SUSPECTING GLAUCOMA

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Orlando, Florida

NO FINANCIAL DISCLOSURES.
STATISTICS

• WORLD WIDE
  • GLAUCOMA AFFECTS > 45 MILLION
  • OAG AND ANGLE CLOSURE ARE 2ND LEADING CAUSE OF BILATERAL BLINDNESS (CATARACTS)
  • 8.4 MILLION PEOPLE ARE BILATERALLY BLIND FROM IT
    • ~ 4.5 MILLION OAG
    • ~ 3.9 MILLION ACG

• UNITED STATES
  • 3.36 MILLION WITH OAG BY 2020
  • OVERALL PREVALENCE OF POAG FOR ADULTS > 40 YO = 2% (2004)
  • OAG 7X MORE PREVALENT THAN ACG
  • 50% WITH ONH DAMAGE ARE UNAWARE
## KNOW YOUR PATIENT POPULATION

### Table IV. Frequency of Nonrefractive Ocular Diagnoses

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glaucoma</td>
<td>168</td>
<td>25.5</td>
</tr>
<tr>
<td>Suspect</td>
<td>133</td>
<td>20.2</td>
</tr>
<tr>
<td>Primary Open Angle</td>
<td>27</td>
<td>4.1</td>
</tr>
<tr>
<td>Angle Closure</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>Pseudoxvilliation</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Traumatic</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Diabetes</td>
<td>91</td>
<td>13.8</td>
</tr>
<tr>
<td>No Retinopathy</td>
<td>68</td>
<td>10.3</td>
</tr>
<tr>
<td>Nonproliferative</td>
<td>16</td>
<td>2.4</td>
</tr>
<tr>
<td>Macular Edema</td>
<td>2</td>
<td>0.3</td>
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<tr>
<td>Proliferative</td>
<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>AMD</td>
<td>31</td>
<td>4.7</td>
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<tr>
<td>Nonexudative</td>
<td>21</td>
<td>3.2</td>
</tr>
<tr>
<td>Drusen</td>
<td>8</td>
<td>1.2</td>
</tr>
<tr>
<td>Exudative</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>Other</td>
<td>159</td>
<td>21</td>
</tr>
<tr>
<td>Blepharitis</td>
<td>43</td>
<td>6.5</td>
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<tr>
<td>Cataract</td>
<td>39</td>
<td>5.9</td>
</tr>
<tr>
<td>Retinal Vascular Disease</td>
<td>22</td>
<td>3.3</td>
</tr>
<tr>
<td>Severe Dry Eye</td>
<td>14</td>
<td>2.1</td>
</tr>
<tr>
<td>Optic Neuropathy</td>
<td>11</td>
<td>1.7</td>
</tr>
<tr>
<td>Peripheral Retinal Disease</td>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>(Lattice, Retinal Break, Detachment)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Ocular Diagnoses in Veterans in the Veterans Affairs Capital Health Care Network from Fiscal Year 2007 to Fiscal Year 2011

<table>
<thead>
<tr>
<th>Disease category, n (%)</th>
<th>2007 (N = 130,709)</th>
<th>2007 (N = 130,709)</th>
<th>2007 (N = 130,709)</th>
<th>2007 (N = 130,709)</th>
<th>2007 (N = 130,709)</th>
<th>2007 (N = 130,709)</th>
<th>( \beta )</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disorders of refraction and accommodation</td>
<td>11,067 (8.5)</td>
<td>12,046 (9.2)</td>
<td>14,150 (10.3)</td>
<td>16,078 (12.4)</td>
<td>18,854 (13.1)</td>
<td>1.13 &lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glaucoma</td>
<td>8815 (6.7)</td>
<td>9003 (6.9)</td>
<td>9494 (6.9)</td>
<td>9921 (7.7)</td>
<td>10,431 (7.4)</td>
<td>0.14 .03</td>
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<td></td>
</tr>
<tr>
<td>Ophthalmic complications of diabetes</td>
<td>2806 (2.2)</td>
<td>3180 (2.4)</td>
<td>3065 (2.2)</td>
<td>2962 (2.1)</td>
<td>2908 (2.0)</td>
<td>-0.07 .148</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cataract</td>
<td>9215 (7.1)</td>
<td>8827 (6.7)</td>
<td>11,292 (8.2)</td>
<td>12,050 (8.5)</td>
<td>13,529 (8.6)</td>
<td>0.68 .02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any ophthalmic diagnosis</td>
<td>26,804 (20.5)</td>
<td>27,552 (21.1)</td>
<td>29,877 (21.5)</td>
<td>31,461 (22.2)</td>
<td>33,811 (23.3)</td>
<td>0.67 &lt; .01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Veteran Eye Disease After Eligibility Reform: Prevalence and Characteristics

(Atlanta)

Military Medicine, 178, 7:811, 2013

### Trends in Prevalence of Diagnosed Ocular Disease and Utilization of Eye Care Services in American Veterans

(MD, DC, and Parts of VA, WV, PA)

Am J Ophthalmol. 2017 Jan;173:70-75
“…WE RECOMMEND THAT EVERY COMPLETE OCULAR EXAMINATION BE PERFORMED WITH THE POSSIBILITY OF GLAUCOMA FIRMLY IN MIND…”

Drs. Hodapp, Parrish and Anderson
*Clinical Decisions in Glaucoma*
1993, Mosby

and again in

Drs. Chang, Ramulu and Hodapp
*Clinical Decisions in Glaucoma*
WHAT’S THE DIFFERENCE BETWEEN HAVING GLAUCOMA AND BEING A SUSPECT?
PRIMARY OPEN-ANGLE GLAUCOMA

“A CHRONIC, PROGRESSIVE OPTIC NEUROPATHY IN ADULTS IN WHICH THERE IS A CHARACTERISTIC ACQUIRED ATROPHY OF THE OPTIC NERVE AND LOSS OF RETINAL GANGLION CELLS AND THEIR AXONS. THIS CONDITION IS ASSOCIATED WITH AN OPEN ANTERIOR CHAMBER ANGLE BY GONIOSCOPY.”

AMERICAN ACADEMY OF OPHTHALMOLOGY
Preferred Practice Pattern
2015
GLAUCOMA SUSPECT

• “SOMEONE WHO, FOR ONE OR MORE REASONS, IS AT HIGHER THAN USUAL RISK OF DEVELOPING GLAUCOMATOUS OPTIC NERVE DAMAGE AND VISUAL DEFICIENCY AND THEREFORE WARRANTS CAREFUL FOLLOW-UP.”

• “AN INDIVIDUAL WITH CLINICAL FINDINGS AND / OR A CONSTELLATION OF RISK FACTORS THAT INDICATE AN INCREASED LIKELIHOOD OF DEVELOPING PRIMARY OPEN-ANGLE GLAUCOMA.”
RISK FACTORS ASSOCIATED WITH OPEN-ANGLE GLAUCOMA

• NUMEROUS STUDIES IDENTIFY THESE
  • HIGHER IOP
  • OLDER AGE
  • FAMILY HISTORY OF GLAUCOMA
  • AFRICAN RACE OR LATINO / HISPANIC ETHNICITY
  • THINNER CENTRAL CORNEA
  • LOW OCULAR PERFUSION PRESSURE
  • TYPE 2 DIABETES MELLITUS
  • MYOPIA
  • LOWER SYSTOLIC AND DIASTOLIC BLOOD PRESSURE
  • DISC HEMORRHAGE
  • LARGER CUP-TO-DISC RATIO
  • HIGHER PSD ON THRESHOLD VISUAL FIELD

• OTHER FACTORS
  • MIGRAINES / PERIPHERAL VASOSPASM
  • SYSTEMIC ARTERIAL HYPERTENSION
  • TRANSLAMINAR PRESSURE GRADIENT
  • GENETICS

AMERICAN ACADEMY OF OPHTHALMOLOGY
Preferred Practice Pattern
2015
• PREVALENCE OF GLAUCOMA
  • INCREASES WITH AGE
  • FRAMINGHAM EYE STUDY
    • PREVALENCE OF POAG
      • 52-85 YO = 1.65%
      • IF YOU ADD VF TESTING = 2.1%
• OVERALL PREVALENCE
  • 4-10X HIGHER IN OLDER AGE GROUPS COMPARED TO THOSE IN 40S
  • 2004 DATA
    • 2% OF POPULATION > 40 YO HAD POAG

<table>
<thead>
<tr>
<th>Study</th>
<th>Age Groups (yrs)</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>40-49</td>
<td>50-69</td>
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<tr>
<td>Baltimore Eye Study16</td>
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<td>Barbados Eye Study17</td>
<td>1.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Los Angeles Latino Eye Study14</td>
<td>1.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Proyecto Vision Evaluation Research19</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Baltimore Eye Study16</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Blue Mountains Eye Study18</td>
<td>0.4*</td>
<td>1.3</td>
</tr>
<tr>
<td>Visual Impairment Project19</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Beaver Dam Eye Study21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roscommon22</td>
<td>0.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>
RACE

- AFRICAN AMERICANS
  - DEVELOP DISEASE EARLIER
  - DO NOT RESPOND AS WELL TO TREATMENT
  - MORE LIKELY TO REQUIRE SURGERY
  - HIGHER PREVALENCE OF BLINDNESS
  - BALTIMORE EYE SURVEY
    - PREVALENCE OF GLAUCOMA
    - AA WERE 4.3X CAUCASIANS

- AFRO-CARIBBEAN
  - BARBADOS EYE STUDY
    - HIGHER THAN AA > 60 YO

<table>
<thead>
<tr>
<th>Study</th>
<th>Ethnoracial Group</th>
<th>40–49</th>
<th>50–59</th>
<th>60–69</th>
<th>70–79</th>
<th>80+</th>
<th>Total</th>
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<tbody>
<tr>
<td>Baltimore Eye Study16</td>
<td>African American</td>
<td>1.3</td>
<td>4.2</td>
<td>6.2</td>
<td>8.9</td>
<td>12.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Barbados Eye Study17</td>
<td>Afro-Caribbean</td>
<td>1.4</td>
<td>4.1</td>
<td>6.7</td>
<td>14.8</td>
<td>23.2</td>
<td>6.8</td>
</tr>
<tr>
<td>Los Angeles Latino Eye Study14</td>
<td>Latino</td>
<td>1.3</td>
<td>2.9</td>
<td>7.4</td>
<td>14.7</td>
<td>21.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Proyecto Vision Evaluation Research19</td>
<td>Latino</td>
<td>0.5</td>
<td>0.6</td>
<td>1.7</td>
<td>5.7</td>
<td>12.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Baltimore Eye Study16</td>
<td>NHW</td>
<td>0.2</td>
<td>0.3</td>
<td>1.5</td>
<td>3.3</td>
<td>1.94</td>
<td>1.4</td>
</tr>
<tr>
<td>Blue Mountains Eye Study18</td>
<td>NHW</td>
<td>0.4</td>
<td>1.3</td>
<td>4.7</td>
<td>11.4</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Visual Impairment Project20</td>
<td>NHW</td>
<td>0.5</td>
<td>1.5</td>
<td>4.5</td>
<td>8.6</td>
<td>9.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Beaver Dam Eye Study21</td>
<td>NHW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Roscommon22</td>
<td>NHW</td>
<td>0.7</td>
<td>1.8</td>
<td>3.2</td>
<td>3.1</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>
RACE

