RECOGNIZING AND PREVENTING
“RED AND GREEN DISEASE”

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GLAUCOMA SUSPECT

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

AAO Preferred Practice Pattern, POAG Suspect, 2010

THE GLAUCOMA SUSPECT
WORK-UP

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

AAO Preferred Practice Pattern, POAG Suspect, 2010

TRENDS IN DIAGNOSTIC TESTING STUDY

- 2001-2009
- 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
    - OPTOMETER USES INCREASED BUT NOT AS MUCH AS OPTOMETRISTS
  - VISUAL FIELDS
    - OPTOMETER USES INCREASED BUT NOT AS MUCH AS OPTOMETRISTS

Ophthalmology 2012; 119: 748-758
IMAGING DEVICES

- **OPTIONS**
  - HRT, OCT, GDX, ETC.
  - ALL REVISED SINCE INCEPTION
  - SOME DO MORE THAN GLAUCOMA
  - STUDIES HAVE SHOWN VARIOUS STRENGTHS / WEAKNESSES
  - DIAGNOSTIC CAPABILITIES
    - USED TO HELP DISCRIMINATE NORMALS FROM EARLY GLAUCOMA
    - USED TO MONITOR FOR CHANGE (PROGRESSION)

IMAGING DEVICE

- **PROS**
  - QUICK
  - EASY TO PERFORM
    - CAN BE DONE BY TECHNICIAN
    - PUPIL DILATION NOT NECESSARY (USUALLY)
  - PAINLESS
  - OBJECTIVE
    - COMPARED TO VISUAL FIELD
  - BILLABLE
  - ABILITY TO DETECT PROGRESSION?

- **CONS**
  - EXPENSIVE

GROWTH OF THE OCT

FROM: http://www.octnews.org
Ocular Coherence Tomography News 12/01/12

WHY THE INCREASE IN USAGE OF IMAGING DEVICES?

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WHY THE INCREASE IN USAGE OF IMAGING DEVICES?
**How Did Our Reliance on the OCT Evolve?**

**January 1991**

**Clinical RNFL Evaluation**
- 1344 eyes with OC HTN
- VF loss developed in 83 eyes
- RNFL defects detected 6 years before VF loss
- Location of RNFL loss correlated with VF defect
- Focal RNFL defects easier to detect than diffuse loss
- RNFL defects expand with time


**November 1991**

**First OCT Developed**
- Non-invasive cross-sectional imaging in biological systems
- 2-dimensional image of optical scattering analogous to ultrasound
- Resolution to a few micrometers


**1995**

**First Glaucoma OCT Developed**

2000
RNFL PHOTOS vs STRATUS OCT
• MEASURED REDUCTIONS IN RNFL CORRELATE WITH RNFL LOSS SEEN ON PHOTOS

2006 TIME DOMAIN OCT PREDICTS GLAUCOMA
• THINNER MEASURED RNFL AT BASELINE IS ASSOCIATED WITH DEVELOPMENT OF GLAUCOMATOUS CHANGES

2009
TIME vs SPECTRAL DOMAIN
• SENSITIVITY AND SPECIFICITY OF CIRRUS TO DETECT EARLY TO MODERATE GLAUCOMA IS EQUIVALENT TO STRATUS

2011 SPECTRAL DOMAIN DEVICE COMPARISON
• SPECTRALIS, CIRRUS, RTVUE
• DIFFERENT ACQUISITION RATES
• DIFFERENT RESOLUTION
• ABILITY TO DETECT GLAUCOMA IS SIMILAR
COMMERCIAL OCT EVOLUTION

SPECTRAL DOMAIN OCT OPTIONS
AS OF FEBRUARY 2014

• GREATEST MARKET SHARE
  • ZEISS
  • OPTOVUE
  • HEIDELBERG
  • TOPCON

COMMERCIAL Ophthalmic OCT Evolution

David Huang, MD, PhD: Big Trends in the History of OCT – Inventor’s Perspective
Ophthalmic Photographer’s Society Meeting, Orlando, FL, 10/23/11

