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.

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

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

- **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

Image credit to Scott Lee, OD. 

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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

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

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

Goldmann 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
- 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

<table>
<thead>
<tr>
<th>Body Contact</th>
<th>Disinfection Requirement</th>
<th>FDA Device Class</th>
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</thead>
<tbody>
<tr>
<td>Sterile body cavity or blood present</td>
<td>Sterilization</td>
<td>Critical</td>
</tr>
<tr>
<td>Mucous membrane or non-intact skin</td>
<td>High level</td>
<td>Semi-critical</td>
</tr>
<tr>
<td>Intact skin</td>
<td>Low level</td>
<td>Non-critical</td>
</tr>
</tbody>
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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

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.

• Mires overlap well but they’re too thick.
  • This will result in IOP overestimation.
  • Blot the eye & make sure lids are not touching the probe.

• Mires overlap well but they’re too thin.
  • This will result in IOP underestimation.
  • Re-instill a drop of Fluress.

• 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?
### 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 \text{ 19}
  
  \frac{20}{19}
  
  2:15 \text{pm, 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
- Calibration set at 20 months
- Calibration set at 60 months
For Haag Streit-style SL
Set at 20mmHg

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

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