• LATINO / HISPANIC ETHNICITY
  • PREVALENCE
    • INCREASES WITH AGE
    • > 40 YO 1.7% > 80 YO 7.4%
  • STARTING AT AGE 60
    • ≥ AFRICAN AMERICANS

• OTHER RACES
  • JAPANESE
    • HIGHER PREVALENCE OF NORMAL TENSION
  • CHINESE, VIETNAMESE, PAKISTANI, INUIT
    • HIGHER PREVALENCE OF ANGLE CLOSURE
DIABETES

• CONFLICTING REPORTS
  • SOME STUDIES FIND NO RELATIONSHIP
  • OTHERS SAY DM IS PROTECTIVE
  • OTHERS SAY DM IS RISK FACTOR FOR POAG

• POPULATION BASED STUDIES
  • HIGHER ODDS OF DM WITH POAG
    • 40% HIGHER ODDS IN HISPANICS
    • 2X HIGHER IN NONHISPANIC WHITES
    • LONGER DURATION OF TYPE 2 = HIGHER RISK OF HAVING POAG
  • META-ANALYSIS OF 47 STUDIES
    • INCREASED RISK OF GLAUCOMA AND MAY BE ASSOCIATED WITH ELEVATED IOP

• MECHANISM THEORY
  • MICROVASCULAR CHANGES MAY MAKE ONH MORE SUSCEPTIBLE TO DAMAGE IN THOSE WITH TYPE 2 DM
OCULAR PERFUSION PRESSURE and BP

- OCULAR PERFUSION PRESSURE
  - DIFFERENCE BETWEEN BP AND IOP
    - SYSTOLE OR DIASTOLE

- MECHANISM THEORY
  - REDUCED PERFUSION AND/OR VASCULAR DYSREGULATION AND THE SUBSEQUENT ISCHEMIA OF THE ONH CONTRIBUTE TO GLAUCOMA DAMAGE

- HOW TO CALCULATE IT
  - MEAN OPP = 2/3 MAP - IOP
    - MEAN ARTERIAL PRESSURE (MAP) = DBP + [1/3 X (SBP-DBP)]
  - IT IS NOT EXACT

- SHOULD WE BE CALCULATING IT?
  - THINGS OTHER THAN IOP IMPACT GLAUCOMA
  - CHECK BLOOD PRESSURE
  - LOW BP WITH HIGH IOP = AT RISK (LOWER OPP)
    - RISK OF REDUCTION IN VOLUME OF BLOOD TO ONH
    - EYE AT RISK DUE TO IMPAIRED AUTO-REGULATION
    - RISK OF ISCHEMIA, OXIDATIVE STRESS
FAMILY HISTORY

• ROTTERDAM EYE STUDY
  • ALL SIBLINGS OF GLAUCOMA CASES AND CONTROLS EVALUATED
    • ODDS OF POAG WERE 9.2X HIGHER IF FIRST DEGREE RELATIVE WITH POAG
      • FIRST DEGREE = SIBLING OR PARENT

• BALTIMORE EYE SURVEY AND LALES
  • ODDS OF POAG 1.92 AND 2.85 IF FIRST DEGREE RELATIVE
  • ODDS OF 3.7 AND 3.47 IF SIBLING WITH GLAUCOMA
  • 5X HIGHER IF TWO OR MORE SIBLINGS
THE GLAUCOMA SUSPECT WORK-UP

• VA
• PUPILS
• SLIT-LAMP
• IOP
• CENTRAL CORNEAL THICKNESS
• GONIOSCOPY

AAO Preferred Practice Pattern, POAG Suspect, 2015

• DILATED FUNDUS EVALUATION
• MAGNIFIED, STEREOSCOPIC EVALUATION OF
  • ONH
  • RNFL
• DOCUMENTATION OF ONH
  • STEREOPHOTOGRAPHY
  • OR
  • COMPUTER BASED ANALYSIS
• VISUAL FIELD BY AUTOMATED PERIMETRY
REFRACTIVE ERROR

• MYOPIA
  • 1999 BLUE MOUNTAINS STUDY (AUSTRALIA)
    • 3654 PATIENTS
    • GLAUCOMA DIAGNOSED BASED ON VISUAL FIELDS, OPTIC DISC CUPPING, RIM THINNING
    • GLAUCOMA PRESENT IN
      • 1.5% NO MYOPIA. 4.2% OF LOW MYOPIA (1-3D). 4.4% MODERATE-HIGH MYOPIA (>3D)
  • CONCLUSIONS
    • 2-3X GREATER RISK IF MYOPIC, INDEPENDENT OF OTHER GLAUCOMA RISK FACTORS AND IOP

• LALES
  • LONGER AXIAL LENGTH HAS HIGHER PREVALENCE OF POAG

• POSSIBLE MECHANISM
  • WEAKER SCLERAL SUPPORT AT ONH = GREATER SUSCEPTIBILITY OF OPTIC NERVE TO DAMAGE

• HYPEROPIA
  • RISK OF ANGLES BEING NARROW
    • CONSIDER GONIOSCOPY
PRELIMINARY TESTING

• VISUAL STATUS
  • POSSIBLY NORMAL OR
    • 20/20 OR REDUCED DUE TO SEVERE GLAUCOMA
      • OR AMBLYOPIA OR OTHER DISEASE
  • HYPEROPIES
    • RISK OF NARROW ANGLES

• LENSOMETRY / AUTOREFRACTION
  • AXIAL MYOPES
    • SUSCEPTIBLE TO ONH DAMAGE
  • HYPEROPIES
    • RISK OF NARROW ANGLES

• PUPILS
  • POSSIBLY NORMAL OR
  • APD POSSIBLE IF ASYMMETRIC GLAUCOMA
    • OR OTHER DISEASE
  • MID-DILATED IF ACUTE ANGLE CLOSURE
  • SURGICAL
    • LOOK FOR BLEB

• CONfrontATION FIELDS
  • FULL IS POSSIBLE
  • CONSTRICTED
    • INF NASAL OR 360 DEGREES
    • GLAUCOMA OR OTHER DISEASE
SLIT LAMP EXAMINATION

• CONJUNCTIVA / SCLERA
  • POSSIBLY NORMAL OR...
    • HYPEREMIA
      • POSSIBLE SIGN OF INFLAMMATION
        • ? UVEITIC
        • ON PROSTAGLANDIN OR OTHER
    • SCARRING
      • ? H/O FAILED SURGERY
  • OTHER INDICATORS
    • TUBE PLATE
    • SUTURES
    • FILTRATION BLEB
SLIT LAMP EXAMINATION

• CORNEA
  • POSSIBLY NORMAL OR...
    • SCARRING
    • PIGMENT
      • KRUKENBERG SPINDLE
    • KERATIC PRECIPITATES
    • EDEMA
      • IF PRESSURE HIGH

• GUTTATA
  • MAY THROW OFF IOP READING

• WHORL KERATOPATHY
  • MAY BE ON RHO-KINASE INHIBITOR
SLIT LAMP EXAMINATION

• IRIS
  • NORMAL OR...
    • TRANSILLUMINATION DEFECTS
    • WHITE FLAKES AT PUPILLARY BORDER
    • SPHINCTER TEARS
    • HETEROCHROMIA
    • KOEPPE OR BUSACCA NODULES
    • IRIDECTOMY / IRIDOTOMY
    • NEOVASCULARIZATION
      • RARE IF ASYMPTOMATIC
    • DEVELOPMENTAL ABNORMALITIES
      • ICE SYNDROMES (UNILATERAL)
      • AXENFELD-REIGER’S (BILATERAL)
SLIT LAMP EXAMINATION

• ANTERIOR CHAMBER
  • NORMAL OR…
    • CELLS AND / OR FLARE
      • ACTIVE INFLAMMATION
    • SYNECHIAE
      • PRIOR INFLAMMATION
  • MIGS
    • WILL NEED GONIO LENS TO VIEW
  • TUBES / EXPRESS SHUNT
  • ACIOL
    • COMPLICATED CATARACT
    • COMBINED PROCEDURE
• ESTIMATE DEPTH
  • < GRADE 2, DO GONIOSCOPY
ESTIMATE ANGLE DEPTH
IS VH REALLY GOOD ENOUGH?

• 2018 RETROSPECTIVE STUDY
  • 1314 EYES
  • 14% OF EYES WITH NARROW ANGLES ON GONIOSCOPY WERE CLASSIFIED AS DEEP ON VH ALONE

• INDEPENDENT RISK FACTORS
  • MALE
  • MYOPIA
  • BLACK OR ASIAN RACE

Risk Factors Associated with Missed Diagnoses of Narrow Angles by the Van Herick Technique

Alic C. Thompson, MD, MPH,1 Daniel M. Vu, MD,1 Lisa A. Cossen, MD, PhD,2 Sanjeev Aravind, MD

Purpose: To identify which factors are associated with a deep-appearing anterior chamber on slit-lamp examination by the Van Herick (VH) technique in eyes with a diagnosis of narrow angle (NA) on gonioscopy.

Design: Retrospective review.

Participants: One thousand three hundred fourteen eyes in 696 participants with NA on indirect gonioscopy.

Methods: All included eyes were graded as narrow with indirect contact on indirect gonioscopy in a darkened room by a single trained glaucoma specialist. Before gonioscopy, eyes were graded as narrow or deep by VH slit-lamp examination technique. Demographic and clinical factors predictive of a deep VH grading were assessed using logistic regression with generalized estimating equations.

Main Outcome Measures: Factors associated with deep versus narrow VH grade.

Results: Using the VH technique, 13.7% of eyes (n = 180/1314) with NA on gonioscopy were classified as deep. Eyes with primary angle-closure glaucoma (PACG; odds ratio, 2.43; P < 0.001) and primary angle closure (PAC; odds ratio, 1.35; P = 0.006) were significantly more likely to be graded as deep by the VH technique relative to eyes that were primary angle-closure suspects (PACSs). In multivariate analysis, male gender (odds ratio, 2.22; P < 0.001), myopia (odds ratio, 1.4; P = 0.048), and black (odds ratio, 4.11; P < 0.001) and Asian (odds ratio, 2.24; P = 0.044) race were independent risk factors for a deep grading with the VH technique in eyes with NA on gonioscopy.