SPECTRAL DOMAIN OCT OPTIONS
FROM CARL ZEISS MEDITEC

• SPECTRAL DOMAIN
• 27,000 A SCANS / SECOND VS 400
• 50x FASTER ACQUISITION
• 3 um DEPTH RESOLUTION VS 10
• CENTERS 1.73 mm RADIUS CIRCLE
• 6 mm x 6 mm CUBE CREATED
• TESTING STRATEGIES
  • RNFL / MACULA
  • NEWER MODELS / SOFTWARE
  • AUTOCENTER FUNCTION
  • REPEATABLE
  • GCC

WHAT IS “RED DISEASE”??

• RED DISEASE
  – FALSE POSITIVES
    • 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
WARNINGS ABOUT “RED DISEASE”

POTENTIAL CAUSES OF “RED DISEASE”

- ANATOMIC ANOMALIES
  - LARGE OPTIC NERVES
  - TILTED DISC SYNDROME

- MEDIA OPACITIES
  - LENS
    - OPERATOR DECENTERS CIRCLE TO GET BETTER VIEW
    - IMPACTS SUPERIOR / Inferior Measurement
  - DRY EYE
  - CORNEAL OPACITIES
  - VITREOUS FLOATER
    - SHADOWING
  - *ALL MAY REDUCE SIGNAL STRENGTH*

EXAMPLES OF “RED DISEASE”

EXAMPLES OF “RED DISEASE”

5/10 and 5/10 SIGNAL STRENGTH

Same Patient, Repeated: 7/10 and 8/10
EXAMPLES OF “RED DISEASE”

INCOMPLETE SCAN

2011 vs 2012

DECREASED SIGNAL DUE TO CORNEAL SCAR

SIGNAL STRENGTH

• SIGNAL STRENGTH AND THE RNFL
  • PRE AND POST CATARACT SURGERY STUDY
    • FOR EVERY 1 PT REDUCTION IN SS, ~5 um REDUCTION IN RNFL
      • J Glaucoma. Volume 21, Number 2, February 2012

EXAMPLES OF “RED DISEASE”

DECREASED SIGNAL DUE TO PVD

Ophthalmic Surgery Lasers and Imaging 41, No.6, 2010

EXAMPLES OF “RED DISEASE”

STRATUS SCAN CENTRATION

J Glaucoma 2008; 17: 341-349
OTHER POTENTIAL CAUSES OF “RED DISEASE”

- REFRACTIVE ERROR
  - MYOPIA
  - PERIPAPILLARY ATROPHY
- OTHER DISEASES
  - DM MACULAR EDEMA / AMD
    - INCREASED REFLECTIVITY FROM CYSTS, EXUDATES, HEMES
  - GLAUCOMA MASQUERADERS
    - OPTIC NEUROPATHY FROM
      - SYMPHYSIS
      - OPTIC NEURITIS (MS)
      - ISCHEMIC OPTIC NEUROPATHY
      - COMPRESSIVE OPTIC NEUROPATHY
      - TOXIC OPTIC NEUROPATHY
      - CRVO / HRVO OCCLUSION
      - OPTIC NERVE HEAD DRUSEN

EXAMPLES OF “RED DISEASE”

- TILTED DISC SYNDROME
- POHS

EXAMPLES OF “RED DISEASE”
ONH DRUSEN

EXAMPLES OF “RED DISEASE”
H/O OPTIC NEURITIS FROM MS

PS
REPEAT THE OCT

WHY IS “RED DISEASE” IMPORTANT?

