TONOMETRY AND PACHYMETRY

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Intraocular Pressure (IOP)

- The fluid pressure inside the eye
- The pressure created by the continual renewal of fluids (aqueous humor) within the eye
  - Maintains shape of eye
  - Provides nutrients to ocular tissues
  - Carries away metabolic waste products
  - Helps defend against ocular pathogens
- Measured clinically via tonometry
  - Recorded in mmHg

Aqueous Secretion

- Secreted by non-pigmented epithelial cells of the ciliary body
- Flows into the posterior chamber, around the lens, and through the pupil into the anterior chamber.

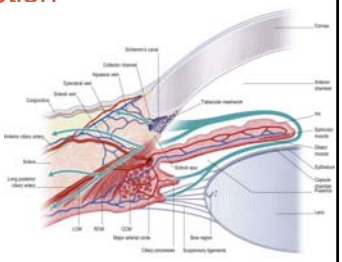
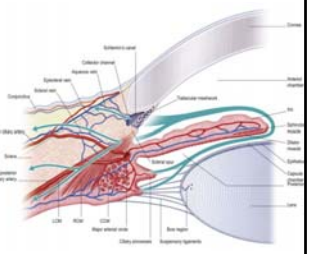


Image from Kaufman PL, Wiedman T, Robinson JR: Cholinergics. In Sears ML [ed]: Pharmacology of the eye: handbook of experimental pharmacology, Berlin, 1984, Springer-Verlag.

Aqueous Drainage (via two main pathways)

1. Conventional Route (Trabecular Meshwork Route)
   - Through trabecular meshwork (TM), into lumen of Schlemm's canal, ending in the episcleral venous circulation
2. Unconventional Route (Uveoscleral Route)
   - Across iris root, uveal meshwork, ciliary muscle, suprachoroidal space, and out through the sclera



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Aqueous Humor Dynamics

- The entire aqueous turns over in about 100 minutes
- Production must equal drainage rate
  - Overproduction or decreased draining →increased IOP

'Normal' Intraocular Pressure (IOP)

- Mean IOP is about 15.5 mmHg +/- 2.6
  - Distribution is skewed toward high end
- 'Normal' Range = 10 - 21 mmHg
  - Pressure which does not lead to glaucomatous damage to the optic nerve head

Terms related to Intraocular Pressure (IOP)

- Ocular Hypertension = IOP ABOVE normal
  - IOP is greater than 21 mmHg but there is no sign of glaucomatous optic nerve head damage
  - Normal optic nerve head
  - No glaucomatous visual field damage
- Hypotony = IOP BELOW normal
  - IOP ≤5mm Hg
  - Can lead to corneal decompensation, accelerated cataract formation, discomfort, retinal changes

Factors Influencing IOP

- Time of day = Diurnal Variation
  - Generally less than 5-6 mmHg
  - > 10 mmHg pathologic
- Respiration
- Heartbeat
- Valsalva (increases 4-5mmHg)
- Posture (2-3 mmHg change)
- Voluntarily widening fissure
- Forced blink
- Exercise
- Pregnancy
- Age/Race
- Medications

Why do we check IOP?

- Part of "routine" ophthalmic exam
- Post-operative examinations
- Evaluation and management for glaucoma
  - Although IOP is not the sole component of glaucoma, it is one component of the disease we can manage

Key Points

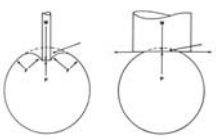
- Never consider IOP's in isolation!
- "There is no IOP below which optic nerve damage will never occur, nor is there any IOP above which damage will always occur."

