SUSPECTING GLAUCOMA

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Orlando, Florida

NO FINANCIAL DISCLOSURES.
COINCIDENTALLY...

January is National Glaucoma Awareness Month
SUSPECTING GLAUCOMA

It all Starts with YOU
SUSPECT EVERYONE

“…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
WORLDWIDE

• GLAUCOMA AFFECTS > 45 MILLION PEOPLE

• 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
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
AT SOME POINT...
THE PATIENT WAS A GLAUCOMA SUSPECT

WHAT DOES THAT MEAN?
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
• 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
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>TABLE 1</th>
<th>PREVALENCE (%) OF DEFINITE OPEN-ANGLE GLAUCOMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study</td>
<td>Ethonoracial Group</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Baltimore Eye Study</td>
<td>African American</td>
</tr>
<tr>
<td>Barbados Eye Study</td>
<td>Afro-Caribbean</td>
</tr>
<tr>
<td>Los Angeles Latino Eye Study</td>
<td>Latino</td>
</tr>
<tr>
<td>Proyecto Vision Evaluation Research</td>
<td>Latino</td>
</tr>
<tr>
<td>Baltimore Eye Study</td>
<td>NHW</td>
</tr>
<tr>
<td>Blue Mountains Eye Study</td>
<td>NHW</td>
</tr>
<tr>
<td>Visual Impairment Project</td>
<td>NHW</td>
</tr>
<tr>
<td>Beaver Dam Eye Study</td>
<td>NHW</td>
</tr>
<tr>
<td>Roscommon</td>
<td>NHW</td>
</tr>
</tbody>
</table>
RACE

• LATINO / HISPANIC ETHNICITY
  • PREVALENCE
    • > 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
KNOW YOUR PATIENT POPULATION

VETERAN EYE DISEASE AFTER ELIGIBILITY REFORM:
PREVALENCE AND CHARACTERISTICS

(ATLANTA)

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>Pseudexfoliation</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>
</tr>
<tr>
<td>Proliferative</td>
<td>5</td>
<td>0.8</td>
</tr>
<tr>
<td>AMD</td>
<td>31</td>
<td>4.7</td>
</tr>
<tr>
<td>Nonexudative</td>
<td>21</td>
<td>3.2</td>
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<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>139</td>
<td>21</td>
</tr>
<tr>
<td>Blepharitis</td>
<td>43</td>
<td>6.5</td>
</tr>
<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>

TRENDS IN PREVALENCE OF DIAGNOSED OCULAR DISEASE AND UTILIZATION OF EYE CARE SERVICES IN AMERICAN VETERANS

(MD, DC, AND PARTS OF VA, WV, PA)

Table 2

Ocular Diagnoses in veterans in the VA Capitol Health Care Network FY 2007 to FY 2011

<table>
<thead>
<tr>
<th>Variable</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>R</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease Category</td>
<td>Total (Mean % of sample)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disorder of retina and accommodation</td>
<td>11097 (8.5%)</td>
<td>12346 (9.2%)</td>
<td>14565 (10.6%)</td>
<td>16078 (11.4%)</td>
<td>1888 (13.1%)</td>
<td>1.43</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>8835 (6.7%)</td>
<td>9003 (6.9%)</td>
<td>9494 (6.9%)</td>
<td>9253 (7.0%)</td>
<td>9643 (7.4%)</td>
<td>0.14</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Ophthalmic complications of Diabetes</td>
<td>2806 (2.2%)</td>
<td>3180 (2.5%)</td>
<td>2805 (2.7%)</td>
<td>2952 (2.4%)</td>
<td>2956 (2.4%)</td>
<td>0.57</td>
<td>0.18</td>
</tr>
<tr>
<td>Cataract</td>
<td>9115 (7.1%)</td>
<td>8827 (6.7%)</td>
<td>11901 (8.3%)</td>
<td>12058 (8.9%)</td>
<td>13328 (9.4%)</td>
<td>0.68</td>
<td>0.02</td>
</tr>
<tr>
<td>ANY ophthalmic diagnosis</td>
<td>20804 (15.0%)</td>
<td>27553 (21.1%)</td>
<td>29027 (21.5%)</td>
<td>33460 (22.2%)</td>
<td>33561 (22.3%)</td>
<td>0.67</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Am J Ophthalmol. 2017 Jan;173:70-75
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