• ASSUMING AN ABNORMAL RNFL OCT IS ONLY DUE TO GLAUCOMA COULD LEAD TO
  • RELIANCE ON A MACHINE THAT IS NOT 100% SENSITIVE OR SPECIFIC
  • MISDIAGNOSIS OF OCULAR DISEASES
  • MISSING AN OCULAR MANIFESTATION OF A SYSTEMIC DISEASE
  • OVER TREATMENT
“RED DISEASE” PREVENTION

• AS THE PROVIDER OF CARE
  • UNDERSTAND THE STRENGTHS AND WEAKNESSES OF THE MACHINE
  • TRAIN YOUR TECHNICIANS WELL
  • EDUCATE THE PATIENT
    – EXPLAIN WHY TEST IS BEING DONE

“RED DISEASE” PREVENTION

• MUST OBTAIN GOOD SIGNAL STRENGTH / QUALITY
  • OCT
    • STRATUS / CIRRUS > 5 IS MINIMUM, PREFER > 8 FOR BEST QUALITY
    • DATABASE FOR CIRRUS IS ALL > 6
    • SPECTRALIS > 18 IS RECOMMENDED PER COMPANY REPS
  • ACTIVE TRACKING / IMAGE LOCK, LOCKS THE IMAGE TO THE FUNDUS
    • AVAILABLE ON SPECTRALIS AND CIRRUS UPGRADES
  • HRT
    • < 30 PER COMPANY REPS, < 40 HRT STILL REPORTS ACCEPTABLE
  • GDx
    • > 7 PREFERRED, CENTERED AND EVENLY ILLUMINATED

REMINDER

• RETINAL NERVE FIBER LAYER LOSS IS NOT SPECIFIC FOR GLAUCOMA
• RNFL LOSS CAN BE CAUSED BY
  – ANY OPTIC NEUROPATHY
  – ANY RETINOPATHY
  – IN OTHER WORDS
    – DISORDERS OTHER THAN GLAUCOMA CAN CAUSE A YELLOW OR RED RNFL ON THE OCT
    – CLINICIANS MUST SEE THE ENTIRE PICTURE
    – IF OTHER CLINICAL FINDINGS DO NOT POINT TOWARDS GLAUCOMA, GO LOOKING FOR ANOTHER CAUSE

• OPERATOR / TECHNICIAN
  – MUST UNDERSTAND NEED FOR GOOD DATA
  – MUST BE WILLING TO EDUCATE, WORK WITH THE PATIENT
  – MUST CENTER THE OPTIC NERVE
  – ENCOURAGE GOOD FIXATION
  – INSTILL LUBRICATING DROPS AS NECESSARY
  – BLINK RIGHT BEFORE IMAGES ARE ACQUIRED
  – REPEAT UNTIL A GOOD SCAN IS ACHIEVED

“RED DISEASE” PREVENTION

• RETINAL NERVE FIBER LAYER LOSS IS NOT SPECIFIC FOR GLAUCOMA
• RNFL LOSS CAN BE CAUSED BY
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WHAT IS “GREEN DISEASE”?  

- 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

WARNINGS ABOUT “GREEN DISEASE”

- AUTOMATION COMPLACENCY  
  - COMPUTER LULLS US INTO A FALSE SENSE OF SECURITY  
  - WHEN WE PLACE TOO MUCH FAITH IN THE ACCURACY OF THE INFORMATION COMING THROUGH

- EXAMPLES OF WHO IS AT RISK?
  - AVERAGE PEOPLE, INUIT HUNTERS, AIRLINE PILOTS, LAWYERS, BANKERS, ARCHITECTS, DOCTORS

THE OCT IS NOT PERFECT

- A. Localized RNFL defect seen on Cirrus and Stratus circular diagrams, also on deviation from normal map and TSNIT graph  
  - What I would call: An accurate OCT

- B. Localized RNFL defect not seen on Cirrus or Stratus or TSNIT graph but seen on deviation from normal map
  - What I would call: Green Disease

- C. Normal eye showing defects on deviation from normal map. True Subclinical RNFL loss or False Positives
  - What I would call: Red Disease

REMINDER

- SOMETIMES GLAUCOMATOUS OPTIC NERVES CAN HAVE A GREEN RNFL ON THE OCT
  - BE CAREFUL
  - THE OCT SHOULD MATCH THE
    - CLINICAL OPTIC NERVE EVALUATION
    - CLINICAL RETINAL NERVE FIBER LAYER EVALUATION
    - VISUAL FIELD
  - TRUST YOUR TRAINING AND NOT JUST THE MACHINE
POTENTIAL CAUSES OF “GREEN DISEASE”

