Does My Patient Have Glaucoma?
Risk Assessment and Treatment Options

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Question 1

Which of the following is associated with a decreased risk for glaucoma:

1. Low Blood Pressure
2. Asian Ancestry
3. Thick Cornea
4. Disc hemorrhage
Question 2: When checking IOP with Goldmann applanation tonometry, the mires should:

1. Be as thick as possible
2. Directly align
3. Inner edges align
4. Outer edges should align
Question 3: It is important to perform gonioscopy:

1. In myopes
2. In hyperopes
3. In eyes with shallow chambers
4. In anyone diagnosed with glaucoma
5. In eyes with high IOP
6. All of the above
Question 4: Glaucomatous Visual Field defects typically have the following characteristics:

1. Respect the vertical meridian
2. Cluster in an arcuate pattern
3. Spare the paracentral area
4. Are easily distinguished from defects that develop after a branch retinal vein occlusion
Question 5: Features of glaucomatous optic nerves include:

1. Notching
2. Saucerization
3. Disc hemorrhage
4. Peripapillary atrophy
5. Generalized rim loss
6. All of the above
Glaucoma

- Group of diseases that cause damage to the nerve of the eye
- Usually associated with high pressure in the eye
Glaucoma

- Progressive damage to the nerve fibers of the optic nerve
- Specific pattern of optic nerve damage (cupping)
- Associated with defects in visual function
Global Prevalence of Glaucoma and Projections of Glaucoma Burden through 2040

A Systematic Review and Meta-Analysis

Yih-Chung Tham, BSc Hons,1,2,* Xiang Li, BSc,1,3,* Tien Y. Wong, FRCS, PhD,1,2 Harry A. Quigley, MD,4 Tin Aung, FRCS (Ed), PhD,1,2 Ching-Yu Cheng, MD, PhD1,2,5,6

- 2013 64.3 million worldwide with glaucoma
  - POAG 44 million
  - PACG 20 million
For population aged 40-80 years

- The global prevalence of glaucoma is 3.54% (95% CrI, 2.09-5.82).
- POAG is highest in Africa (4.20%; 95% CrI, 2.08-7.35).
- PACG is highest in Asia (1.09%; 95% CrI, 0.43-2.32).
Population over 60

Image: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2008 revision
Aging Population in Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage of population aged 65 and over in 2000</th>
<th>Percentage of population aged 65 and over in 2050</th>
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<tbody>
<tr>
<td>Japan</td>
<td>17.2%</td>
<td>36.5%</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>11%</td>
<td>35.5%</td>
</tr>
<tr>
<td>Singapore</td>
<td>7.3%</td>
<td>28.9%</td>
</tr>
<tr>
<td>S. Korea</td>
<td>7.3%</td>
<td>34.9%</td>
</tr>
<tr>
<td>China</td>
<td>6.9%</td>
<td>23.9%</td>
</tr>
<tr>
<td>Indonesia</td>
<td>4.7%</td>
<td>15.8%</td>
</tr>
<tr>
<td>India</td>
<td>4.4%</td>
<td>12.7%</td>
</tr>
</tbody>
</table>
The Aging Worldwide Population

- **2010:**
  - 64 million people with glaucoma
  - 7.5 million with blindness both eyes

- **2020:**
  - 76 million people with glaucoma
  - 11.1 million with blindness both eyes

- **2040:**
  - 111.8 million people with glaucoma

Quigley and Boman. BJO 2006; 90:262-7,
Underdiagnosed

- In US, half of glaucoma cases go undiagnosed
- Worldwide, this burden is even greater.

Why is Glaucoma so Difficult to Diagnose?

- Asymptomatic
- Failure to have a routine eye exams
- Great variability in what is normal
  - IOP----OHT vs NTG
  - Optic nerves, VF
- Great overlap Normal vs. Pathologic
Tips to Aid in Correctly Diagnosing Glaucoma

- Assess risk factors
- Measure IOP
- Gonioscopy
- Clinical evaluation of the optic nerve/RNFL
- OCT
- Visual Fields
Risk Factor Assessment: OHTS and European Prevention Trial

- Older Age
- Thinner Cornea
- Higher IOP
- Increased vertical CDR
- Higher PSD
Global Risk Factor Assessment

- Race
- Family history:
  - Vision loss
  - First degree relatives, esp. sibs
- Ocular History
  - Ocular anomalies
  - trauma
Risk Factor Assessment