<p>| TABLE. STUDIES DEMONSTRATING AN ASSOCIATION OF LOW PERFUSION PRESSURE WITH OAG |</p>
<table>
<thead>
<tr>
<th>Survey/Study</th>
<th>Design</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore Eye Survey (Tielsch et al. 1995)(^1)</td>
<td>Population-based prevalence survey</td>
<td>DOPP &lt; 60 mm Hg associated with a sixfold increase in OAG prevalence</td>
</tr>
<tr>
<td>Egna-Neumarkt study (Bosom et al. 2000)(^2)</td>
<td>Population-based prevalence survey</td>
<td>DOPP &lt; 60 mm Hg associated with a threefold increase in OAG prevalence</td>
</tr>
<tr>
<td>Project EYES (Quigley et al. 2001)(^3)</td>
<td>Population-based prevalence survey</td>
<td>DOPP &lt; 50 mm Hg associated with a fourfold increase in OAG prevalence</td>
</tr>
<tr>
<td>The Los Angeles Latino Eye Study (LALES, Memarzadeh et al. 2018)(^4)</td>
<td>Population-based prevalence survey</td>
<td>SOPP ≥ 80 mm Hg, DOPP ≥ 40 mm Hg, or mean OPP ≥ 50 mm Hg associated with a 2.3-, 1.9-, and 3.6-fold increase, respectively, in OAG prevalence</td>
</tr>
<tr>
<td>The Baltimore Eye Study (LeSke et al. 2008)(^5)</td>
<td>Population-based longitudinal study</td>
<td>SOPP ≥ 101 mm Hg, DOPP &lt; 55 mm Hg, or mean OPP &lt; 42 mm Hg associated with a 26-, 32-, and 3.1-fold increased risk, respectively, of developing glaucoma at &lt; years</td>
</tr>
</tbody>
</table>

Abbreviations: OAG, open-angle glaucoma; DOPP, diastolic ocular perfusion pressure; SOPP, systolic ocular perfusion pressure; OPP, ocular perfusion pressure.
**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

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

AAO Preferred Practice Pattern, POAG Suspect, 2015
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
  • 20/20 OR REDUCED DUE TO SEVERE GLAUCOMA
    • OR AMBYLIOPIA OR OTHER DISEASE
• LENSOMETRY / AUTOREFRACTION
  • AXIAL MYOPES
    • SUSCEPTIBLE TO ONH DAMAGE
  • HYPEROPES
    • RISK OF NARROW ANGLES
• PUPILS
  • APD POSSIBLE IF ASYMMETRIC GLAUCOMA
    • OR OTHER DISEASE
  • MID-DILATED IF ACUTE ANGLE CLOSURE
• SURGICAL
  • LOOK FOR BLEB
• CONFRONTATION FIELDS
  • FULL IS POSSIBLE
  • CONSTRUCTED
    • INF NASAL OR 360 DEGREES
    • GLAUCOMA OR OTHER DISEASE
SLIT LAMP EXAMINATION

• LIDS / LASHES
  • NORMAL OR…
    • SIGNS ON PROSTAGLANDIN USAGE
      • LONGER LASHES
      • PERIOCULAR PIGMENT
      • PERIORBITOPATHY
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
  • NORMAL OR…
    • SCARRING
    • PIGMENT
      • KRUKENBERG SPINDLE
    • KERATIC PRECIPITATES
    • EDEMA
      • IF PRESSURE HIGH

• GUTTATA
  • MAY THROW OFF IOP READING
SLIT LAMP EXAMINATION

- **IRIS**
  - NORMAL OR...
    - TRANSILLUMINATION DEFECTS
    - WHITE FLAKES AT PUPILLARY BORDER
    - SPHINCTER TEARS
    - HETEROCHROMIA
    - KOEPPPE 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
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 1**
Original van Herick grading scale

<table>
<thead>
<tr>
<th>Van Herick’s grading</th>
<th>Ratio of gap to limbal corneal section</th>
</tr>
</thead>
<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
• 4-MIRROR IS PREFERRED
• WHAT TO LOOK FOR
  • MENTALLY NOTE
    • OPEN, SUSPICIOUSLY NARROW
    • ASYMMETRIC DIFFERENCES
  • RECORD THE DEPTH
    • MOST POSTERIOR STRUCTURE IN ALL QUADRANTS OD / OS
    • IF NARROW, DOES ANGLE OPEN WITH COMPRESSION?
• RECORD PRESENCE / ABSENCE OF
  • PIGMENT, PAS, RECESSION, NV
• 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 vs 1.5% IF IOP < 20 mmHg