Conclusions: Patients with NAS on gonioscopy who are men, myopic, and of black or Asian race are at increased risk of being misdiagnosed with deep angles if examined with the VH technique alone. Eyes with PACG and PAC may be more likely than those with PACS to be misdiagnosed as deep with the VH technique. It is possible that by being missed by the VH technique, these eyes could have progressed from PACS to PAC and PACG. Patients with these demographic and clinical characteristics in the presence of other risk factors for glaucoma should undergo careful gonioscopy. Ophthalmology Glaucoma 2018;109:114 © 2018 by the American Academy of Ophthalmology.
GONIOSCOPY

• WHY DO IT?
  • IS IT SAFE TO DILATE?
    • DONE IF < GRADE 2 ON VAN HERICK
    • CONSIDER ON ALL > +2.50
  • DIFFERENTIATE
    • OPEN VS ANGLE CLOSURE GLAUCOMA
      • IF NARROW, MAY INFLUENCE TREATMENT OPTIONS
    • PRIMARY OPEN ANGLE VS SECONDARY OPEN ANGLE
      • IF SECONDARY, MAY INFLUENCE TREATMENT OPTIONS
  • MONITOR FOR CHANGE
  • ANGLE CLOSURE SUSPECT
    • IF < 180 DEGREES OF VISIBLE TM (POSTERIOR/PIGMENTED)

<table>
<thead>
<tr>
<th>Van Herick's grading</th>
<th>Ratio of gap to limbal corneal section</th>
</tr>
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<tbody>
<tr>
<td>Grade 1</td>
<td>&lt;1:4</td>
</tr>
<tr>
<td>Grade 2</td>
<td>1:4</td>
</tr>
<tr>
<td>Grade 3</td>
<td>1:2</td>
</tr>
<tr>
<td>Grade 4</td>
<td>1:1 (or &gt;1:1)</td>
</tr>
</tbody>
</table>
NORMAL VS ABNORMAL GONIOSCOPY
GONIOSCOPY DOCUMENTATION

- SEVERAL GRADING SYSTEMS CAN BE USED
  - SHAFFER, SPAETH, SCHEIE (1957)
  - 4-MIRROR IS PREFERRED
- WHAT TO LOOK FOR
  - MENTALLY NOTE
    - OPEN, SUSPICIOUSLY NARROW
    - ASYMMETRIC DIFFERENCES
  - RECORD THE DEPTH
    - MOST POSTERIOR STRUCTURE VISUALIZED IN ALL QUADRANTS OD / OS
    - IF NARROW, DOES ANGLE OPEN WITH COMPRESSION?
  - RECORD PRESENCE / ABSENCE OF
    - PIGMENT, PAS, RECESSION, NV
PDS / PIGMENTARY GLAUCOMA

- KRUKENBERG SPINDLE AND/OR IRIS TRANSILLUMINATION DEFECTS (SPOKE-LIKE, MID-PERIPHERAL)
- DARKLY PIGMENTED TM ON GONIOSCOPY
- MIDPERIPHERAL POSTERIOR IRIS BOWING
- TRANSIENT EPISODES OF BLURRED VISION OR SEEING HALOS AROUND LIGHTS AFTER EXERCISE
- MODERATELY MYOPIC MEN < AGE 50
- MAPPED TO CHROMOSOME 7q35-q36 (GPDS1 GENE)
- IOP MAY SPIKE
  - OBSTRUCTION OF TRABECULAR MESHWORK BY PIGMENT AND PIGMENT-LADEN MACROPHAGES
- GLAUCOMA DEVELOPS IN 25-50% WITH PDS
PSEUDOEXFOLIATION / GLAUCOMA

- Gray-white material deposition on pupil margin, anterior lens capsule or corneal endothelium
  - Also found in skin, heart, lungs
- Loss of pupillary ruff, transillumination defects
- Pigmented TM and Sampaolesi’s line
- White material on zonules
- Bilateral > unilateral, asymmetric
- Rarely < age 65
- IOP may spike
  - From accumulation of material in angle or lenticular pupillary block from zonular laxity and movement of lens
- 60% develop OC HTN or glaucoma
INTRAOCULAR PRESSURE

• A RISK FACTOR ONLY
  • NOT PART OF THE DEFINITION

• PREVALENCE OF GLAUCOMA INCREASES WITH LEVEL OF IOP

• THE HIGHER THE IOP, THE GREATER THE RISK AND SEVERITY OF GLAUCOMA

• RISK OF DEVELOPING GLAUCOMA
  • IOP > 21 mmHg 16X RISK VS < 16 mmHg

• DEVELOPING VF DEFECT OVER 5 YEARS
  • 6.7% IF IOP > 20 mmHg
  • 1.5% IF IOP < 20 mmHg

INTRAOCULAR PRESSURE

• WORRIED ABOUT THE IOP > 21mmHg?
  • THAT NUMBER IS ARBITRARY
    • 2 STANDARD DEVIATIONS ABOVE THE MEAN IN THE EUROPEAN POPULATION

• WHAT IF THE IOP IS NOT “HIGH”?
  • IT DOES NOT MATTER
    • BALTIMORE EYE SURVEY
      • 55% NEWLY DIAGNOSED POAG HAD INITIAL IOP < 22 mmHg
      • 24% < 22 mmHg ON TWO READINGS
      • 16% < 22 mmHg ON THREE READINGS
INTRAOCULAR PRESSURE

• > 22 mm Hg = FURTHER TESTING RECOMMENDED

• IF IOP IS NOT ELEVATED
  • NO GUARANTEE OF NORMALCY

• IF IOP IS ELEVATED
  • GOAL IS TO FIND THE CAUSE
  • POAG IS A DIAGNOSIS OF EXCLUSION
  • THE CAUSE WILL INFLUENCE TREATMENT OPTIONS

• IF IOP IS ASYMMETRIC
  • NORMALS RARELY DIFFER BY 2 mmHg
  • POAG MAY HAVE MODERATE ASYMMETRY
  • IF WIDELY DISPARATE, CONSIDER UNILATERAL PROCESS (SECONDARY CAUSE)
    • PSEUDOEXFOLIATION, TRAUMA, ETC.
INTRAOCULAR PRESSURE

• HOW MANY IOP READINGS SHOULD I GET?
  • AT LEAST 3 READINGS, ON DIFFERENT DAYS, AT DIFFERENT TIMES OF THE DAY

• WHAT DEVICE SHOULD I USE?
  • APPLANATION PREFERRED FOR MANAGEMENT
  • NCT / TONOPEN / ACCEPTABLE FOR SCREENING
    • NOT AS ACCURATE / REPEATABLE FOR HIGH AND LOW IOP
  • OTHER OPTIONS
    • ICARE, ORA, DCT, ETC.
  • BE CONSISTENT
  • TRAIN TECHNICIANS WELL, REPEAT AS NEEDED

• RECORD TIME TESTED
  • CONSIDER MODIFIED DIURNAL TESTING
INTRAOCULAR PRESSURE

• BUT…

• SUSCEPTIBILITY OF OPTIC NERVE DAMAGE VARIES
• 3-6 MILLION PEOPLE HAVE OCULAR HYPERTENSION WITHOUT GLAUCOMATOUS DAMAGE
IOP

• FROM THE OHTS
  • 1300 PATIENTS
• RESULTS
  • IOP RELATED INFO
    • LOWERING IOP DELAYS OR PREVENTS DEVELOPMENT OF GLAUCOMA IN PATIENTS WITH ELEVATED IOP
    • MAJORITY OF OCULAR HTN PATIENTS DO NOT DEVELOP GLAUCOMA
    • ALL PATIENTS WITH OCULAR HTN DO NOT NEED TREATMENT
    • TREAT THOSE AT GREATEST RISK

IOP AND CENTRAL CORNEAL THICKNESS

FROM THE OHTS

1300 PATIENTS

RESULTS

CCT RELATED INFO

INFLUENCES GOLDMANN TONOMETRY

A RISK FACTOR FOR DEVELOPING POAG

THICKNESS < 555 um 3X RISK COMPARED TO > 588

RISK FACTOR FOR PROGRESSION?

NOT ALL STUDIES AGREE

STILL TO BE DETERMINED

CENTRAL CORNEAL THICKNESS

- Racial variations are present
  - African American: 534 um
  - Latino: 546 um
  - Caucasian: 556 um

- Say No to Nomograms

- Think: Thin / Normal / Thick
  - Thin = At Risk

“The implication that IOP can be corrected with an arithmetic, linear correction factor of some mmHg / um clearly represents an oversimplification of what is undoubtedly a complex and nonlinear relationship between corneal thickness and true IOP”

Brandt JD, et al
OHTS. Ophthalmology 2001; 108: 1779-1788
SLIT LAMP EXAMINATION

• LENS ASSESSMENT (TYPICALLY ONCE DILATED)
  • PIGMENT
    • TRAUMA, POSTERIOR SYNECHIAE
  • PSEUDEOXFOLIATION
  • SUBLUXATION
  • CATARACT
    • ROSETTE
    • PHACOLYTIC
    • PHACOMORPHIC
  • PSEUDOPHAKIC
    • UNEVENTFUL?
    • COMPLICATED?
      • ? PSEUDEOXFOLIATION VS OTHER
FUNDUS EXAMINATION

**POSSIBLE REASONS FOR VF DEFECT**
- ARTERY / VEIN OCCLUSION
- OTHER RETINAL LESIONS
- OTHER OPTIC NEUROPATHIES
- S/P PRP

**POSSIBLE SECONDARY GLAUCOMA**
- TRAUMA
  - CHORIORETINAL SCAR
  - CHOROIDAL RUPTURE
  - MACULAR HOLE
  - RETINAL TEAR / RD
- NVG
  - VASCULAR OCCLUSION
  - OIS
  - SICKLE CELL
CLINICAL FINDINGS
CHARACTERISTIC OF POAG

• **OPTIC DISC** STRUCTURAL ABNORMALITIES

• **RETINAL NERVE FIBER LAYER** STRUCTURAL ABNORMALITIES

• RELIABLE AND REPRODUCIBLE **VISUAL FIELD** ABNORMALITY
WHAT’S THE FIRST THING WE NOTICE WHEN LOOKING AT THE OPTIC NERVE?
THE C/D RATIO

“WHEN A CLINICIAN EXAMINES A PATIENT FOR THE FIRST TIME, THERE IS NO WAY TO DETERMINE WHETHER THE C/D RATIO OBSERVED HAS BEEN STABLE DURING THE PATIENT’S LIFETIME OR HAS ENLARGED AS PART OF THE DISEASE PROCESS, ASSUMING THAT NO PREVIOUS PHOTOGRAPHS OR MEASUREMENTS ARE AVAILABLE FOR COMPARISON”

GORDON MO, ET AL.
THE OHTS: BASELINE FACTORS THAT PREDICT THE ONSET OF POAG

ARCH OPHTHALMOL 2002; 120: 701-713.
GO BEYOND THE C/D

• WHY?
  • NO LINE SEPARATING NORMAL FROM GLAUCOMA
  • NORMAL VERTICAL C/D RATIO VARIES FROM 0.00-0.85
  • C/D RATIO OF ≥ 0.65 OCCURS IN 2.2 - 4% OF NORMALS
  • C/D RATIO IS A FUNCTION OF DISC DIAMETER