- Vasospastic syndrome
- Hypertension
  - Overmedication
- Low BP
  - Shock optic neuropathy
- Steroid use
- Sleep apnea
- Inverted posture
- External eye pressure during sleep
- Wind instruments
Intraocular Pressure

- Causative risk factor
- 50% POAG will not have elevated pressure at a single measurement time.
- Majority of OHT will not develop glaucomatous damage.
Corneal Thickness

• Greatly impacts applanation IOP
• Thick corneas: falsely high IOP reading
• Thin corneas: falsely low IOP reading
Corneal Thickness

- Normal approx 550-560 µ.
- NTG thin corneas
- OHT thick corneas
- Thinner corneas in AA in OHTS
IOP:
Goldmann Technique

- Proper thickness of mires
- High astigmatism:
  - average meridians
- Proper alignment with ocular pulse
- Lift upper lid off tonometer
IOP: Technique

- Avoid pressure on globe
- Avoid having patient grip handles
- Encourage breathing
- Discourage forced eyelid opening
- Loosen neckties
- Use handheld techniques with larger patients
Intraocular Pressure

- Multiple readings
- Diurnal checks
- Alternate instruments:
  - Tonopen
  - iCare
  - Non-Contact, Ocular response analyzer/Corneal hysteresis
  - Pascal Dynamic Contour tonometer
  - Pneumotonometer
IOP is more important in the management of glaucoma than in the diagnosis.
Slit Lamp Examination

Look for signs of secondary glaucoma

- Old KP
- Kruckenberg's spindle
- Iris transillumination
- Pseudoexfoliation at pupil margin
- Signs of trauma: angle recession, sphincter ruptures, phacodonesis, chronic mydriasis
Examine the Angle

- Gonioscopy is often not performed routinely
- Anyone with any refractive error can have narrow angles
- Subacute and chronic angle closure glaucoma
  - More common than acute
  - Frequently missed or misdiagnosed.
  - Can occur with any refractive error.
Gonioscopy should be performed on every patient

- Learn a recording system
Gonioscopy

- Learn your landmarks with a Goldmann lens if inexperienced
- Have a 4 mirror lens available
- Know when you are compressing
- Have patient look towards the mirror
Gonioscopy

- Perform in light to identify landmarks
- Recheck in dim illumination
- Recheck with and without compression
LIGHT vs DARK
Gonioscopic Landmarks

- Remember, indirect goniolenses are simple mirrors
Help! Gonioscopic mishaps:

- Lightly pigmented TM
- Mistaking Sampaolesi’s line for TM
- PAS vs. Iris processes
Lightly pigmented TM
Learn Landmarks: 
Sampaolisi’s Line vs. TM

Beware pigmented Schwalbe’s Line: Check superior angle
Iris Processes vs. PAS
What you can learn from gonioscopy

- Angle recession
- Pigment dispersion
- Prior pigment dispersion
- PAS
- Narrow angle
- Plateau iris
- KP
- Bumpy peripheral angle
Gonioscopy

- Can only diagnose open angle glaucoma if gonioscopy is performed.

- Chronic angle closure glaucoma is indistinguishable from open angle glaucoma unless the angle is examined.
Optic Nerve Head:

Inadequate assessment is #1 cause of under treatment of glaucoma

- Look closely at the optic nerve even if IOP is normal!
Optic Disc Assessment: SHIP

- Size
- Hemorrhages
- ISN’T Rim tissue thickness
- Parapapillary atrophy

 Bonus: RNFL
What is normal?

- Rim tissue composed of ganglion cell axons, glial tissue and blood vessels.

- Axons pass through the pores of the lamina cribrosa
Normal Optic Nerve

- Vertically oval
- ISN’ T Rule
- C/D < 0.5

Armaly: Archives Ophthalmol 78, 1967
SHIP

- **Size**
- **Heme**
- **ISNT**
- **PPA**

- Size of cup varies with size of disc
- Large discs have large cups in healthy eyes

![Small](#) 1.4

![Average](#) 1.9

![Large](#) 2.4
Disc Size Is Important

- Great variation in the size of the normal optic nerve.
Techniques to Measure Disc Size

- **Direct ophthalmoscope**
  - 5° degree spot
  - 1.5 mm diameter
  - 1.8 mm²

- **Fundus Lens**
  - 90 diopter lens
  - Average 1.4 mm
  - Large > 1.6 mm
  - Small < 1.2 mm
SHIP