INTRAOCULAR PRESSURE

• BUT…
  • SUSCEPTIBILITY OF OPTIC NERVE DAMAGE VARIES
  • 3-6 MILLION PEOPLE HAVE OCULAR HYPERTENSION WITHOUT GLAUCOMATOUS DAMAGE
WORRIED ABOUT THE IOP > 21mmHg?
- THAT NUMBER IS ARBITRARY
  - 2 STANDARD DEVIATIONS ABOVE THE MEAN IN THE EUROPEAN POPULATION
- PROPORTION OF PATIENTS WITH GLAUCOMA DIFFERS IN
  - 13%-71% BASED ON THE STUDY

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

• RECORD TIME TESTED
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
  • PSEUDOEXFOLIATION
  • SUBLUXATION
  • CATARACT
    • ROSETTE
    • PHACOLYTIC
    • PHACOMORPHIC
  • PSEUDOPHAKIC
    • UNEVENTFUL?
    • COMPLICATED?
      • ? PSEUDOEXFOLIATION 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 NOTE 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>
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<th>-2std</th>
<th>-1std</th>
<th>Mean</th>
<th>+1std</th>
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<td>1.8</td>
<td>2.0</td>
<td>2.2</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>
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</table>
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 ophthalm (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

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<tr>
<th>Lens</th>
<th>Present study</th>
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<tr>
<td>60 D</td>
<td>0.88</td>
<td>0.92</td>
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<tr>
<td>78 D</td>
<td>1.11</td>
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<td>1.33</td>
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<td>Nikon</td>
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<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>
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</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?
OPTIC DISC STRUCTURAL ABNORMALITIES

• 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
LOSS OF NEURAL TISSUE

QUIGLEY HA. GLAUCOMA. LANCET 2011; 377: 1367-77. ONLINE 3/30/11.
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?
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
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
    - INFEROTEMPORALLY 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
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
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**

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

![Nasalization examples](image1.png)
- Nasalization no glaucoma
- Glaucoma with no nasalization

**Nasalization of Central ONH Vessels**

![Central ONH vessel images](image2.png)

**Baring of Circulinear Vessel**

![Circulinear vessel images](image3.png)

**Absence of Neuroretinal Rim Pallor**

![Rim pallor images](image4.png)
SUMMARY...

5 RULES OF ONH EVALUATION

Five Rules for Assessment of the Optic Disc in Glaucoma

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

This section was developed by Robert N. Weinreb, MD, Felipe Madrigal, MD, and Luis Suzman, Jr, MD.
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

2006
Time Domain OCT Predicts Early Glaucoma

2015
OCT may detect glaucoma 8 years prior to VF loss

1991
First OCT Developed

2000
RNFL Photos vs Time Domain OCT are Similar

2009
Spectral Domain OCT Similar to Time Domain

2011
Spectral Domain OCTs are all similar

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

Cited:
Alfred SanGiovanni, MD, William L. Carson, Jr., MD, Barry A. Agins, MD, Ned K. Rifkin, MD

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

Cited:
James M. Hwang, MD, PhD, Menager Meng, MD, PhD, Lidal M. Espaldón, MD, Robert J. Weinbarch, MD
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
WHICH OCT TO USE?
THAT’S YOUR CALL

<table>
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<th>Company</th>
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<tr>
<td>Heidelberg Engineering, Inc.</td>
<td>SPECTRALIS Diagnostic Imaging Platform</td>
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<tr>
<td>NIDEK</td>
<td>Retina Scan Duo™ Optical Coherence Tomography</td>
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<tr>
<td>Topcon Medical Systems</td>
<td>3D OCT-2000 Spectral Domain OCT</td>
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<tr>
<td>Optovue, Incorporated</td>
<td>iVue Spectral-Domain OCT</td>
</tr>
<tr>
<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

• AGE
  - 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 NOT COMPARE DISC SIZE FOR RNFL EVALUATION
  - SOFTWARE DOES COMPARE DISC SIZE FOR ONH EVALUATION
    • SMALL OR LARGE DISC AREA NOT COMPARED DUE TO TOO FEW IN DATABASE
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
    - 1.06-3.38 mm² (AVG 1.83)
    - 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
GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS OCT FOR ONH ANALYSIS

Ability of Cirrus HD-OCT Optic Nerve Head Parameters to Discriminate Normal from Glaucomatous Eyes