• LETTING THE MACHINE MAKE THE DIAGNOSIS
  – THINKING GREEN IS ALWAYS GOOD
  – NOT LOOKING CRITICALLY AT THE OCT
• MISSING OTHER SIGNS OF GLAUCOMA
  – IN OTHER WORDS
  – JUST BECAUSE THE RNFL IS GREEN ON THE OCT, IT DOES NOT MEAN THE PATIENT IS NORMAL
  – PROCEED WITH CAUTION

“GREEN DISEASE” PREVENTION

• GET BACK TO BASICS
  – LOOK CLINICALLY FOR SIGNS OF GLAUCOMA
    • THE OPTIC NERVE
    • THE RETINAL NERVE FIBER LAYER
    • THE VISUAL FIELD
  – LOOK CRITICALLY AT THE OCT

BACK TO CASE MH… “GREEN DISEASE” NOW WHAT?

CLINICAL FINDINGS CHARACTERISTIC OF POAG

• OPTIC NERVE
  – DISC STRUCTURAL ABNORMALITIES
    • ESPECIALLY AT SUPERIOR / INFERIOR POLES
    – DIFFUSE THINNING OF RIM
    – FOCAL NARROWING OF RIM
    – NOTCHING OF RIM
  – DOCUMENTED, PROGRESSIVE THINNING OF NEURORETINAL RIM WITH INCREASED CUPPING
  – DISC RIM / PERIPAPILLARY RNFL HEMORRHAGES
  – OPTIC DISC RIM ASYMMETRY
    • WITH LOSS OF NEURAL TISSUE

AAO Preferred Practice Pattern, POAG, 2010
CLINICAL FINDINGS CHARACTERISTIC OF POAG

• RETINAL NERVE FIBER LAYER
  – ABNORMALITIES
    • ESPECIALLY AT SUPERIOR / INFERIOR POLES
    – DIFFUSE LOSS
    – LOCALIZED LOSS

AAO Preferred Practice Pattern, POAG, 2010

CLINICAL FINDINGS CHARACTERISTIC OF POAG

• VISUAL FIELD ABNORMALITY
  – *MUST BE RELIABLE AND REPRODUCIBLE*
  – CONSISTENT WITH RETINAL NERVE FIBER LAYER DAMAGE
    • NASAL STEP
    • ARCUATE DEFECT
    • PARACENTRAL DEPRESSION IN CLUSTERS
  – DIFFERENCE IN HEMIFIELD
  – ABSENCE OF OTHER EXPLANATIONS

AAO Preferred Practice Pattern, POAG, 2010

VISUAL FIELDS

• FIELD LOSS IS AN INDICATOR OF ADVANCED DISEASE
• EARLY IN DISEASE
  • FOLLOW OPTIC NERVE FOR CHANGES
• LATE IN DISEASE
  • FOLLOW VISUAL FIELD FOR CHANGES
    • MAY HAVE TO CONSIDER 10-2, MACULA
    • ESTERMAN FOR DRIVING, KINETIC III4E FOR LEGALLY BLIND
• COMMON GLAUCOMATOUS VF DEFECTS
  • THE ARCUATE DEFECT
  • THE NASAL STEP
  • THE PARACENTRAL DEFECT
  • DIFFUSE VISUAL FIELD LOSS

MINIMUM DIAGNOSTIC CRITERIA FOR A GLAUCOMATOUS VISUAL FIELD

• TWO “OUTSIDE NORMAL LIMITS” ON GHT
OR
• CLUSTER OF THREE OR MORE POINTS IN A LOCATION CHARACTERISTIC 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

STRUCTURE / FUNCTION RELATIONSHIP

• 2002 OHTS
  - 35% PATIENTS HADVF LOSS WITHOUT SIGNS OF STRUCTURAL PROGRESSION
• 2009 STUDY
  - 34% OF GLAUCOMA SUSPECT CONVERTERS PROGRESS WITHOUT STRUCTURAL CHANGES

CASE MH...“GREEN DISEASE”

VF INTERPRETATION

INTERPRETATION: OU reliable, WNL, no cluster defects = Normal OU
Looking at the VF alone has not helped in this case.