• REMEMBER
  • LOOK AT THE CONTOUR OF THE CUP, NOT THE COLOR

• DOCUMENT WHAT YOU SEE, NOT JUST THE C/D
  • DESCRIBE THE ONH
OPTIC NERVE EVALUATION TECHNIQUE

- DILATED PUPIL
- STEREOSCOPIC EVALUATION
- CLEAR 78/90/60/SUPERFIELD LENS AT SLIT-LAMP
- DETERMINE THE SIZE OF THE OPTIC NERVE
  - SMALL
  - MEDIUM
  - LARGE
- WHY?
WHICH ONE OF THESE PATIENTS DO YOU THINK HAS GLAUCOMA?
Expected Physiologic Cup Size
Based on Measured Vertical Disc Diameter
Using a 60 Diopter Lens At The Slit Lamp

<table>
<thead>
<tr>
<th>Vertical Height (mm)</th>
<th>-2std</th>
<th>-1std</th>
<th>Mean</th>
<th>+1std</th>
<th>+2std</th>
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<tr>
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<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
<td>2.4</td>
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<tr>
<td>Expected C/D ratio</td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

-2std
-1std
Mean
+1std
+2std
Vertical Height (mm)
Expected C/D ratio

Vertical Height: 1.54 mm, 1.64 mm, 2.44 mm
Area: 1.67 mm², 1.35 mm², 4.19 mm²
HOW TO MEASURE OPTIC DISC DIAMETER

• USE 60D LENS AT SLIT LAMP
  • IF NOT, USE CORRECTION FACTOR
• MAKE THIN VERTICAL BEAM, ADJUST BEAM HEIGHT
• READ HEIGHT OFF SCALE
  • > 2.2 mm IS A LARGE DISC
  • < 1.8 mm IS A SMALL DISC
  • THIS IS A ROUGH ESTIMATE
    • REFRACTIVE ERROR / WORKING DISTANCE INFLUENCE READINGS

• OTHER METHODS
  • DIRECT OPHTHAL (GROSS ESTIMATE)
    • SOME DEBATE AS TO IF LARGER THAN SMALLER SPOT OR MIDDLE SPOT?
  • CAMERAS WITH SOFTWARE
  • ADVANCED IMAGING DEVICES
    • HRT
      • DISC AREA, SMALL / AVG / LARGE
    • OCT CIRRUS CALCULATES DISC AREA
      • 1.06-3.38 mm² (avg 1.83)
      • SMALL <1.63
      • MEDIUM 1.63-1.97
      • LARGE > 1.97

---

**TABLE 3.** Magnification correction factors for the aspheric lenses

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<tr>
<th>Lens</th>
<th>Present study</th>
<th>Manufacturer’s data</th>
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<td>Volk</td>
<td></td>
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</tr>
<tr>
<td>60 D</td>
<td>0.88</td>
<td>0.92</td>
</tr>
<tr>
<td>78 D</td>
<td>1.11</td>
<td>1.15</td>
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<td>90 D</td>
<td>1.33</td>
<td>1.39</td>
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<tr>
<td>Nikon</td>
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<td></td>
</tr>
<tr>
<td>60 D</td>
<td>1.03</td>
<td>1.02</td>
</tr>
<tr>
<td>90 D</td>
<td>1.63</td>
<td>1.54</td>
</tr>
</tbody>
</table>

SIZE AWARENESS

• SMALL SIZED OPTIC NERVES
  • WITH SMALL CUPS = NO GLAUCOMA
  • WITH AVERAGE OR LARGE CUPS = SUSPICIOUS, ANY OTHER SIGNS?

• MEDIUM SIZED OPTIC NERVES
  • WITH SMALL CUPS = NO GLAUCOMA
  • WITH AVERAGE CUPS = NO GLAUCOMA IF NO OTHER SIGNS
  • WITH LARGE CUPS = SUSPICIOUS, ANY OTHER SIGNS?

• LARGE SIZED OPTIC NERVES
  • WITH SMALL CUPS = NO GLAUCOMA
  • WITH AVERAGE CUPS = NO GLAUCOMA IF NO OTHER SIGNS
  • WITH LARGE CUPS = NO GLAUCOMA OR SUSPICIOUS, ANY OTHER SIGNS?
• DISC RIM CHANGES AT SUPERIOR OR INFERIOR POLES (ISNT RULE)
  • DIFFUSE THINNING OF RIM
  • FOCAL NARROWING OF RIM
  • NOTCHING OF RIM

• PROGRESSIVE NEURORETINAL RIM NARROWING / INCREASED CUPPING

• HEMORRHAGES AT DISC RIM, PARAPAPILLARY RNFL, LAMINA

• OPTIC DISC NEURAL RIM ASYMMETRY OF THE TWO EYES
  • CONSISTENT WITH LOSS OF NEURAL TISSUE

• LARGE EXTENT OF PARAPAPILLARY ATROPHY
DISC RIM CHANGES
AT SUPERIOR OR INFERIOR POLES

• DIFFUSE
  • CONCENTRIC
  OR
  • LOCALIZED TO ONE POLE

• FOCAL NARROWING OR NOTCHING
THE ISNT RULE

• 1988 FIRST REPORT BY JONAS ET. AL
  • 457 NORMAL EYES
    • INFERIOR RIM > SUPERIOR > NASAL > TEMPORAL
  • GLAUCOMA VIOLATES THE RULE
    • 80% OF THE TIME
      • WHAT ABOUT THE OTHER 20%?

• IT IS NOT FULLPROOF
  • VARIOUS STUDIES AGREE
    • DO NOT PLACE YOUR FULL FAITH IN ISNT RULE
WHICH EYE HAS GLAUCOMA?
WHICH EYE HAS GLAUCOMA?
PROGRESSIVE NEURORETINAL RIM NARROWING / INCREASED CUPPING

• OPTIONS TO CONSIDER
  • WAS PATIENT BORN THAT WAY
  • IS IT A RECENT CHANGE
  • IS IT A LONG TERM CHANGE

• HOW TO TELL?
  • LOOK FOR CHANGE OVER TIME
  • DRAWING, WRITTEN DESCRIPTIONS
    • NO LONGER GOOD ENOUGH
  • TAKE PICTURES
    • KEEP DOING THESE. SUPPLEMENTAL TO OCT
  • BILLING
    • DO PHOTOS ON DFE DAY
    • DO OCT SAME DAY AND NOT BILL
    • OR
    • DO OCT ON IOP CHECKS / VF DAY

2009 VS 2013
WITHOUT PHOTOS, WOULD YOU BE ABLE TO TELL IF THIS PATIENT CHANGED?

2011 vs 2013 vs 2016
HEMORRHAGES AT DISC RIM, PARAPAPILLARY RNFL, LAMINA

• HISTORY
  • 1889 BJERRUM
    • ASSOCIATION WITH GLAUCOMA
  • 1970 DRANCE AND BEGG
    • ASSOCIATION WITH OPEN-ANGLE GLAUCOMA

• APPEARANCE
  • FLAME OR SPLINTER SHAPED
    • RESULT OF ORIENTATION OF AXONS IN RNFL
    • MAY BE MISTAKEN FOR A BLOOD VESSEL
  • EXTEND RADially FROM THE OPTIC NERVE

• LOCATION
  • PRELAMINAR AREA OF THE OPTIC DISC
  • IN ADJACENT SUPERFICIAL RNFL
  • UPPER AND LOWER POLES
    • INFEROTEMPORALy MOST COMMON

• DURATION
  • LAST FROM 2 WEEKS TO 8 MONTHS
  • 92% LAST MORE THAN 4 WEEKS
HEMORRHAGES AT DISC RIM, PARAPAPILLARY RNFL, LAMINA

- OHTS
  - POAG INCIDENCE OVER 8 YEARS
    - 13.6% WITH DISC HEME
    - 5.2% WITHOUT DISC HEME

- EMGT
  - 13% OF PATIENTS HAD DISC HEMES AT BASELINE
  - HEMORRHAGES ASSOCIATED WITH PROGRESSION

- ASSOCIATED WITH
  - NFL DEFECT, NOTCH, VF LOSS, LARGER C/D, PARAPAPILLARY ATROPHY
  - PREDICTS SITE OF RNFL DEFECTS

- NORMAL TENSION GLAUCOMA
  - RELATIONSHIP BETWEEN LOCATION AND PROGRESSION OF VF LOSS IN 65.4%

- SHOULD BE LOOKED FOR AT EACH VISIT
  - UNDILATED EVALUATION WITH DIRECT OR 90D LENS AT IOP CHECKS
HOW TO DETECT DISC HEMORRHAGES

• CLOSE OBSERVATION OF THE OPTIC NERVE
  • LOOK WHERE THERE’S A NOTCH
  • LOOK WHERE THE RIM IS THINNER
  • LOOK WHERE THERE IS A CLINICAL RNFL DEFECT
  • LOOK WHERE THERE IS AN OCT RNFL DEFECT
  • LOOK AT THE OPPOSITE LOCATION OF A VISUAL FIELD DEFECT

• THEY ARE NOT DETECTED BY THE OCT

• DISC PHOTOGRAPHS ARE THE MOST SENSITIVE METHOD
  • TAKE PHOTOS
  • REVIEW THEM
DISC HEMORRHAGE
EXAMPLE
OPTIC DISC NEURAL RIM ASYMMETRY OF THE TWO EYES

• C/D ASYMMETRY
  • SUGGESTIVE OF GLAUCOMATOUS ONH DAMAGE
    • > 0.2 IN LESS THAN 0.5% OF NORMALS VS 48% IN GLAUCOMA
  • PREDICTOR OF FUTURE GLAUCOMATOUS VF LOSS
  • EVALUATE FOR SECONDARY FORMS OF GLAUCOMA
  • EYE WITH THE LARGER CUP TYPICALLY HAS THE HIGHER IOP

• CAUTION
  • EVALUATE FOR UNEQUAL DISC SIZES
C/D ASYMMETRY
EXAMPLES

WHICH C/D ASYMMETRY IS MORE SUSPICIOUS?
PARAPAPILLARY ATROPHY

• ZONE BETA
  • CLOSER TO ONH
  • COMPLETE LOSS OF RETINAL PIGMENT EPITHELIUM AND CHORIOCAPILLARIS
  • VISIBILITY OF LARGER CHOROIDAL BLOOD VESSELS AND WHITE SCLERA MORE SPECIFIC TO GLAUCOMA DAMAGE
  • INCREASE IN ZONE BETA
    • ASSOCIATION OF ADJACENT THINNING OF NEURO RETINAL RIM
    • ASSOCIATION OF DECREASED RNFL
  • ABSOLUTE SCOTOMA (ENLARGED BLIND SPOT) ON VISUAL FIELD
• LESS SPECIFIC SIGN OF DAMAGE
PARAPAPILLARY ATROPHY

- ETIOLOGY IS NOT CLEAR
  - ? VASCULAR
- BETTER SENSITIVITY SMALL DISCS VS C/D
- ASSOCIATED WITH
  - RIM THINNING
  - CONVERSION TO GLAUCOMA IN PATIENTS WITH OC HTN
- PRECURSOR TO
  - VF LOSS (50-54%)
  - DISC DAMAGE (75%)
  - DISC HEMORRHAGE
- CHANGES IN 21% WITH PROGRESSIVE CUPPING VS 4%Normals
- LOOK AT PHOTOS FOR CHANGE
OTHER FEATURES THAT MAY INDICATE GLAUCOMATOUS OPTIC NEUROPATHY

- **Nasalization** not always marked in advanced glaucoma

**Vessels**

- Nasalization no glaucoma
- Glaucoma with no nasalization

**Nasalization of Central ONH Vessels**

**Baring of Circumlinear Vessel**

**Absence of Neuroretinal Rim Pallor**
SUMMARY…

5 RULES OF ONH EVALUATION

1. Observe the scleral ring to identify the limits of the optic disc and its size.
2. Identify the size of the rim.
3. Examine the retinal nerve fiber layer.
4. Examine the region of parapapillary atrophy.
5. Look for retinal and optic disc hemorrhages.
RETINAL NERVE FIBER LAYER STRUCTURAL ABNORMALITIES

• ABNORMALITIES OF PARAPAPILLARY RNFL
  • DIFFUSE OR LOCALIZED
  • ESPECIALLY AT SUPERIOR / INFERIOR POLES
WHY DO WE EVALUATE THE RNFL?
HOW DO WE EVALUATE THE RNFL?