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 OCT FOR THE RNFL
(COMPiled FROM VARIOUS ARTICLES)

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

Structural loss precedes functional loss

OHTS results show that without optic disc assessment you may be missing up to 35% of glaucoma patients.
WHICH VF DEVICE TO USE?
THAT’S YOUR CALL

OCULUS
CENTER FIELD / EASYFIELD

HUMPHREY
FDT / MATRIX / HFA II-i

HAAG-STREIT OCTOPUS
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
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
  • - KATZ, SOMMER, GAASTERLAND, ANDERSON. ARCH OPHTHAL 1991.
  • - 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
### 24-2 Visual Fields Miss Central Defects Shown on 10-2 Tests in Glaucoma Suspects, Ocular Hypertensives, and Early Glaucoma

**Purpose:** To investigate the prevalence of visual field defects in glaucoma suspects, ocular hypertensives, and early glaucoma.

**Design:** Prospective, cross-sectional study.

**Participants:** Participants with or suspected glaucoma tested with 24-2 and 10-2. Patients were classified into 3 groups based on the presence of glaucomatous optic neuropathy (ION) and 24-2 visual field abnormalities: early glaucoma ION and abnormal visual field (mean deviation < -6 decibels (dB)), glaucoma suspects ION and normal visual field, and ocular hypertensive (normal disc, normal visual field, and intraocular pressure > 21 mmHg).

**Methods:** The 10-2 test was compared to the 24-2 test using software for the analysis of visual field tests. The 10-2 test was administered to all participants.

**Main Outcome Measures:** The 24-2 test sensitivity and the 10-2 test specificity for detecting early glaucoma.

**Results:** Of the 136 eyes in the study, 40 eyes had ION, 44 eyes had ocular hypertension, and 52 eyes had normal optic nerves.

**Conclusion:** The 24-2 test detected central defects more frequently than the 10-2 test, indicating that the 24-2 test may be more sensitive in detecting early glaucoma.

---

**Prevalence, Features, and Severity of Glaucomatous Visual Field Loss Measured With the 10-2 Achromatic Threshold Visual Field Test**

**Conclusion (FOR NOW): MORE STUDY IS NEEDED**

**2016 MAYBE**

**2017 YES**

**2018 MAYBE**

---

**10-2 vs 24-2**

---

**Optimal Sentence 2018:** "10-2 vs 24-2"
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

Ganglion cell death/axon loss

Retinal nerve fiber layer change (undetectable)

Retinal nerve fiber layer change (detectable)

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
RETINAL GANGLION CELLS

- GLAUCOMA AFFECTS THE GANGLION CELL COMPLEX (GCC)
  - RNFL
  - AXONS OF GANGLION CELLS
  - GANGLION CELL LAYER
  - CELL BODIES
  - INNER PLEXIFORM LAYER
  - DENDRITES

Ishikawa H., et al., IOVS 2005
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
RETINAL GANGLION CELLS

• 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
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 OCT 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
• Glaucoma 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

MILD GLAUCOMA

MODERATE GLAUCOMA

SEVERE GLAUCOMA

5 VISITS OVER 2 MONTHS
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 COMMERCIALY 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, GCC, 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 2.4 mm), centered on fovea</td>
<td>GCC/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; GC/IPL, ganglion cell and inner plexiform layers.

FROM: AREF, AA. GLAUCOMA TODAY, MARCH/APRIL 2013
SPECTRALIS OCT 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
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, DIOPSYS

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 FIELDS OR OCTS?
  • 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
    • ABNORMALITY DETECTED 8 YEARS PRIOR TO TIME DOMAIN OCT
      • THIS IS NO LONGER THE STANDARD OF CARE
      • SHOULD BE REPEATED WITH SPECTRAL DOMAIN
SOMETHING TO KEEP AN EYE ON FOR FUTURE
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>Highlights capillary abnormalities much better</td>
</tr>
<tr>
<td>In case of CNV; fluorescein leaks too much to see the structures as distinctly</td>
</tr>
<tr>
<td>The afferent core vessels and peripheral anastomoses can be seen clearly</td>
</tr>
<tr>
<td>Produces much crisper images of choroidal neovascularisation</td>
</tr>
</tbody>
</table>
OCT ANGIOGRAPHY and GLAUCOMA

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

• TESTS
  • VESSEL DENSITY
    • OPTIC NERVE
    • PERIPAPILLARY RETINA
    • MACULA
  • FLOW INDEX OF OPTIC NERVE

• 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

Review

Optical coherence tomography angiography in glaucoma

Karine D Bojikian, Philip P Chen, Joanne C Wen

Optical coherence tomography angiography (OCTA) studies have demonstrated reduced microcirculation in the superficial optic nerve, peripapillary retina, and the macula of glaucoma patients. The scope of this review is to outline recent studies using OCTA in glaucoma and highlight how OCTA may help improve diagnosis and follow-up in glaucoma patients.
DO YOU FEEL MORE CONFIDENT RECOGNIZING GLAUCOMA?
WHAT’S YOUR DIAGNOSIS?