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.

CUP TO DISC RATIO

• 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 NORMAL
• IS A FUNCTION OF DISC DIAMETER
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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.6</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Expected C/D ratio

-2std -1std Mean +1std +2std

Vertical Height (mm) 1.6 1.8 2.0 2.2 2.4

HOW TO MEASURE OPTIC DISC DIAMETER

- USE 60D LENS AT SLIT LAMP
- 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 RUGGED ESTIMATE
- REFRACTIVE ERROR / WORKING DISTANCE INFLUENCE READINGS

OTHER METHODS
- CAMERAS WITH SOFTWARE
- ADVANCED IMAGING DEVICES
  - HRT
  - OCT/CIRCU ABALAVI
  - OCT/CIRCU calculates disc area
  - OCTAL 5.13.8.1
  - OCTAL 5.13.8.2
  - 1.80
  - 1.85
  - 1.90
  - 1.95

THE ISNT RULE

- FIRST REPORTED BY JONAS ET. AL 1988
- 457 NORMAL EYES
- INFERIOR RIM > SUPERIOR > NASAL > TEMPORAL
- GLAUCOMA VIOLATES THE RULE
- HOWEVER, NOT ALWAYS
- 2006 STUDY ARCH OPHTHALMOL
  - 66 NORMAL EYES, 43 WITH OAG
  - ISNT RULE INTACT IN 79% OF NORMALS VS 28% OF OAG (P=0.001)
CLINICAL SIGNS OF A GLAUCOMATOUS OPTIC NERVE

- Diffuse Rim Loss
- Focal Narrowing of Rim
- Notching of Rim
- Optic Disc Rim Asymmetry with Loss of Neural Tissue
- Progressive Change
- Disc Hemorrhage

ONH EVALUATION TECHNIQUE

- DILATED PUPIL
- STEREOSCOPIC EVALUATION
- CLEAR 78/90/60/SUPERFIELD LENS AT SLIT-LAMP
- DETERMINE IF NORMAL Sized OPTIC NERVE
- LOOK FOR
  - VERTICAL ELONGATION
  - DIFFUSE RIM LOSS
  - RIM NOTCH
  - PERIPAPILLARY ATROPHY
  - DISC HEMORRHAGES
  - C/D ASYMMETRY > 0.2
  - ACQUIRED ONH PIT
  - PROGRESSIVE CHANGE
  - NERVE FIBER LAYER DEFECTS

THE GLAUCOMA CONTINUUM

- 700K - 1.5 MILLION GANGLION CELLS
- AXONS CROSS RETINA
- CONVERGE TO MAKE THE ONH, EXIT THE EYE AT LAMINA ON WAY TO LGN
- SUPERFICIAL BENEATH ILM
- 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
NERVE FIBER LAYER DEFECTS

• FIRST DESCRIBED
  • 1973 HOYT ET. AL
    – LOCALIZED RNFL DEFECTS IN GLAUCOMATOUS EYES
• NORMAL EYES DO NOT HAVE RNFL DEFECTS
• WHEN PRESENT, ALMOST ALWAYS SIGNIFY PATHOLOGY
  BUT NOT ALWAYS GLAUCOMA
• OTHER POTENTIAL CAUSES OF RNFL DEFECTS
  – ANY OPTIC NEUROPATHY
  – ANY RETINOPATHY
  – RETINAL PATHOLOGY

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

CLINICAL SIGNS OF RNFL LOSS

RNFL SLIT DEFECT

• EVIDENCE OF FOCAL OPTIC
  NERVE DAMAGE
• LARGER THAN AN ARTERIOLE
  WIDTH IN SIZE
• TRAVELS ALL THE WAY BACK
  TO THE NERVE
• ¼ mm WIDE = 50 um LOSS
• 50 um LOSS = 15,000 FIBERS
• 15,000 FIBERS = 1% OF TOTAL
RNFL WEDGE DEFECT