TONOMETRY- METHODS AND CLINICAL PROCEDURE

Tonometry

- Tonometer
  - instrument used to measure tension or pressure
- Tonometry
  - test that measures the pressure inside the eyes, intraocular pressure
  - Performed on every patient capable of being tested
  - Performed after refractive procedures but before dilation

Types of Tonometry



1. **Indentation**
   - **indents the corneal surface**
   - direct pressure on the eyeball
   - determines pressure by calculating how much weight is required to flatten, or indent, an area of the cornea
   - must account for ocular rigidity
2. **Rebound**
   - estimates intraocular pressure by bouncing a small plastic tipped metal probe against the cornea and measures the induction current that is created
3. **Applanation**
   - **involves slight flattening of the cornea**
   - intraocular pressure is measured by calculating the force required to flatten or applanate an area of the cornea
     - Imbert-Fick Law

Indentation Tonometry

- Mechanical
  - Schiotz
    - Uses a plunger and weights to indent the anesthetized cornea
    - Pt must be lying down
    - Compare indentation based on weight used to a chart to determine IOP
    - **OUCH!!!**

Rebound Tonometry

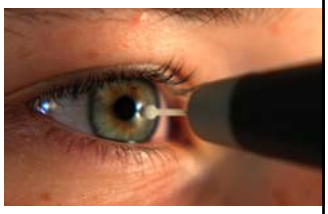
- Icare Tonometer
  - Hand held, portable
  - Does not use anesthetic or dyes!!
  - Great to use with children, scarred corneas, those with disabilities
  - Uses disposable probes

Keep an eye on the display monitor

P_ : standard deviation of measurements is slightly greater than normal but unlikely to have affected results; **no need to repeat measurement**

P- : greater than normal; **repeat measurement if IOP >19mmHg**

P‾ : much greater than normal; **repeat measurement**



Error messages – “double beep”

- E01: Probe did not move
- E02: Probe did not touch eye; too far away
- E03: Probe speed too slow; too far away or tilted upwards
- E04: Probe speed too fast; tilted downwards
- E05: Contact with eye too soft; eyelid in way or patient blinked
- E06: Contact with eye too hard
- E07: “Bad hit”; positioning/centralization on cornea wrong or probe inserted incorrectly
- E08: “Bad data”

Applanation Tonometry

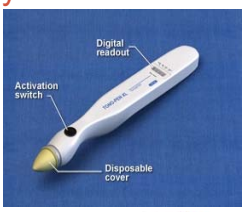
- **Non-contact**
  - Estimates intraocular pressure by measuring the force of the air it takes to applanate an area of the cornea.
  - Does not touch cornea→ no anesthetic needed
  - Good for screenings
  - Portable or stationary

Sight Gags by Scott Lee, OD

- Non-contact
  - **Diaton**
    - Measures IOP through the eyelid (transpalpebral tonometry)
    - No anesthetic required
    - Can be used with patient in seated or reclined position
    - Patient's gaze at approximately 45 degrees, clinician holds tonometer vertical and gently presses down on tonometer to obtain reading

Applanation Tonometry

- Electronic
  - **Tono-Pen**
    - Uses applanation and indentation principles
    - Small size and easily portable
    - Good for scarred corneas, patients with disabilities, and young children
      - Most accurate tonometer if scarred or edematous cornea
    - Uses a latex cover over the tip
    - Requires anesthetic
    - Correlates closely with Goldmann tonometer



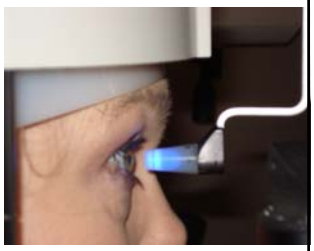
- Approach cornea perpendicularly and applanate with gentle tapping motion
  - Chirping sound for individual readings, beep once measurement complete
- Record IOP along with confidence interval of the reading reading
  - Repeat if >20%