• CLINICALLY

• WITH A MACHINE

Most will say they prefer the machine. Even experts say this. However, you should have a fundamental knowledge of what is being evaluated.
RNFL BACKGROUND

• OPTIC NERVE IS MADE OF
  • 700K-1.5 MILLION GANGLION CELLS
  • THE GANGLION CELL AXONS ARE THE RNFL
  • THEY THEN CROSS RETINA AND CONVERGE TO MAKE THE ONH
  • THEY EXIT THE EYE AT LAMINA ON WAY TO LGN

• CLINICAL APPEARANCE
  • SUPERFICIAL BENEATH ILM
  • ARE IN AN ORGANIZED PATTERN
  • REFLECT LIGHT BACK
  • THE THICKER THE RNFL THE BRIGHTER THE STRIATIONS
    • SUPERIOR / INFERIOR POLES
  • BEST SEEN AGAINST A DARK BACKGROUND
    • DIFFICULT IN A BLONDE FUNDUS
  • NEED CLEAR MEDIA
NORMAL RNFL FEATURES

• FINE WHITE LINEAR STRIATIONS IN ANTERIOR RETINAL LAYER
• BRIGHT STRIATIONS WITH A FULMINANT, COARSE TEXTURE
• CAST A WHITE HAZE OVER THE UNDERLYING RETINAL LAYERS
• TERTIARY BLOOD VESSELS ARE HIDDEN BENEATH THE RNFL
• BECOMES BRIGHTER AS YOU GET CLOSER TO THE ONH
• MOST PROMINENT IN THE SUPERIOR AND INFERIOR ARCADES
• BRIGHT-DIM-BRIGHT PATTERN

RETINAL NERVE FIBER LAYER DEFECTS

• FIRST DESCRIBED
  • 1973 HOYT ET. AL
    • LOCALIZED RNFL DEFECTS IN GLAUCOMATOUS EYES
• 1991 SOMMER, KATZ, QUIGLEY, MILLER ET AL
  • CLINICAL RNFL DEFECTS MAY PRECEDE VF LOSS BY 6 YEARS
• NORMAL EYES DO NOT HAVE RNFL DEFECTS
• WHEN PRESENT, ALMOST ALWAYS SIGNIFY PATHOLOGY
  • NOT ALWAYS GLAUCOMA
  • OTHER POTENTIAL CAUSES OF RNFL DEFECTS
    • ANY OPTIC NEUROPATHY
    • ANY RETINOPATHY
    • OTHER RETINAL PATHOLOGY
FOCAL RNFL DEFECTS

• SLIT DEFECT
  • EVIDENCE OF FOCAL DAMAGE
  • LARGER THAN ARTERIOLE WIDTH
  • TRAVELS ALL THE WAY TO ONH
  • ¼ mm WIDE = 50 um LOSS
  • 50 um LOSS = 15,000 FIBERS
  • 15,000 FIBERS = 1% OF TOTAL

• WEDGE DEFECT
  • EASIEST TO IDENTIFY, LEAST COMMON
  • AN EXPANDING LOSS OF GANGLION CELLS
  • ASSOCIATED ONH NOTCHING
  • ASSOCIATED WITH A VF DEFECT
  • MAY OCCUR AFTER DISC HEME
DIFFUSE RNFL LOSS

• MOST COMMON
• HARDEST TO IDENTIFY
• LOSS OF STRIATIONS IN THE SUPERIOR AND INFERIOR ARCUATE BUNDLES
• RAKED OR THINNED APPEARANCE
• STRIATIONS ARE LESS BRIGHT
• TEXTURE IS FINER
• TERTIARY VESSELS ARE VISIBLE
• COMPARE SUPERIOR TO INFERIOR
• LOOK FOR RIM THINNING OR NOTCH
• COMPARE RIGHT TO LEFT EYE
• REVERSAL MAY OCCUR LATE IN DISEASE
  – DIM / BRIGHT / DIM

THAT’S HARD

• TAKE PICTURES
• GO BACK AND LOOK AT THEM
• COMPARE TO
  • ONH APPEARANCE
  • VISUAL FIELD
  • AND IF AVAILABLE...DO AN OPTIC NERVE RNFL SCAN
    • OCT, GDX, HRT
• LOOK FOR CHANGE OVER TIME
“HIGHLIGHTS” IN THE HISTORY OF RNFL / OCT EVALUATION

1991
Clinical RNFL Loss MAY precede VF loss by 6 years

1995
First Glaucoma OCT Developed

2000
RNFL Photos vs Time Domain OCT are Similar

2006
Time Domain OCT Predicts Early Glaucoma

2009
Spectral Domain OCT Similar to Time Domain

2011
Spectral Domain OCTs are all Similar

2015
OCT may detect glaucoma 8 years prior to VF loss

Clinically Detectable Nerve Fiber Atrophy Precedes the Onset of Glaucomatous Field Loss

Estimating the Lead Time Gained by Optical Coherence Tomography in Detecting Glaucoma before Development of Visual Field Defects

Alfred S. Smay, MD, MShe; Janine Katz, MD; Harry A. Wagner, MD; Neal K. Miller, MD; Ann L. Bolin, MD; Donald C. Richter, MD; Kyle A. Witt, COMT
COMPUTER BASED ONH / RNFL ANALYSIS

**OPTIONS**
- **GDX (RNFL), HRT (ONH, RNFL, Macula, Cornea), OCT (RNFL, Macula), Etc.**
  - ALL REVISED SINCE INCEPTION
  - STUDIES HAVE SHOWN VARIOUS STRENGTHS / WEAKNESSES
  - DIAGNOSTIC CAPABILITIES
    - USED TO HELP DISCRIMINATE NORMALS FROM EARLY GLAUCOMA
    - USED TO MONITOR FOR CHANGE (PROGRESSION)
WHAT DOES THE AAO SAY ABOUT ONH DOCUMENTATION / ANALYSIS?

• APPEARANCE OF ONH SHOULD BE DOCUMENTED
  • COLOR STEREOPHOTOGRAphS ARE ACCEPtable
  • COMPUTER ANALYSIS OF ONH AND RNFL IS AN ALTERNATIVE

• 3 TYPES OF COMPUTER BASED IMAGING
  • SIMILAR IN ABILITY TO DISTINGUISH GLAUCOMA FROM CONTROLS
  • USEFUL, WHEN ANALYZED IN CONJUNCTION WITH OTHER RELEVANT CLINICAL PARAMETERS

• EACH METHOD IS COMPLEMENTARY
TRENDS IN DIAGNOSTIC TESTING

• 2001-2009 STUDY
  • MANAGED CARE NETWORK
  • PATIENTS OF OD OR MD
  • > 40 YO, AT LEAST 1 VISIT

• DIAGNOSES
  – OAG = 169,917
  – OAG SUSPECTS = 395,721

• RATES OF CHANGE
  – IMAGING
    • OPHTHALMOLOGISTS INCREASED BUT NOT AS MUCH AS OPTOMETRISTS
  – VISUAL FIELDS
    • OPHTHALMOLOGISTS DECREASED BUT NOT AS MUCH AS OPTOMETRISTS

Ophthalmology 2012; 119: 748-758
<table>
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<tr>
<th>Company</th>
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<td>Heidelberg Engineering, Inc.</td>
<td>SPECTRALIS Diagnostic Imaging Platform</td>
<td>NIDEK</td>
<td>Retina Scan Duo™ Optical Coherence Tomography</td>
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<td>ZEISS</td>
<td>CIRRUS™ HD-OCT 500-The Essential OCT</td>
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THE NORMATIVE DATABASE

• CIRRUS
  • 284 “NORMAL” PATIENTS
  • QUALITY SCORE > 6
  • AGE 19-84 (MEAN 46.5)
  • REFRACTIVE ERROR -12 TO +8
  • ETHNIC “DIVERSITY”
    • 43% CAUCASIAN (122)
    • 24% ASIAN
    • 18% AFRICAN AMERICAN (51)
    • 12% HISPANIC (34)
    • 1% INDIAN
    • 6% MIXED ETHNICITY

• SPECTRALIS
  • 201 “NORMAL” PATIENTS
    • 111 MALES, 90 FEMALES
  • AGE 18-78 (MEAN 48)
  • REFRACTIVE ERROR -7 TO +5
  • 100% CAUCASIAN

KEEP YOUR OWN BRAND OF OCT’S DIFFERENCES IN MIND
FACTORS THAT IMPACT THE CIRRUS NORMATIVE DATABASE

• RNFL
  • SOFTWARE **DOES** COMPARE AGE TO AGE FOR **RNFL** EVALUATION
  • SOFTWARE **DOES NOT** COMPARE BASED ON ETHNIC GROUP
    • FYI: SPECTRALIS IS ONLY CAUCASIANS (A BIG DEAL OR NOT?)