- EASIEST TO IDENTIFY BUT THE LEAST COMMON
- REPRESENTS EXPANDING LOSS OF GANGLION CELLS
- ASSOCIATED WITH NOTCHING OF OPTIC NERVE
- ASSOCIATED WITH A VISUAL FIELD 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

CLINICAL RNFL EVALUATION TECHNIQUE

- DILATED PUPIL
- CLEAR 78D LENS AT SLIT-LAMP
- MAXIMUM ILLUMINATION
- USE THE RED-FREE (GREEN) FILTER
- LOOK FOR ASYMMETRY
  - EXAMINE SUPERIOR AND INFERIOR TEMPORAL RNFL
  - COMPARE DIFFERENCES BETWEEN THE EYES
- ALSO
  - TAKE RED FREE PHOTOS
  - REVIEW THEM CAREFULLY
  - REPEAT AT REGULAR INTERVALS LOOKING FOR RNFL CHANGE

BECAUSE DIFFUSE RNFL LOSS IS SO HARD TO EVALUATE...
THE CIRRUS OCT NORMATIVE DATABASE

- 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 (54)
  - 1% INDIAN
  - 6% MIXED ETHNICITY

FACTORS THAT IMPACT THE NORMATIVE DATABASE

- AGE
  - SOFTWARE DOES COMPARE AGE TO AGE FOR RNFL EVAL
  - SOFTWARE DO NOT COMPARE BASED ON ETHNIC GROUP
- DISC SIZE
  - DISC AREA 1.06 - 3.38 mm² (avg 1.38)
  - SMALL < 1.63 VS MEDIUM 1.63-1.97 VS LARGE > 1.97
  - SOFTWARE DOES NOT COMPARE DISC SIZE FOR RNFL
  - SOFTWARE DOES COMPARE DISC SIZE FOR ONH
  - SMALL OR LARGE DISC AREA NOT COMPARED DUE TO TOO FEW

REMINDER

- OTHER THINGS THAT INFLUENCE THE MEASURED RNFL
  - BLOOD VESSELS
  - ASTROCYTES
  - GLIAL CELLS
- THERE IS A FLOOR (APPROXIMATELY 50 µm) AT WHICH ADDITIONAL MEASUREMENT IS NOT NECESSARY
- INSURANCE COMPANIES MAY NOT PAY / REIMBURSE FOR RNFL MEASUREMENTS IN ADVANCED GLAUCOMA
- FOLLOW WITH VISUAL FIELDS

HOW TO READ CIRRUS RNFL

[Image of CIRRUS RNFL reading instructions]
CIRRUS ONH/RNFL ANALYSIS

- Colors are not
  - Normal
  - Thin
  - Loss
- Colors are this patient being 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
  - Range 0.75-2.38 mm² (Avg 1.31)
  - Compared to normals?
    - People have different amount of ganglion cells, (700K-1.5 MILLION)
    - No way to account for this other than to average the values
- Disc Area
  - Always gray
  - Larger DA will have larger C/D and more neuro rim tissue
    - 1.06-3.38 mm² (Avg 1.83)
    - Small < 1.63
    - Medium 1.63-1.9
    - Large > 1.97

CIRRUS ONH ANALYSIS

- C/D Ratio
  - Dependent on disc area
  - Number of ganglion cell axons in retina
  - Increases as ganglion cell axons are lost
  - Vertical more important
- Cup Volume
  - Increases as excavation increases
  - Poorer reproducibility

CIRRUS RNFL ANALYSIS

- Average RNFL Thickness
  - Thickness of ganglion cell axons
  - It does include
    - Blood vessels, astrocytes, glial cells
  - Is a global index
    - Will miss focal damage
- RNFL Symmetry
  - Compares the entire thickness of the RNFL between R/L eyes
CIRRUS RNFL ANALYSIS