- Size
- Heme
- ISN’ T
- Peripapillary atrophy
- (RNFL)
Small Optic Nerve
Large Optic Nerve
Asymmetric Disc Size
Disc Size

Risk of not recognizing disc size:

- *Small Discs:* Missing the diagnosis of glaucoma
- *Large Discs:* Mis-diagnosing glaucoma
- *Asymmetric Discs:* Mis-diagnosing glaucoma
SHIP

- Size
- Heme
- ISNT
- PPA
Thirteen-Year Follow-up of Optic Disc Hemorrhages in the Ocular Hypertension Treatment Study

Cumulative incidence of POAG
- 25.6% in eyes with ODH
- 12.9% in eyes without ODH

2.6 fold increased risk of developing POAG
- multivariate analysis (95% confidence interval, 1.7-4.0; P < .0001).
SHIP

- Size
- Heme
- ISN’T T
- PPA
SHIP

- Size
- Heme
- ISNT
- PPA

ISNT rule
Inferior > Superior > Nasal > Temporal
SHIP

- Size
- Heme
- ISNT
- PPA

Beta zone Peripapillary Atrophy
- Atrophy of the RPE and choriocapillaris
  - Large choroidal vessels become visible
- More common in glaucomatous eyes
- Width of beta zone inversely correlates with rim width at same area
Retinal Nerve Fiber Assessment
Glaucoma Or Normal?

1. Size: Moderate disc
2. Heme: Yes
3. ISNT rule: Rim thinning (inferiorly)
4. PPA: No significant PPA
5. RNFL: Inferior defect

GLAUCOMA
SHIP

- Size
- Heme
- ISN’ T
- PPA
- (RNFL)
SHIP

- Size
- Heme
- Isn’t
- PPA
• Size
• Heme
• Isn’t
• PPA
Visual Fields:

- Detect glaucoma defects
- Determine progression
Visual Fields

- Is the VF Reliable?
- Are the VFs Consistent?
- Is the VF Abnormal?
- Is the defect Reproducible?
- Is the defect from Glaucoma?
Is the VF Reliable?

- Reliability indices
  - False positives
  - False negatives
- Fixation Losses
- Eye Tracker
Are the Visual Fields Consistent?

- Exam type
- Stimulus size
- Field size
- Pupil size if <2.5
- Refraction
Is the field abnormal?

- The more clustered points
- Nerve fiber layer distribution
- The deeper the defect
- The more reproducible (twice??, thrice??)
Is the defect reproducible?

- Confirm abnormal field even in experienced field takers

In OHTS, 85.9% of abnormal fields reverted to normal on subsequent testing.

Is the defect from glaucoma?

Left

Right
Progression: GPA
FREQUENCY DOUBLING PERIMETRY: THE ILLUSION

- Doubling illusion created by broad, rapidly alternating bars
- Illusion stimulates response from the magnocellular (M-cell) pathway with large diameter axons
- In abnormal regions of the VF, the illusion is present only if the bars are at higher than normal contrast levels.
FREQUENCY DOUBLING PERIMETRY

- Ambient lighting
- No trial lenses for refractive errors <7 D.
- No eye patch.
- No dilation.
**FREQUENCY DOUBLING PERIMETRY**

- Accurately detected glaucomatous damage (sensitivity 93%, specificity 100%).
- Detected damage in the ‘unaffected hemifield’ in 8/11 eyes with NTG who had VF defects using standard perimetry in only one hemifield.

Normal visual field does not mean the patient doesn’t have glaucoma.

Substantial structure damage may exist by the time VF loss is detected by SAP.
Structural Damage May Precede Functional Vision Loss

Structure before function

- Structural damage can be identified in most patients before functional damage with automated perimetry
  - Clinical Examination
  - Optic Nerve Photographs
  - OCT Spectral Domain SD-OCT
OCT in Glaucoma

- Provides qualitative and quantitative information about the optic nerve and nerve fiber layer
- Useful tool for the assessment of glaucoma
- Structure / function correlates
  - Diagnosis of glaucoma
  - Progression of glaucoma
  - Identify areas of abnormality
  - Helps distinguish glaucoma suspects from glaucoma
OCT in Glaucoma

- SD-OCT imaging
  - Excellent reproducibility of measurements
  - Exact correspondence with the fundus image
  - Promise of greater sensitivity to abnormality and change over time