• DISC SIZE
  • DISC AREA 1.06 - 3.38 mm² (avg 1.83)
    • SMALL < 1.63
    • MEDIUM 1.63-1.97
    • LARGE > 1.97
  • SOFTWARE **DOES** COMPARE DISC SIZE FOR **ONH** EVALUATION
    • SMALL OR LARGE DISC AREA NOT COMPARED DUE TO TOO FEW IN DATABASE
  • SOFTWARE **DOES NOT** COMPARE DISC SIZE FOR **RNFL** EVALUATION
CIRRUS ONH / RNFL ANALYSIS

- COLORS ARE NOT
  - NORMAL
  - THIN
  - LOSS

- COLORS ARE PATIENT COMPARED TO NORMALS
  - WHITE - UPPER 5% OF NORMALS
  - GREEN – MIDDLE 90% OF NORMALS
  - YELLOW – LOWER 5% OF NORMALS
  - RED – LOWEST 1% OF NORMALS
  - GRAY – NOT COMPARED
CIRRUS ONH ANALYSIS

- **RIM AREA (RELEVANT? MAYBE)**
  - RANGE 0.75-2.38 mm² (AVG 1.31)
  - COMPARED TO NORMALS?
    - PEOPLE HAVE A NUMBER GANGLION CELLS (700K-1.5 MILLION)
    - CANNOT ACCOUNT FOR THIS OTHER THAN TO AVG VALUES

- **DISC AREA (RELEVANT)**
  - ALWAYS GRAY
  - LARGER DA HAVE LARGER C/D, MORE NEURO RIM TISSUE
    - SMALL <1.63 / MEDIUM 1.63-1.9 / LARGE > 1.97

- **C/D RATIO (RELEVANT)**
  - DEPENDENT ON DISC AREA
  - NUMBER OF GANGLION CELL AXONS IN RETINA
  - INCREASES AS GANGLION CELL AXONS ARE LOST
  - VERTICAL MORE IMPORTANT

- **CUP VOLUME (NOT RELEVANT)**
  - INCREASES AS EXCAVATION INCREASES
  - POORER REPRODUCIBILITY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rim Area</td>
<td>0.75-2.38 mm²</td>
<td>1.31</td>
</tr>
<tr>
<td>Disc Area</td>
<td>1.06-3.38 mm²</td>
<td>1.83</td>
</tr>
<tr>
<td>C/D Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cup Volume</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS FOR ONH ANALYSIS

• ABNORMAL ONH RIM AREA
  • <5% OR <1%

• ABNORMAL VERTICAL C/D
  • <5% OR <1%

• NO DIFFERENCE IN ABILITY OF ONH PARAMETERS COMPARED TO RNFL PARAMETERS TO DISTINGUISH BETWEEN NORMAL AND GLAUCOMATOUS EYES
  • = JUST AS GOOD AS THE RNFL ANALYSIS
  • THEREFORE...DON’T SKIP IT. LOOK AT IT.
CIRRUS RNFL ANALYSIS

Information can be loosely applied to Spectralis

- **AVERAGE (GLOBAL) RNFL THICKNESS**
  - COMPARED TO NORMATIVE DATABASE
  - THICKNESS OF GANGLION CELL AXONS 360 DEGREES AROUND ONH
  - IT INCLUDES RNFL, BLOOD VESSELS, ASTROCYTES, GLIAL CELLS
  - IS A GLOBAL INDEX. IT WILL MISS FOCAL DAMAGE.
  - LOOK FOR R / L ASYMMETRY

- **QUADRANTS**
  - COMPARED TO NORMATIVE DATABASE
  - LOOK WHERE MILD GLAUCOMA OCCURS
    - SUPERIOR
    - INFERIOR
  - SIGNS OF FOCAL DAMAGE
    - *LOOK FOR R / L ASYMMETRY

- **CLOCK HOURS (SECTORS)**
  - COMPARED TO NORMATIVE DATABASE
  - LOOK WHERE MILD GLAUCOMA OCCURS
    - SUPERIOR, SUPERIOR TEMPORAL
    - INFERIOR, INFERIOR TEMPORAL
  - SIGNS OF FOCAL DAMAGE
    - *LOOK FOR R / L ASYMMETRY
CIRRUS RNFL ANALYSIS

- **RNFL THICKNESS MAP**
  - Similar to appearance of the GDX
  - Not as detailed
  - “More blurry”
  - Is a topographical display of the RNFL
  - An “Hourglass” pattern
    - Thicker superior and inferior
    - Red / yellow = thicker
    - Blue as RNFL thins / decreases

- **RNFL DEVIATION MAP**
  - Boundaries of the cup and disc are plotted
    - Too small to be of use?
  - RNFL deviations from normal are plotted
    - Yellow < 5% of normals
    - Red < 1% of normals
CIRRUS ONH / RNFL SYMMETRY ANALYSIS

- NEURO-RETINAL RIM THICKNESS SYMMETRY
  - COMPARED TO NORMATIVE DATABASE
    - LOOK FOR R / L ASYMMETRY

- RNFL THICKNESS / CONTOUR SYMMETRY
  - COMPARED TO NORMATIVE DATABASE
    - LOOK FOR R / L ASYMMETRY
    - DIFFERENCES BETWEEN EYES
    - FOCAL DIPS AT SUP / INF POLES
MY GUIDE FOR SUSPECTING GLAUCOMA
(IF YOU THINK THE CLINICAL ONH / RNFL LOOKS SUSPICIOUS)
USING THE CIRRUS FOR THE RNFL
(COMPILED FROM VARIOUS ARTICLES)

Average thickness outside 95% CI (yellow <5% or red <1%)

OR

1 quadrant (sup / inf) outside 95% CI (yellow <5% or red <1%)

OR

2 clock hours (not directly temporal, nothing nasally) outside 95% CI (yellow <5% or red <1%)

OR

Asymmetry between the R / L eyes’ average thickness / quad / clock hr / sector > 9 um

Information can be loosely applied to Spectralis
2 clock hours = 1 Spectralis sector
DOES THE **ONH / RNFL** GUIDE I PROVIDED ALWAYS WORK?

- NOT ALWAYS
  - USE THE INFORMATION COMPILED FROM THE LITERATURE AS A GENERAL GUIDE
  - NO ONE METHOD WILL DIAGNOSE EVERY PATIENT
  - YOUR DEVICE MAY BE SLIGHTLY DIFFERENT
  - DO NOT COMPARE DATA ACROSS DEVICES

- RESULTS SHOULD CORRELATE WITH YOUR CLINICAL EXAM
  - ONH
  - RNFL
  - VISUAL FIELD
KEEP IN MIND

**RED DISEASE (FALSE POSITIVE)**
- A **RED** OCT that is believed to be glaucoma but may be indicative of another disease or just **red** as a result of poor imaging quality
  - Ex: Decentration, PVD, segmentation error, poor signal quality, etc.

**GREEN DISEASE (FALSE NEGATIVE)**
- A **green** OCT that is believed to be normal but actually has clinically detectable evidence of glaucoma found by methods of testing other than just looking at the colors on the OCT
  - Ex: Visible notch / disc hemorrhage / clinical focal RNFL defect but OCT is green
SHOULD YOU STILL BOTHER TO LOOK AT THE ONH OR RNFL?

• YES
  • YOU ARE THE DOCTOR
  • DO NOT RELY ON A MACHINE
  • LOOKING ALLOWS YOU TO DETERMINE IF
    • NORMAL, SUSPICIOUS, DAMAGE
  • CORRELATE WHAT SEEN CLINICALLY WITH WHAT SHOWN ON THE OCT
  • THINGS YOU MAY SEE DON’T ALWAYS SHOW UP ON OCT
    • NOTCH, DISC HEME, CHANGE
BE AWARE, IF THERE IS ONH DAMAGE OR RNFL LOSS BEFORE VISUAL FIELD LOSS...

• PREVIOUSLY KNOWN AS PREPERIMETRIC GLAUCOMA
  • THE CONCEPT REFERS TO GLAUCOMATOUS DAMAGE, USUALLY MANIFESTED BY A SUSPICIOUS OPTIC DISC AND / OR THE PRESENCE OF RETINAL NERVE FIBER LAYER DEFECTS, IN WHICH NO VISUAL FIELD ABNORMALITY HAS DEVELOPED.

• NOW = MILD / EARLY GLAUCOMA
  • CONSIDER TREATMENT

Mild or Early Stage Glaucoma
ICD-9 365.71; ICD-10 7th digit “1”
• Optic Nerve abnormalities consistent with glaucoma
• but NO visual field abnormalities on any visual field test
• OR abnormalities present only on short-wave-length automated perimetry or frequency doubling perimetry
RELIABLE AND REPRODUCIBLE VISUAL FIELD ABNORMALITY

• CONSISTENT WITH RETINAL NERVE FIBER LAYER DAMAGE
  • NASAL STEP
  • ARCUATE DEFECT
  • PARACENTRAL DEPRESSION IN CLUSTERS OF TEST SITES

• VISUAL FIELD LOSS ACROSS HORIZONTAL MIDLINE IN ONE HEMIFIELD EXCEEDS LOSS IN THE OPPOSITE HEMIFIELD (IN EARLY / MODERATE CASES)

• ABSENCE OF OTHER EXPLANATIONS
WHY DO VISUAL FIELDS?

• **2002 OHTS**
  - 35% patients had VF loss without signs of structural progression

• **2009 STUDY**
  - 34% of glaucoma suspect converters progressed on visual field without structural changes

Weinreb RN et al.
AJO. September 2004

**Infographic:**

- Structural loss precedes functional loss
- OHTS results show that without optic disc assessment you may be missing up to 55% of glaucoma patients.

David Huang, MD, PhD [www.COOLlab.net](http://www.COOLlab.net)
A NORMAL VISUAL FIELD DOES NOT EXCLUDE GLAUCOMA

- NORMAL FIELD EXCLUDES ADVANCED DISEASE
  - BUT DOES NOT RULE IT OUT
  - DUE TO OVERLAP OF RECEPTOR SITES IN THE RETINA
- 20-40% OF RGC LOST BEFORE 5-10 DB VF REDUCTION
- SOME SHOW INNOCUOUS VF DESPITE GLAUCOMA
- VF WILL EVENTUALLY CATCH UP TO THE ONH
- IF NORMAL BUT STILL STRONGLY SUSPICIOUS ONH
  - CONSIDER ADDITIONAL ONH / RNFL / GCC / ALTERNATIVE VF TESTING
    - FDT, 10-2
WHICH VF DEVICE TO USE?
THAT’S YOUR CALL

OCULUS
CENTER FIELD / EASYFIELD

HAAG-STREIT OCTOPUS

HUMPHREY
FDT / MATRIX / HFA II/III
GLAUCOMATOUS VISUAL FIELDS

• **VF LOSS = MODERATE OR SEVERE DAMAGE**

• **EARLY IN DISEASE**
  • BASELINE VF
  • FOLLOW OPTIC NERVE / RNFL FOR CHANGES

• **LATE IN DISEASE**
  • FOLLOW VISUAL FIELD FOR CHANGES
  • MAY HAVE TO CONSIDER 10-2 OR MACULA VF
  • SIZE V TARGET 24-2 OR 10-2
  • ESTERMAN FOR DRIVING OR KINETIC III4e FOR LEGAL BLINDNESS

• **IS IT GLAUCOMATOUS?**
  • OBVIOUS DEFECTS
    • THE NASAL STEP
    • THE ARCUATE DEFECT
    • THE PARACENTRAL DEFECT
  • DIFFUSE VISUAL FIELD LOSS ?
    • TYPICALLY NOT GLAUCOMA

• **EARLIEST DEFECTS?**
  • FIELD MUST MATCH THE OPTIC NERVE / RNFL
MINIMUM DIAGNOSTIC CRITERIA FOR A GLAUCOMATOUS VISUAL FIELD

- IN THE ABSENCE OF OTHER CAUSES FOR FIELD ABNORMALITY AND IN THE PRESENCE OF SUSPICION FOR GLAUCOMA
  - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

- TWO “OUTSIDE NORMAL LIMITS” ON GHT
  - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

  OR

- CLUSTER OF THREE OR MORE POINTS IN A LOCATION TYPICAL FOR GLAUCOMA, ALL DEPRESSED ON PATTERN DEVIATION PLOT AT A P < 5% AND ONE DEPRESSED AT A P < 1% ON TWO CONSECUTIVE FIELDS (24-2 COUNTS EDGE POINTS, 30-2 ONLY COUNTS 2 NASAL PTS), ALL PTS RESPECT HORIZONTAL MERIDIAN
  - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

  OR

- PSD P < 5% (SUMMARIZES EXTENT OF LOCALIZED LOSS, NOT AFFECTED BY GENERALIZED DEPRESSION)
  - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

- IF REPEATABLE
  - Budenz, D. African Glaucoma Summit 8/06/10
WHAT MEETS THE MINIMUM CRITERIA?

