Technician Breakout Session: Humphrey Visual Fields

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UNFORTUNATELY, I have no financial interest in this presentation.

Course Description:

• Review of the visual pathway
• Principles and techniques of Humphrey visual fields (HVF)
• Basics of HVF interpretation and analysis
• Types of technology currently being used
• Pearls for obtaining optimum results
Introduction

- Visual field examination is at the heart of the care of many patients with ocular and neurological disease.
- Substantial advances have been made in automated perimetry, since the first Octopus machines in the 1970’s.
- Quality of visual field results is significantly enhanced by a knowledgeable, alert, and compassionate technician.
- Errors on part of technician or patient can still render test results useless.
- Most patients dread this test (try it yourself)!

Humphrey History

- 1971- Humphrey Instruments founded by William Humphrey, PhD in San Leandro, CA
- 1977- Vision Analyzer marketed by Humphrey and Louis Alvarez, PhD (Nobel laureate in physics)
- 1978- Automatic Lens Analyzer introduced
- 1982- First prototypes of Humphrey Field Analyzer displayed at AAO 1984- Production unit delivery begins
- 1986- STATPAC first released for sale; 1991- FASTPAC
- 1995- HFAII including SWAP; 1997- SITA
THE VISUAL PATHWAY

The Visual Pathway

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The Visual Field

• 2-D mapping of everything visible with each eye while fixing on a single point in space.
• Testing measures the integrity of the visual pathway from the retina to the visual cortex.
• Testing can detect, localize and follow the course of many ocular and neurologic disorders.

Visual Fields and the Visual Pathway
Normal Dimensions

- Center is patient’s fixation (usually fovea)
- 90-95° temporally
- 60° nasally
- 60° superiorly
- 75° inferiorly
- Physiologic blind spot (7.5° X 5.5°)
  - Located 12-15° temporal to fixation
  - 1.5° below horizontal meridian

Adding a 3rd Dimension

- Threshold of each point in the xy plane is extended along the z-axis, a surface of threshold sensitivity is created.
Pathologic Defects

- In front of retina (vitreous or macular hemorrhage)
  - Patient aware of “something black”
- Optic nerve to occipital lobe
  - Loss of vision, but no sense of blackness
  - Complain about effects of vision loss
- Retinal disease
  - Both types

Scotoma

- Area of partial (relative) or complete (absolute) blindness within visual field
  - Central (involves fixation and decreased visual acuity)
  - Pericentral (fixation relatively clear, defect in immediately surrounding area)
  - Paracentral (one side of fixation)
  - Cecal (involves blind spot)
  - Nerve fiber bundle (arcuate, Bjerrum, comet occurs above or below blind spot)
Common Defects

<table>
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Glaucoma
Contraction

• Area of blindness emanating from periphery towards the center (usually neurological and respect vertical meridian)
  – Sector
  – Hemianopia
  – Quadrantanopia
  – Bilateral
  – Congruous
  – Homonymous
Perimetry

- Science of measuring “-metry” the peripheral “-peri” vision in order to determine the visual field. Retinal map of threshold contrast sensitivity.
- Clinical assessment of an “island of vision in a sea of darkness.”
- Hill of vision is 3-D surface of threshold sensitivity
- Accurate reproducible fields
  - Identify abnormalities (OHTS found 3 consecutive abnormal fields necessary to diagnosis glaucoma)
    - Correlate with changes in optic disc?
    - If not, other causes should be considered
  - Quantitate visual function for comparison over time

Perimetry

- Types of Perimetry-based on stimulus and whether manual or automated
  - Kinetic (variable location, fixed intensity) Goldmann, Tangent Screen
    - Move target from non-seeing to seeing
    - Size constant
    - Isopter-line of points of equal visual sensitivity
  - Static (fixed location, variable intensity) Octopus, Humphrey
    - Suprathreshold (Screening Strategies)
    - Threshold (Diagnosis of or following patients with damage)
Types of Manual Visual Fields