- Development of OCT statistical software for the measurement of glaucoma progression
Normative Database

- Color codes the patient’s TISNT scan in comparison to the normative database
  - Red: Lowest 1% of normal measurements
    - Outside normal limits
  - Yellow: Lowest 5% of normal measurements
    - Borderline
  - Green: 90% (from 5%-95%) of all normal measurements
    - Within normal limits
  - White: Highest 5% of normal measurements
Limitations of Normative Database
Varies by instrument

- Limited number of subjects in each group, underestimates normal variation
- Children under age 18
- High refractive errors
  - Use caution with high myopia and high hyperopia
- Non-white ethnicities
- Large and small optic discs
- Tilted optic discs, anomalous optic discs
- Caveat: by definition, 1/20 normal eyes will fall below the green zone.
Reliability
Cirrus SD-OCT Printout
Structure/Function

- Good structural and functional correlation in normal and glaucomatous eyes
- Significant difference in RNFL thickness between healthy and glaucomatous eyes
- Comparisons to normative database highlight pathology
Ganglion Cell Layer: Macula Scan
TSNIT ‘Within normal limits’ but asymmetric
### ONH and RNFL OU Analysis: Optic Disc Cube 200x200

<table>
<thead>
<tr>
<th>Component</th>
<th>OD</th>
<th>OS</th>
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</thead>
<tbody>
<tr>
<td>Average RNFL Thickness</td>
<td>100</td>
<td>83</td>
</tr>
<tr>
<td>RNFL Symmetry</td>
<td>73%</td>
<td>73%</td>
</tr>
<tr>
<td>Rim Area</td>
<td>1.27 mm²</td>
<td>1.07 mm²</td>
</tr>
<tr>
<td>Disc Area</td>
<td>1.63 mm²</td>
<td>1.72 mm²</td>
</tr>
<tr>
<td>Average OD Ratio</td>
<td>0.47</td>
<td>0.61</td>
</tr>
<tr>
<td>Vertical OD Ratio</td>
<td>0.53</td>
<td>0.65</td>
</tr>
<tr>
<td>Cup Volume</td>
<td>0.055 mm³</td>
<td>0.116 mm³</td>
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</tbody>
</table>

### Ganglion Cell OU Analysis: Macular Cube 512x128

<table>
<thead>
<tr>
<th>Component</th>
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</thead>
<tbody>
<tr>
<td>Average GCL + IFL Thickness</td>
<td>92</td>
<td>79</td>
</tr>
<tr>
<td>Minimum GCL + IFL Thickness</td>
<td>91</td>
<td>55</td>
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Focal RNFL Defect

RNFL THICKNESS AVERAGE ANALYSIS

OD

OS

Diagnosis:
- OD: 0.06
- OS: 0.02
- OD(OS): <0.07

Scores:
- Epi/Atlas: 1.05
- Sharp/Max: 2.29
- Sharp/Thang: 1.09
- Inten/Thang: 0.21
NFL OCT

Hit the floor
OCT: Progression

- Retinal nerve fiber layer thickness may be followed for change over time to track glaucoma progression.


Rate of Progression: -4.2 ± 3.6%/year (95% confidence)
Slope significant at P < 5%

Rate of change: -9.043 ± 6.337 μ/year
Statistically significant P < 5%, seek clinical correlates
Progression OCT
RTVue

B. Avanti RTVue XR. Normal pRNFL and ONH analysis compared to normative data.
RTVue
RTVue: Ganglion Complex Thickness

- GCC thickness map showing thickness change over multiple visits
- OD RNFL thickness map showing change over multiple visits
- Graphs showing RNFL and GCC thickness, respectively, on the y-axis over age on the x-axis. The graphs demonstrate rate of change over multiple visits with best fit line and prediction capability

I. Avanti RTVue XR. A combined GCC and RNFL thickness progression map OD demonstrates thinning of the RNFL and GCC compared with normative data with no statistically significant progression over serial scans.

- Color-coded statistical analysis of the GCC and RNFL parameters compared to normative data
- TSNIT graph with different color lines representing each visit and corresponding to RNFL thickness in each peripapillary quadrant
RTVue
SD-OCT

- Excellent at detecting early glaucoma damage
- OCT imaging may be difficult in the presence of media opacities such as cataract, corneal disease, vitreous hemorrhage.
- Not useful in advanced glaucoma
- SD-OCT still requires development of robust alignment and registration algorithms to approach its clinical potential
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