- RNFL THICKNESS MAP
  - REMINISCENT OF GDx
  - NOT AS DETAILED, MORE BLURRY
  - TOPOGRAPHICAL DISPLAY OF THE RNFL
  - AN HOURGLASS PATTERN
    - THICKER SUPERIOR AND INFERIOR
    - RED / YELLOW – THICKER
    - BLUE AS RNFL THINS / DECREASES

CIRRUS RNFL ANALYSIS

- 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 ASYMMETRY
- RNFL THICKNESS SYMMETRY
  - COMPARED TO NORMATIVE DATABASE
  - LOOK FOR ASYMMETRY

CIRRUS RNFL ANALYSIS

- QUADRANTS
  - COMPARED TO NORMATIVE DATABASE
  - LOOK FOR ASYMMETRY
- CLOCK HOURS
  - COMPARED TO NORMATIVE DATABASE
  - LOOK FOR ASYMMETRY
SO...WHAT CONSTITUTES A GLAUCOMATOUS RNFL ON THE OCT?

- AVERAGE?
- QUADRANTS?
- CLOCK HOURS?
- ASYMMETRY?
- OTHER?

- THAT IS SUBJECT TO DEBATE

MY GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS OCT FOR THE RNFL

RNFL average thickness outside 95% CI (yellow <5% or red <1%) OR
RNFL thickness in 1 quadrant (sup / inf) outside 95% CI (yellow <5% or red <1%) OR
RNFL thickness in at least 2 clock hours (not directly temporal, nothing nasally) outside 95% CI (yellow <5% or red <1%) OR
Asymmetry between the 2 eyes’ average thickness of > 9 um

HOWEVER...

Remember, each patient is different.

Also need to be aware of the following:
Asymmetry Quads / Asymmetry of the Clock / Thickness Map / Deviation Map / RNFL Thickness Plot

Results should correlate with the clinical ONH exam, clinical RNFL exam and VF exam.

WHAT CONSTITUTES A GLAUCOMATOUS ONH ON THE OCT?

- RIM AREA?
- DISC AREA?
- AVERAGE C/D RATIO?
- VERTICAL C/D RATIO?
- CUP VOLUME?
GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS OCT FOR ONH

Abnormal Optic Nerve Rim Area
OR
Abnormal Vertical C/D Ratio

Remember, each patient is different.

Also need to be aware of the following:
OCT RETINAL NERVE FIBER LAYER

Results should correlate with the clinical ONH exam, clinical RNFL exam and VF exam.

DO THE GUIDES ALWAYS WORK?

• NOT ALWAYS
• USE THE INFORMATION AS A GENERAL GUIDE
• NO ONE METHOD WILL DIAGNOSE EVERY PATIENT
• YOUR DEVICE MAY BE SLIGHTLY DIFFERENT
• DO NOT COMPARE DATA ACROSS DEVICES
• COMPARE TO CLINICAL ONH, CLINICAL NFL, VISUAL FIELD

MH CLINICAL RNFL vs OCT

INTERPRETATION: OD clinical RNFL defect, normal/green RNFL on OCT

MH OCT INTERPRETATION

• AFTER EVALUATING
  • ONH, CLINICAL RNFL, VF
  • OCT RNFL
    • RNFL AVERAGE < 5% or < 1% SYMMETRY
    • SUP/INF QUADRANT < 5% or < 1% SYMMETRY
    • RELEVANT CLOCK HRS < 5% or < 1% SYMMETRY
  • OCT ONH
    • RIM AREA
    • VERTICAL C/D
  • OTHER THINGS TO CHECK
    • RNFL THICKNESS MAP
    • RNFL DEVIATION MAP
    • NEURO-RETINAL RIM THICKNESS
    • RNFL THICKNESS OD VS OS
MH SYMMETRY ANALYSIS

INTERPRETATION: OD @ 7 = 96 vs OS @ 5 = 126. That is Asymmetric / Suspicious. Also OD 12 = 77, OS @ 12 = 106 and OD @ 11 = 153, OS @ 1 = 107.