Applanation Tonometry

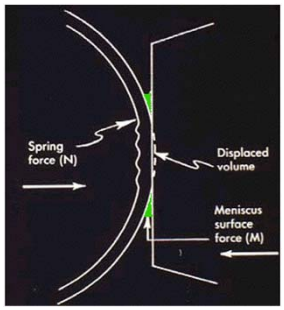
- **Perkins**
  - Uses the Goldmann applanating prism
  - Requires anesthetic and fluorescein dye
  - Portable (illumination built into instrument)
  - No restrictions on patient positioning
  - Great to use in patients who can't be positioned in SL

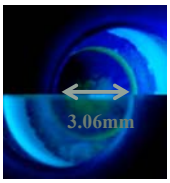
Applanation Tonometry

- **Goldmann**
  - The "Gold Standard" by which all other methods are compared
  - The illuminated Goldmann probe applanates a 3.06 mm diameter circle on the cornea



Goldmann Tonometry





GoldmannTonometry

- Alignment of Probe

- Side view of probe in holder
- Note axis scale from 0 – 180
- If corneal cyl <3D, align with 180 mark
- If corneal cyl >3D, align minus cyl axis with red mark

Goldmann Preparation

➢Disinfection

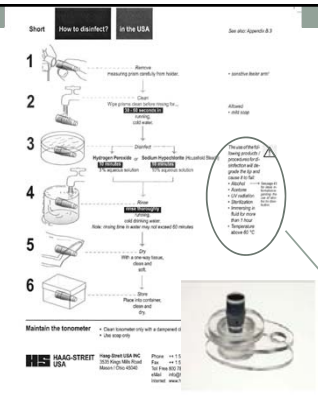
- Clean head & chin rest of slit lamp with alcohol prep, tissue dry
- Probe tip requires **high-level disinfection** since it comes in contact with a mucous membrane

Body Contact	Disinfection Requirement	FDA Device Class
Sterile body cavity or blood present	Sterilization	Critical
Mucous membrane or non-intact skin	High level	Semi-critical
Intact skin	Low level	Non-critical

CDC, Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008

High-level disinfection

- CDC recommendations: (HIV, HBV, HCV, HSV, Adenovirus)
- Wipe instrument clean, followed by:
  - **10 minute soak in 3% H2O2**
  - **15 minute soak in 1:10 bleach dilution**
  - **20 minute soak in 2% glutaraldehyde**
- Rinse well with sterile saline, air dry



- Clean probe
- High level disinfection with soak in 3% H2O2 or 1:10 bleach
  - Do not leave in solution for > 1 hour!
- Rinse thoroughly
- Dry and store

Traditional vs. Disposable Tonometer Tips

Tonosafe Disposable Prism

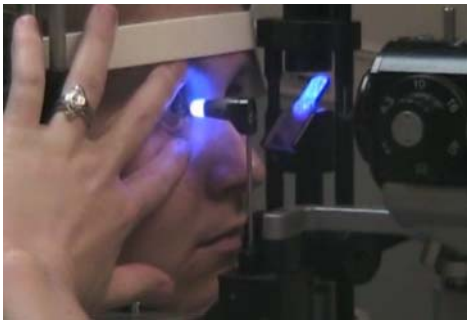
Patient preparation

- Explain purpose of the test to the patient
- Instill anesthetic + fluorescein dye
  - Pre-combined drops available (Fluress, Flurox) or can use Proparacaine + NaFl strip
    - Educate patient about possible sting
    - Wait about 30 seconds for anesthetic to take effect
- Check corneal integrity before/after procedure

Patient Preparation

- Position patient properly in slit lamp, ensuring canthus alignment
- Illuminate probe with cobalt blue filter, light housing positioned temporally
- Set pressure dial 10-20 mmHg

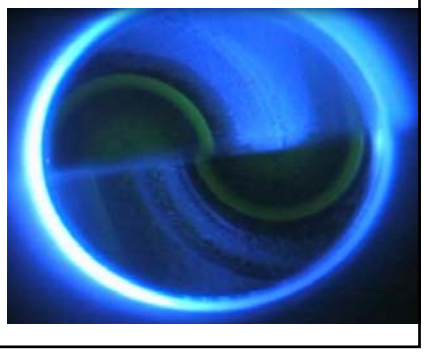
Holding lids



Goldmann Technique – Proper endpoint

•Mires are centered and overlapped perfectly.