- NORMAL OR PHYSIOLOGIC CUPPING
- OCULAR HYPERTENSION
- GLAUCOMA SUSPECT
- GLAUCOMA UNDETERMINED STAGE
- MILD OPEN ANGLE GLAUCOMA
- MODERATE OPEN ANGLE GLAUCOMA
- SEVERE OPEN ANGLE GLAUCOMA
ONH / RNFL / VISUAL FIELDS
IF NORMAL...ASSESS FOR RISK
IF GLAUCOMA... STAGE CORRECTLY and TREAT

**ONH / RNFL / VISUAL FIELDS**

**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
- Pseudexfoliation or pigment dispersion syndrome

> 3 risk factors = high risk
> 2 risk factors = low risk

**VISUAL FIELDS**

- Center ONL
- Cluster of three points in area typical for glaucoma, all <5%, one <1%
- PSD <5%
- Repeatable
- Matches ONH/RNFL

**OCT RNFL EVAL**
- AVG / GLOBAL
  - <5 OR <1
- SUP / INF QUADS
  - <5 OR <1
- ST / IT CLK / SECTORS
  - <5 OR <1
- ASYMMETRY > 9 um
WHAT ABOUT GLAUCOMA SUSPECTS?
RISK ASSESSMENT
THERE ARE GLAUCOMA RISK CALCULATORS

[Image: https://ohts.wustl.edu/risk/]

Continuous method for estimating 5-year risk of developing POAG:

INSTRUCTIONS:
1. Enter Patient Age and Ocular Data, (at least one measurement must be entered in each row.)
2. Click "Estimate Risk" to obtain the predicted 5-year risk of developing POAG.
3. Tooltips can be invoked by moving your mouse over any question mark.

[Image: https://oil.wilmer.jhu.edu/risk/]

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

### Glaucoma Quick Reference Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>6400</td>
<td>No risk factors</td>
<td>Excluded</td>
</tr>
<tr>
<td>6401</td>
<td>African American or Hispanic race</td>
<td>Excluded</td>
</tr>
<tr>
<td>6402</td>
<td>Family history of glaucoma in 1st degree relative</td>
<td>Excluded</td>
</tr>
<tr>
<td>6403</td>
<td>Thin central corneal thickness</td>
<td>Excluded</td>
</tr>
<tr>
<td>6404</td>
<td>High IOP</td>
<td>Excluded</td>
</tr>
<tr>
<td>6405</td>
<td>Pseudophakia or pigment dispersion syndrome</td>
<td>Excluded</td>
</tr>
</tbody>
</table>

### 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**
- **Pseudophakia or pigment dispersion syndrome**

- 3 risk factors = high risk
- 2 risk factors = low risk

---

**RISks 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

---

*American Academy of Ophthalmology. Preferred Practice Pattern 2015*
LOW OR HIGH RISK...
CAN IT BE THAT SIMPLE?
IN CONCLUSION

• GATHER YOUR DATA
  • HISTORY
  • IOP, PACHYM, GONIO
  • LOOK CAREFULLY AT THE ONH / RNFL / TAKE PHOTOS
  • DO OCT RNFL / GCC
  • VISUAL FIELD

• RECOGNIZE SIGNS OF GLAUCOMA

• THOSE YOU ARE SUSPICIOUS ABOUT
  • ASSESS THE RISK (CODE PROPERLY)
    • RECOGNIZE SUSPECTS BEFORE DAMAGE
    • RECOGNIZE THOSE AT GREATEST RISK

• FUTURE DISCUSSION
  • TREAT THOSE AT GREATEST RISK OR WITH DAMAGE
  • MONITOR FOR CHANGE
  • ADJUST TREATMENT
THANK YOU

January is Glaucoma Awareness Month

Speed the cure.
www.glaucoma.org

Spread the word.