DIGGING A LITTLE DEEPER

OD OCT vs NORMATIVE DATA

INTERPRETATION: OD @ 12, 7, 8 close to being in lowest 5% of normal (yellow).

OS OCT vs NORMATIVE DATA

INTERPRETATION: OS Sup quad and @ 1 and 8 close to being in lowest 5% of normal (yellow).
WHAT ELSE CAN BE DONE TO PREVENT “GREEN DISEASE”? 

TRY A DIFFERENT MACHINE?  
CIRRUS vs SPECTRALIS 2013

INTERPRETATION: That did not help. The Spectralis is Green too.

WHAT ELSE CAN BE DONE TO PREVENT “GREEN DISEASE”? 

MONITOR OCT FOR CHANGE

• REGARDLESS OF WHAT YOU THINK OF THE NORMATIVE DATABASE
  • PERFECT OR IMPERFECT
  • ONCE THE PATIENT HAS HAD A BASELINE TEST
  • THE PATIENT CAN BE MONITORED FOR CHANGE FROM BASELINE
WHAT'S THE LATEST STEP IN “GREEN DISEASE” PREVENTION?

INTERPRETATION: OU on surface looks stable. ONH may have changed. NFL still Green.

MH OCT LOOK FOR CHANGE 2011 vs 2012 vs 2013

INTERPRETATION: OD NFL appears stable. OS NFL avg likely loss?, scan 3 not reliable. OU ONH (C/D) appears stable.

MH GPA EVALUATION

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

QUESTION
The Glaucoma Continuum

Weinreb RN et al. AJO. September 2004

The Glaucoma Continuum

Ganglion Cell Analysis

Glaucoma affects 3 areas in the posterior segment of the eye

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

Optical Coherence Tomography as a Marker of Axonal Damage in Multiple Sclerosis

Shiv Saidha, MRCPI, Christopher Eckstein, MD, and John N Ratchford, MD

Int J Clin Rev 2010;10:01
JUSTIFICATION FOR IMAGING 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 MEAN DEVIATION

• MACULAR THICKNESS CORRELATE WITH PERIPAPILLARY RNFL MEASUREMENTS

WHAT’S THE LATEST?

• 2014 JAPANESE STUDY
  • USING THE 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
• GGG EVAL MAY BE USEFUL IN LARGE OR SMALL DISC
• PERIPAPILLARY ATROPHY
• TILTED DISC

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

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

HOW TO READ CIRRUS GANGLION CELL ANALYSIS

• FROM THE CIRRUSS OCT RVer 7.0 Manufacurer’s Guide
  • MEASURE WALL-thickness at both nasal poles and inferotemporal and superotemporal poles
  • DETERMINE THICKNESS USING THE TOPCON 3D OCT 2000
  • COMPARISON OF GROUPS...
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, ETC.
- NO ONE TEST IS SUFFICIENT FOR ALL PATIENTS
  - NEED ONH, RNFL AND GCC

MH 2013
GCA CIRRUS

INTERPRETATION: OD inferotemporal 4%, OS normal?

HOW TO READ SPECTRALIS GANGLION CELL ANALYSIS

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 (83.2%) AND SPECIFICITY (92.6%) WHEN USING 3 CONSECUTIVE BLACK CELLS TO DETECT GLAUCOMA
WHAT DOES THE AAO SAY ABOUT ONH AND RNFL 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 complimentary

AAO Preferred Practice Pattern, POAG, 2010

GREEN DISEASE

- Another way of saying preperimetric glaucoma
- The patient is worthy of another look, a closer look
- Remember each patient is different
- Damage occurs at different locations in different people
- You have the responsibility to check everything
  - Clinical: ONH, RNFL, VF
  - OCT
    - RNFL
      - AVG, QUADS, SECTORS, COMPARISONS, DEVIATION MAP, ETC.
    - ONH
      - RIM AREA, C/D VERTICAL
    - GCC

QUESTION

Which is more dangerous, Red or Green Disease?