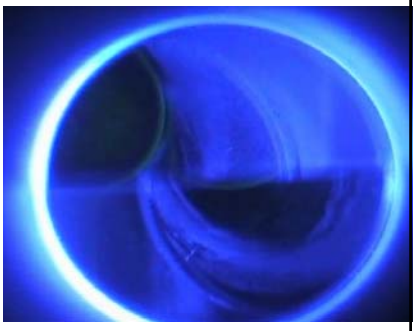
•Mire thickness is satisfactory.



Goldmann Technique

•One semi-circle is larger than the other one.

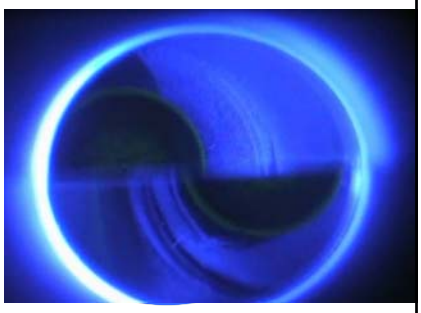
•Move the probe toward the larger one.



Goldmann Technique

•Mires are overlapping too much.

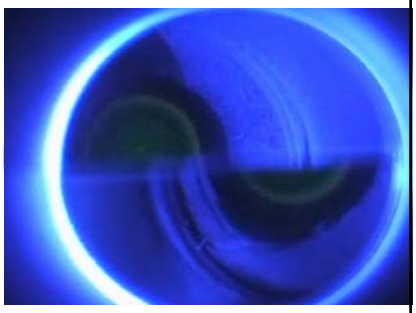
•Indicates there's too much force dialed in.



Goldmann Technique

•Mires are not overlapping.

•Indicates there's not enough force on the probe.

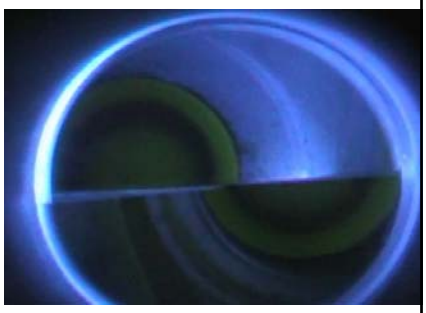


Goldmann Technique

•Mires overlap well but they're too thick.

•This will result in IOP over-estimation.

•Blot the eye & make sure lids are not touching the probe.



Goldmann Technique

•Mires overlap well but they're too thin.

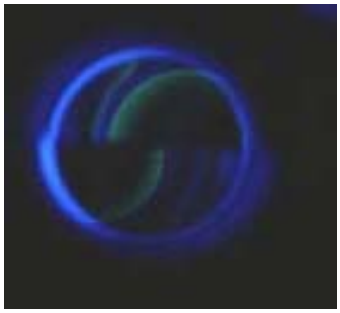
•This will result in IOP under-estimation.

•Re-instill a drop of Fluress.

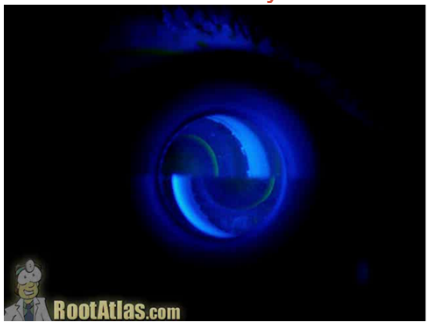
Goldmann Technique

•Mires that are significantly separated and don't move much even with changes in the dial.