- Poor attention span or understanding
- Aged
- Children
- Those with decreased levels of consciousness
- Ptosis
- Posture abnormalities
Hysterical Visual Field

- Functional versus organic
  - Narrowed to only 10-20°
  - Spiral or star-shaped
- Move patient back another meter and double size of target with Tangent Screen
  - If diameter doubles in size (tubular field=vitamin deficiency, retinitis pigmentosa, glaucoma)
  - If stays same (nonorganic cause strongly suspected)

Advantages of Automated Perimetry

- Standardized
- Not subject to examiner bias
- Detects loss earlier
- Data can be manipulated by the computer
  - Stored, compared to known normals, recalled for comparative analysis,
Disadvantages of Automated Perimetry

- Entirely dependent on subjective responses
- Note cooperation and reliability: good, fair, or poor
- Not an exact science, but should be reproducible

HVF Parameters

- Conform to Goldmann perimeter standards
  - Bowl is 33 cm in radius
  - Background luminance 31.5 apostilb (asb)
    - Luminance: amount of light leaving a surface
  - Default stimulus is Goldmann size III (IV and V)
  - Stimulus Bulb Luminance: 10,000 asb
  - Shutter opened to project stimulus
Stimulus Size

• Defined by Roman numerals
  – Range in size from 0.25-64 mm²
    • Each increment reflects 4-fold increase in size
  – Stim III and V most common
    • Stim III: 4 mm² circular stimulus
    • Stim V: 64 mm² circular stimulus

Threshold Sensitivity

• Luminance at which 50% of the stimulus presentations at a given location are seen
  – Source of patient anxiety
• Defines the “Hill of vision”
  – Integral component of HVF perimetry
  – One should see no stimuli outside and all stimuli inside their “hill of vision”
  – Determination must be accurate and reliable
Stimulus Intensity

• 1 decibel (dB) = 0.1 log unit
  – A 30 dB stimulus is 20 dB (2 log units) dimmer than a 10 dB stimulus or 100X less intense

• Apostilb (asb) luminance
  – 10,000 asb max = 0 dB
    • Full moon on clear night

“Normal”

• Absence of disease or statistical values differ from average (2 SD± mean)
• Absence of deviations from expected height and shape of island of vision
• Models based on visual fields of numerous patients, adjusted for age, with no ocular disease
• Interpretation must still be taken in clinical context before MD diagnoses disease or changes therapy
Measuring Threshold Sensitivity

• Basic algorithm: double-cross bracketing
  – Initial stimulus is presented and adjusted by 4dB at a time until threshold is crossed, then adjusted by 2 dB at a time in the opposite direction until threshold is crossed again


Full Threshold Testing

• Measures sensitivity at each test point
• Constructs map of the island of vision
• Fluctuations measured
• Numerical data generated, stored, and can be recalled for analysis
• Use whenever possible, maximize information obtained and minimize need to retest
Full Threshold Testing

- Short-Term Fluctuation (STF)
  - Intra-test threshold fluctuation (during one test)
  - SD of 2 threshold measurements at 10 locations
  - Affected by attentiveness and/or locus instability
    - Abnormal loci have more variable sensitivity or flatter frequency of seeing (FOS) curves
    - 4 seed loci (circled)
    - 6 additional loci (squared)


- Repeat measurements at other loci
  - If threshold at given loci significantly different from age-matched control → repeat measurement
  - Also affected by attentiveness and/or loci instability

3 loci of abnormal threshold sensitivity (triangles)
Suprathreshold Screening Tests

• Quick assessment for presence/absence of abnormalities
• Each point tested with a stimulus 6 dB brighter than expected normal
• If no response, brighter stimulus to distinguish relative from absolute scotoma
• No numerical data obtained
• Abnormal requires further testing

FASTPAC Testing

• Longer steps/fewer Xing in stimulus staircase
  – Similar to threshold testing except crosses threshold only once and uses 3dB adjustments
  – Improves 24-2 Full Threshold time from 10-11 min/eye to 7 min per test
  – Shorter; less reliable data
SITA