THE VF DEFECT STILL MUST CORRELATE WITH
THE OPTIC NERVE APPEARANCE AND RNFL APPEARANCE / OCT
STD / FAST / FASTER?

- MAJORITY OF CLINICAL TRIALS / STUDIES DONE WITH SITA STANDARD
- EXPERTS OPINION
  - STD IS MORE PRECISE
  - UNLIKELY TO MAKE SIZEABLE DIFFERENCE TO IMPROVE THE TIME TO DETECT VF PROGRESSION
- THOUGHTS
  - PATIENTS PREFER FASTER PROGRAM
  - MAY HELP RELIABILITY
  - START PATIENTS WITH SITA FAST
  - CONVERT STD TO FAST
    - IT DEPENDS. IF EARLY IN PROCESS
  - GPA DATA NOT COMPARABLE
- NEWEST PROGRAM
  - FASTER
  - AVAILABLE ON HFA 3
2016 MAYBE

2017 YES

2018 MAYBE

CONCLUSION (FOR NOW): MORE STUDY IS NEEDED
SHOULD YOU ORDER A 10-2 FOR SUSPECTS?
MY OPINION

• START WITH 24-2
  • STANDARD PREFERRED OVER FAST BUT STICK WITH WHAT YOU STARTED (FUTURE SITA FASTER?)
    • TIME SAVINGS NOT MUCH
    • EXTENT/ DEPTH OF DEFECT MAY BE UNDERESTIMATED ON FAST

• IF ABNORMAL, STICK WITH IT
  • SHOULD MATCH
    • ONH
    • CLINICAL RNFL
    • OCT

• IF 24-2 HAS CENTRAL INVOLVEMENT
  • DO 10-2

• IF 24-2 NORMAL AND ONH / RNFL / OCT / GCC ARE ABNORMAL OR SUSPICIOUS
  • CONSIDER FDT AND/OR 10-2

• REGARDLESS…MONITOR FOR CHANGE
FUTURE VISUAL FIELDS?

COMBINED 10-2 / 24-2 VF
CLASSIFY THE STAGE OF GLAUCOMA BASED ON VISUAL FIELD LOSS...

**Moderate Stage Glaucoma**

ICD-9 365.72; ICD-10 7th digit “2”
- Optic nerve abnormalities consistent with glaucoma
- AND glaucomatous visual field abnormalities in ONE hemifield and
- NOT within 5 degrees of fixation (note: 5 degrees = involvement of spots nearest fixation)

**Advanced, Late, Severe Stage**

ICD-9 365.73; ICD-10 7th digit “3”
- Optic nerve abnormalities consistent with glaucoma
- AND glaucomatous visual field abnormalities in BOTH hemifields
- AND/OR loss within 5 degrees of fixation in at least one hemifield.
SOME OTHER USEFUL TESTS
OCULAR RESPONSE ANALYZER

• AROUND SINCE 2008
• MEASURES
  • BIOMECHANICAL PROPERTIES OF CORNEA
  • SPECIFICALLY
    • CORNEAL HYSTERESIS
    • THOUGHT TO REFLECT
    • VISCOELASTICITY
    • CORNEAL DAMPENING CAPACITY
      • RESISTANCE TO DEFORMATION
      • ABILITY TO BUFFER FLUCTUATIONS IN IOP
      • ABILITY TO ABSORB / DISSIPATE ENERGY
• DEVICE
  • REICHERT’S OCULAR RESPONSE ANALYZER
OCULAR RESPONSE ANALYZER

• METHOD
  • RAPID AIR PULSE
  • ELECTRO-OPTICAL SYSTEM MONITORS CORNEAL DEFORMATION
  • 2 APPLANATION EVENTS OCCUR IN MILLISECONDS
    • INWARD AND OUTWARD
  • RESULTS
    • GOLDMANN-CORRELATED IOP = IOPG
    • DIFFERENCE = CORNEAL HYSTERESIS = CH
    • CORNEAL COMPENSATED IOP = IOPCC
      • LOW HYSTERESIS WILL HAVE HIGHER IOPCC THAN GAT
    • NO CORRELATION WITH CCT
    • STAYS CONSTANT POST-LASIK
    • CORNEAL RESISTANCE FACTOR
    • WAVE SCORE (RECOMMEND > 7)
CORNEAL HYSTERESIS

• GLAUCOMA INTERPRETATION
  • HIGHER CORNEAL HYSTERESIS (> 9)
    • MORE LIKELY TO CUSHION SHORT / LONGTERM IOP INCREASES = MORE PROTECTIVE

  • LOWER CORNEAL HYSTERESIS (< 9)
    • LOWER CAPACITY TO DAMPEN IOP SPIKES AND/OR REDUCED ABILITY OF ONH STRUCTURES TO RESPOND TO IOP FLUCTUATIONS
    • INCREASED RISK FOR DEVELOPING GLAUCOMA
    • 2006, 2012 STUDIES
      • ASSOCIATED WITH PROGRESSIVE VF WORSENING

• CAN IT HELP IMPACT TREATMENT DECISIONS?
  • LESS CONCERNED IN A PATIENT WITH HIGH IOP AND HIGH CORNEAL HYSTERESIS
    • LESS LIKELY TO PROGRESS
  • MORE CONCERNED IN A PATIENT WITH LOW CORNEAL HYSTERESIS
    • MORE LIKELY TO HAVE RAPID PROGRESSION
    • BE MORE AGGRESSIVE IN TREATMENT, FOLLOW MORE FREQUENTLY
CORNEAL HYSTERESIS

• OTHER USES
  • CORNEAL ECTASIA
  • FUCH’S DYSTROPHY
  • REFRACTIVE SURGERY SCREENING

• COST
  • $16250 ONLINE AT WESTERN OPHTHALMIC

• BILLING
  • CPT 92145 ($16 UNILATERAL OR BILATERAL PER MEDICARE)
    • $7 FOR TECHNICAL COMPONENT, $9 FOR PROFESSIONAL COMPONENT
    • MAY REPEAT WHEN “MEDICALLY INDICATED” (NOT SURE WHAT THAT IS, IF IN DOUBT, REPEAT)
QUESTION

GLAUCOMA IS A DISEASE OF…?

1. THE INTRAOCULAR PRESSURE
2. THE VISUAL FIELD
3. THE OPTIC NERVE
4. THE RETINAL NERVE FIBER LAYER
5. THE RETINAL GANGLION CELLS
THE GLAUCOMA CONTINUUM

- Normal
- Acceleration of apoptosis
- Ganglion cell death/axon loss
- Retinal nerve fiber layer change (undetectable)
- Short wavelength automated perimetry VF changes
- Standard automated perimetry VF change
- VF change (moderate)
- VF change (severe)
- Blindness

Weinreb RN et al. AJO. September 2004
STRUCTURAL LOSS

- **3 AREAS IMPACTED**
  - OPTIC NERVE
    - VISUALIZED
    - MEASURABLE
  - NERVE FIBER LAYER
    - VISUALIZED
    - MEASURABLE
  - GANGLION CELLS
    - NOT VISUALIZED
    - MEASURABLE

Glaucoma affects 3 areas in the posterior segment of the eye:
- Cupping
- Nerve fiber thinning
- Ganglion cell loss

David Huang, MD, PhD [www.COOLab.net](http://www.COOLab.net)
RETINAL GANGLION CELLS

• GLAUCOMA AFFECTS THE GANGLION CELL COMPLEX (GCC)
  • RNFL
    • AXONS OF GANGLION CELLS
  • GANGLION CELL LAYER
    • CELL BODIES
  • INNER PLEXIFORM LAYER
    • DENDRITES
• 700K-1.5 MILLION RETINAL GANGLION CELLS
• 50% LOCATED WITHIN 4.5 mm OF THE FOVEA
• LESS VARIABILITY AMONG NORMAL INDIVIDUALS THAN ONH AND RNFL
WHY IMAGE THE GANGLION CELLS

• SINCE A LARGE PROPORTION OF RGCS RESIDE IN THE MACULA, LOSS MIGHT BE A SIGN OF GLAUCOMATOUS DAMAGE

• MACULAR VOLUME
  • NORMALS > SUSPECTS > EARLY GLAUCOMA > ADVANCED

• CORRELATION BETWEEN MACULAR THICKNESS AND VF MD
  • GREENFIELD DS ET AL. Arch Ophthal. 2003;121(1):41-46

• MACULAR THICKNESS CORRELATES WITH PERIPAPILLARY RNFL
Comparative study of macular ganglion cell complex thickness measured by spectral-domain optical coherence tomography in healthy eyes, eyes with preperimetric glaucoma, and eyes with early glaucoma

Yu Jeong Kim · Min Ho Kang · Hee Yoon Cho · Han Woong Lim · Mincheol Seong

Received: 19 May 2013 / Accepted: 16 January 2014
© Japanese Ophthalmological Society 2014

- 2014 JAPANESE STUDY
- TOPCON 3D OCT 2000
- 264 EYES
  - 64 HEALTHY EYES, 68 PREPERIMETRIC, 72 EARLY GLAUCOMA
- RETINAL GANGLION CELL COMPLEX MEASUREMENT IS AS ACCURATE AS CIRCUMPAPILLARY RNFL MEASUREMENT
- GCC EVAL MAY BE USEFUL IN
  - LARGE OR SMALL DISC
  - PERIPAPILLARY ATROPHY
  - TILTED DISC
GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS FOR GCC

**AREAS OF INTEREST**

- **MINIMUM**
  - BEST PERFORMANCE (2013 study)
- **INFEROTEMPORAL**
  - BEST PERFORMANCE (2012 study)

**RESULTS NOT APPLICABLE TO PATIENTS WITH CONCURRENT MACULAR DISEASE**

- AMD, CSME, CME, ERM, ETC.
- NO ONE TEST IS SUFFICIENT FOR ALL PATIENTS
  - NEED ONH, RNFL, GCC, VF

---


THE GCA
“SQUEEGEE SIGN”

• GLAUCOMA
  • INITIALLY DAMAGES TEMPORAL SIDE OF GANGLION CELL BODIES IN MACULA
  • ASYMMETRICALLY DAMAGES BETWEEN SUPERIOR / INFERIOR GANGLION CELL BODIES

• “SQUEEGEE SIGN” TO THE SUPERIOR OR INFERIOR TEMPORAL GANGLION CELL BODIES IS THE INITIAL INDICATION OF GLAUCOMA DAMAGE ON THE GCA
THE GCA IS REPRODUCIBLE

5 VISITS OVER 2 MONTHS
SPECTRALIS FOR GCC

- 61 LINES, CENTRAL 20 DEGREES
- 6x6 mm SCAN
- EQUIVALENT TO 10 DEGREE VF
- 8X8 GRID REPORT
- NO NORMATIVE DATABASE
- ONE IS COMING
- COMPARISON
- PATIENT SUPERIOR TO INFERIOR
- PATIENT RIGHT TO LEFT
- ANOTHER STUDY
- HIGH DIAGNOSTIC SENSITIVITY (83.3%) AND SPECIFICITY (92.6%) WHEN USING 3 CONSECUTIVE BLACK CELLS TO DETECT GLAUCOMA
CAN MY OCT DO THAT?

