accompany pigmentary glaucoma include:
  a) Vossius ring
  b) Crocodile shagreen
  c) Krukenberg's spindles and iris transillumination defects
  d) Iron pigment line and arcus senilus

- Symptoms of congenital glaucoma may include:
  a) Redness and decreased vision
  b) Swelling, photophobia, and diplopia
  c) Epiphora, redness, and mattering
  d) Photophobia, blepharospasm, and epiphora

- Because an infant's sclera is more elastic than an adult's, elevated IOP may cause:
  a) Buphthalmos
  b) Blanched sclera
  c) Yellow sclera
  d) Scleral show

- Corneal enlargement may occur due to elevated IOP. An infant's corneal diameter is considered abnormal (and suspicious for congenital glaucoma) if it is:
  a) Larger than 10.5mm
  b) Larger than 10.0mm
  c) Larger than 9.5mm
  d) Larger than 9.0mm

- The principle that states that the pressure inside a sphere can be measured by applying an equal amount of pressure on the outside of the sphere is:
  a) Imbert-Fick
  b) Mackay-Marg
  c) Roadarmel-Ledford
  d) Friedenwald

- The non-contact "air-puff" tonometer is an example of:
  a) Applanation tonometry
  b) Indentation tonometry
  c) Fixed force tonometry
  d) Manometry

- If compensation for high corneal astigmatism is not made, the IOP measurement could be in error by:
  a) 1 mm Hg
  b) 2-3 mm Hg
  c) 4-5 mm Hg
  d) 8-10 mm Hg

- In order to compensate for high astigmatism with the Goldmann or Perkins tonometers, the biprism should be aligned as follows:
  a) The steepest axis aligned with the red line
  b) The plus axis aligned with the red line
  c) 45 degrees from the minus cylinder should be placed in the 90 degree position
  d) The minus axis aligned with red line