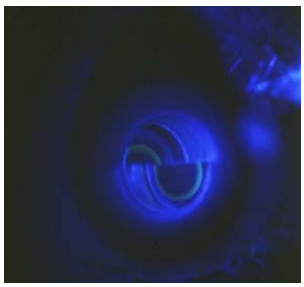
•Too much probe pressure is being applied forward with the joystick—need to pull back to release some of the pressure



Video of Goldmann Applanation Tonometry



WHAT SHOULD WE DO?



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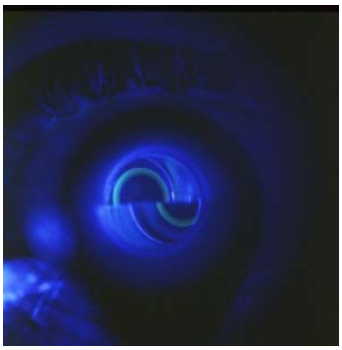

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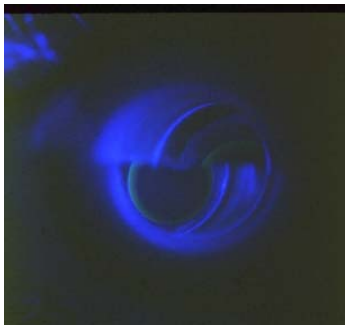

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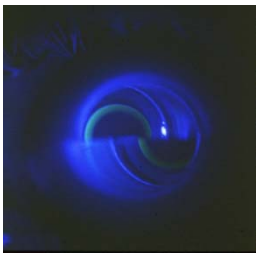


Recording tonometry results

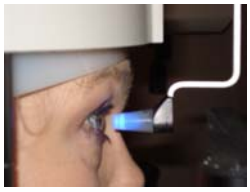
- Actual measurements of right and left eyes (in mmHg)
- Time of day
- Apprehension level (low, moderate, high)
- Type of tonometry performed

- Example:

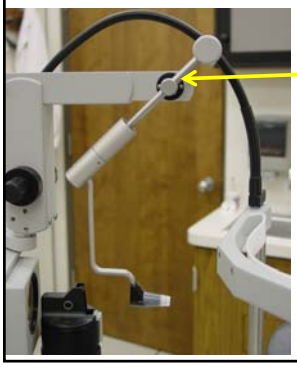
$$T \frac{19}{20}_{\text{(Goldmann)}}$$ 2:15pm, low apprehension

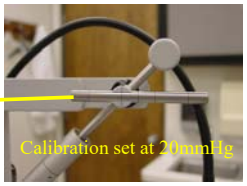
Clinical Pearls for tonometry

- Must be QUICK and accurate
- Must be ready to hold eyelids if you've got a "blinker"….be careful not to push on globe
- Don't be afraid to maneuver probe on the cornea



TONOMETER CALIBRATION





TONOMETER CALIBRATION

Set at 20mmHg

For Haag Streit-style SL

Pachymetry

What does corneal thickness have to do with IOP??

- PACHYMETRY can be a useful tool to better understand a patient's IOP reading
- Ocular Hypertension Treatment Study (2002)
  - Thicker corneas (>555µm) give falsely high IOP readings
  - Thinner corneas (<555µm) give falsely low IOP readings

Pachymetry – Billing and Coding

- CPT 76514
  - Unilateral or bilateral
  - Ultrasound technique
  - **Includes interpretation report**
  - ~$12.00 reimbursement
- Billing frequency
  - Once per lifetime per provider
    - Glaucoma
  - Annually
    - Corneal graft
    - Keratoconic
    - Aphakic contact lens wearers
  - Greater than annually
    - Corneal graft rejection patients
    - Corneal edema

Corneal Hysteresis

- Measures the biomechanical strength, or overall resistance of the cornea

Ocular Response Analyzer (Reichert)

In Summary…

- Tonometry is an important part of the optometric exam
- Goldmann is the gold standard, but reliable alternative methods are available
- IOP's should never be considered in isolation