FROM PREVIOUS ARTICLE

- ALSO THE TOPCON 3D OCT 2000
- OTHERS?
- DIFFERENCES EXIST BASED ON WHAT IS ACTUALLY BEING SCANNED
  - ENTIRE MACULA THICKNESS
  - GCC
    - RNFL / GC / IPL
    - GC / IPL
- WHICH IS BEST?
  - THAT DEPENDS ON THE STUDY

---

TABLE. COMPARISON OF COMMERCIALLY AVAILABLE IMAGING DEVICES FOR MACULAR ANALYSIS IN GLAUCOMA

<table>
<thead>
<tr>
<th>OCT Device</th>
<th>Macular Imaging Protocol</th>
<th>Macular Area of Analysis</th>
<th>Macular Layers Analyzed</th>
<th>Normative Database?</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTVue FD-OCT</td>
<td>Ganglion cell complex analysis</td>
<td>7 mm², centered 1 mm temporal to fovea</td>
<td>RNFL, RGC, IPL</td>
<td>Yes</td>
</tr>
<tr>
<td>Spectralis SD-OCT</td>
<td>Posterior pole asymmetry analysis</td>
<td>8 mm², centered on fovea</td>
<td>All macular layers</td>
<td>No</td>
</tr>
<tr>
<td>Cirrus HD-OCT</td>
<td>Ganglion cell analysis</td>
<td>Elliptical annulus (vertical radius of 2 mm, horizontal radius of 24 mm), centered on fovea</td>
<td>CC-IPL</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Abbreviations:** OCT, optical coherence tomography; RNFL, retinal nerve fiber layer; RGC, retinal ganglion cell; IPL, inner plexiform layer; GCC-IPL, ganglion cell and inner plexiform layers.

FROM: AREF, AA. GLAUCOMA TODAY, MARCH/APRIL 2013
DISCLAIMER

• OTHER THINGS CAN CAUSE GANGLION CELL LOSS
  • ANY OPTIC NEUROPATHY
  • ANY RETINOPATHY
  • OTHER RETINAL PATHOLOGY
  • OTHER NEUROLOGIC DISEASES
    • ALZHEIMERS
    • PARKINSONS
    • MS
    • ETC.
SOME OTHER TESTS PEOPLE HAVE TRIED
ELECTRORETINOGRAPHY

• PATTERN ERG
  • MEASURES ACTIVITY OF RETINAL GANGLION CELLS

• THEORY
  • TESTS HEALTHY/UNHEALTHY CELLS
  • NOT DEAD CELLS
  • OCT GANGLION CELL LOSS
  • VISUAL FIELD DEFECT
  • DETECT FUNCTIONAL ABNORMALITY EARLY IN DISEASE

• COMPANIES
  • LKC TECHNOLOGIES, KONAN MEDICAL, METROVISION, DIOPSIS

http://info.diopsys.com

Weinreb RN et al. AJO. September 2004
EXAMPLE: DIOPSYS

- **USES**
  - GLAUCOMA SUSPECTS, MILD GLAUCOMA
    - ONCE ESTABLISHED DAMAGE, USE VEP

- **SET-UP**
  - DISPOSABLE SENSORS
    - 1 ON EYELID UNDER TESTED EYE
    - 1 ON FOREHEAD

- **TEST**
  - PATIENT WATCHES STIMULUS ON MONITOR
  - 20 MINUTES

- **RESULTS**
  - RAW SCORE
  - COMPARED TO NORMATIVE DATABASE

- **BILLABLE**
  - $100 PER TEST
PATTERN ERG

• IS IT BETTER THAN VISUAL FIELD OR OCT?
  • 2006 STUDY
    • 3YR RESULTS EQUIVALENT TO FLIPPING A COIN
    • 1YR RESULTS 80% SENSITIVITY AND 71 PERCENT SPECIFICITY
      • IS 1 YEAR THAT BIG A DEAL?
  • 2013 STUDY
    • ABNORMALLY DETECTED 8 YEARS PRIOR TO TIME DOMAIN OCT
      • THIS IS NO LONGER THE STANDARD OF CARE
      • SHOULD BE REPEATED WITH SPECTRAL DOMAIN
OCT ANGIOGRAPHY

- MEASURES FLOW, NOT LEAKAGE
- USES
  - RETINA
    - DM RET, DRY/WET AMD, CSC, VASCULAR OCCLUSION, MAC TELANGIECTASIA, CNVM
  - GLAUCOMA
    - OPTIC DISC PERFUSION
    - MACULAR PERFUSION
  - UVEITIS
    - SUPERFICIAL / DEEP RETINAL CAPILLARY PLEXUS
    - CHORIOCAPILLARIS
- LIMITATIONS
  - MEDIA OPACITIES
  - PATIENTS MUST BE STILL
  - CANNOT DO PERIPHERY (YET)

<table>
<thead>
<tr>
<th>CONVENTIONAL FA VS OCT-ANGIOGRAPHY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FFA</strong></td>
</tr>
<tr>
<td>Uses a dye</td>
</tr>
<tr>
<td>Needs to be scheduled</td>
</tr>
<tr>
<td>Cumbersome</td>
</tr>
<tr>
<td>In case of CNV: fluorescein leaks too much to see the structures as distinctly</td>
</tr>
<tr>
<td>Highlights capillary abnormalities much better</td>
</tr>
</tbody>
</table>
OCT ANGIOGRAPHY and GLAUCOMA

• THEORY
  • GLAUCOMA PATIENTS HAVE
    • REDUCED BLOOD SUPPLY IN OPTIC NERVE AND PERIPAPILLARY REGION

• COMPANIES
  • OPTOVUE, ZEISS
OCT ANGIOGRAPHY

**STUDY RESULTS**
- LOWER PERIPAPILLARY AND ONH VASCULAR DENSITIES
  - OAG < SUSPECTS < HEALTHY
  - CORRELATE WITH
    - OCT
    - VF MEAN DEVIATION
    - VISUAL FIELD INDEX
OCT ANGIOGRAPHY SUMMARY

• QUANTIFICATION OF MICROCIRCULATION
  • SUPERFICIAL OPTIC NERVE
  • PERIPAPILLARY RETINA
  • MACULA

• RESULTS OF STUDIES
  • DECREASED MICROCIRCULATION IN VARIOUS STAGES OF GLAUCOMA
  • WHY?
    • NEURONAL DAMAGE
    • REDUCED CONSUMPTION IN DAMAGED TISSUE

• IS IT BETTER THAN CURRENT STRUCTURE / FUNCTION TESTING?
  • DEBATABLE
  • MORE STUDIES STILL NEEDED

Karine D Bojikian, Philip P Chen, Joanne C Wen  Optical coherence tomography angiography in glaucoma Current Opinion in Ophthalmology 2018 December 19
CASE ANALYSIS
PUTTING THIS ALL TOGETHER
WHAT’S YOUR DIAGNOSIS?

• NORMAL OR PHYSIOLOGIC CUPPING
• OCULAR HYPERTENSION
• GLAUCOMA SUSPECT
  • LOW RISK (< 2 RISK FACTORS)
  • HIGH RISK (3 OR MORE RISK FACTORS)
• GLAUCOMA UNDETERMINED STAGE
• MILD OPEN ANGLE GLAUCOMA
• MODERATE OPEN ANGLE GLAUCOMA
• SEVERE OPEN ANGLE GLAUCOMA
RISK ASSESSMENT
THERE ARE GLAUCOMA RISK CALCULATORS (FOR PATIENTS WITH OCULAR HTN)

https://ohts.wustl.edu/risk/

https://oil.wilmer.jhu.edu/risk/

Validation of a predictive model to estimate the risk of conversion from ocular hypertension to glaucoma.

Objective: To develop and validate a predictive model to estimate the risk of conversion from ocular hypertension to glaucoma.

Methods: Predictive models for the 5-year risk of conversion to glaucoma were derived from the results of the Ocular Hypertension Treatment Study (OHTS). The performance of these models was assessed in an independent population of 126 subjects with ocular hypertension from a longitudinal study (Diagnostic Innovations in Glaucoma Study [DIGS]). The performance of the OHTS-derived models was assessed in the DIGS cohort according to equality of regression coefficients, discrimination (c-index), and calibration.

Results: Thirty-one patients (25%) developed glaucoma during follow-up. Hazard ratios for DIGS- and OHTS-derived predictive models were similar for age, intraocular pressure, central corneal thickness, vertical cup-disc ratio, and pattern standard deviation but were significantly different for the presence of diabetes mellitus. When applied to the DIGS population, the OHTS-derived predictive models had reasonably good discrimination (c-indexes of 0.61 [full model] and 0.73 [reduced model]) and calibration.

Conclusions: The OHTS-derived predictive models performed well in assessing the risk of glaucoma development in an independent population of untreated subjects with ocular hypertension. A risk scoring system was developed that allows calculation of the 5-year risk of glaucoma development for an individual patient.
RISK ASSESSMENT: SIMPLIFIED

• RISK FACTORS
  • HIGHER IOP
  • OLDER AGE
  • FAMILY HISTORY OF GLAUCOMA
  • AFRICAN RACE OR LATINO / HISPANIC ETHNICITY
  • THINNER CENTRAL CORNEA
  • LOWER OCULAR PERFUSION PRESSURE
  • TYPE 2 DIABETES MELLITUS
  • MYOPIA
  • LOWER SYSTOLIC AND DIASTOLIC BLOOD PRESSURE
  • DISC HEMORRHAGE
  • LARGER CUP-TO-DISC RATIO
  • HIGHER PSD-ON THRESHOLD VISUAL FIELD

Risk Factors for OAG Suspect Codes

• African American or Hispanic race
• Family history of glaucoma in 1st degree relative
• Thin central corneal thickness
• High IOP
• Pseudoxefoliation or pigment dispersion syndrome

≥ 3 risk factors = high risk
≥ 2 risk factors = low risk

IN CONCLUSION

• CONSIDER EVERYONE A SUSPECT
• GATHER INFORMATION FOR OR AGAINST YOUR CASE
• RECOGNIZE SIGNS OF GLAUCOMA
• ASSESS THE RISK
• TREAT THOSE AT GREATEST RISK OR WITH DAMAGE
• MONITOR FOR CHANGE
• ADJUST TREATMENT

Risk Factors for OAG Suspect Codes
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≥ 3 risk factors = high risk
≤ 2 risk factors = low risk
THANK YOU

Speed the cure.

www.glaucoma.org

Spread the word.