• Swedish Interactive Threshold Algorithm
• Tests threshold points starting close to predicted level using Goldmann stimulus III
• Internally adjusts brightness for adjacent locations
• Window of time (milliseconds) when a patient should respond to stimulus

SITA TESTING

• Fast, very good/excellent sensitivity
  – Modifies full threshold algorithm and utilizes age-matched frequency of seeing (FOS) curves
  – SITA Standard very comparable to full threshold
    • 5 min/eye
  – SITA Fast very comparable to FASTPAC
    • 3.5 min/eye
SWAP

• Short-Wavelength Automated Perimetry
  – More sensitive in detecting early abnormalities
  – Shows abnormal results 2-5 years earlier than SAP

• Tests only isolated part of color vision system
  – Blue sensitive cones and their neural connection
  – Yellow background adapts rods and middle/long wavelength sensitive cones

SITA SWAP TESTING

Stimulus V blue stimulus on yellow background

– Disadvantages
  • Affected by age and cataracts
  • High inter-test variability

– Good for monitoring
  • Younger patients
  • GS, OHTN
  • Pre-perimetric
BASICS OF INTERPRETATION AND ANALYSIS

Basic Principles of Interpretation

- Which test was performed?
- What strategy was used?
- What is the reliability?
- Could any defects be artifacts versus real disease?
Overview

• Test information
• Reliability Indices
• Foveal Threshold
• Raw Data
• Deviation Points
• GHT
• Global Indices

What Do 30-2, 24-2, and 10-2 Mean?

• First number: degrees being tested
  – 30-2 tests central 30 degrees of vision
• Second number: placement of test points
  – 30-2 tests above and below of L/R of x and y axes
• Each test evaluates a different number of points:
  – 30-2 (76 pts), 24-2 (54 pts), 10-2 (68 pts)
Printouts

- Screening tests only show defect depth from expected normal based on shape model
- Threshold graytone (top)
- Threshold defect depth (lower left)
- Threshold value table measurements (lower right)

Test Information
Test Patterns and Parameters

- Central 30-2 (optic nerve/neurological disease), 24-2 (glaucoma), 10-2 (finer detail)
- Macular Disease
- Poor Visual Acuity
  - 20/200 or less use test size V instead of III
- Central Scotoma (eccentric fixation target)
- Color Perimetry

Reliability Indices

- Fixation Monitoring
  - Fixation losses
    - Heijl-Krakau technique
      - Stimuli in blind spot shouldn’t be seen
  - Gaze tracking
    - Located at bottom/left hand corner
      - Tracks reflections from eye
      - Down: blinking  Up: eye movement
Reliability Indices

- **False Positives Responses**
  - Detects “trigger happy” or anxious patients
    - Stimulus noise without stimulus presentation
    - Reliable (mfg) <30%
      - Every 10% FP error can alter MD by 1 dB
      - If field too normal for ONH → tolerate less

- **False Negative Responses**
  - Detects inattentive or tired patients
    - Repeat stimulus 9dB above previously threshold location
    - Reliable (mfg): < 33%
Foveal Threshold

- Optional (better to leave on)
  - Occurs at the very beginning of test
    - Requires very few stimuli
    - Obtained within seconds
  - Helpful if field doesn’t agree with VA and/or ONH
    - VA 20/20-20/40
    - Normal values 36-32 dB

Raw Data

- Numerical Plot
  - Actual threshold values at each location tested
  - Normal values ~36-16 dB
    - Watch for values >36 dB (especially outside fovea)
Raw Data

• Grayscale Plot
  – Extrapolated from numerical plot
    • Less than 1% of this area is actually tested
      – Limited utility!
      – Alert for problem areas
      – Explaining to patients

Deviation Plots

• Total Deviation
• Threshold at each location is compared to age-matched control values (TD=raw data-control)
  – Generalized or localized depression
    • Influenced by any media opacity
  – Numerical Plot
  – Probability Plot
    • Symbol legend shows significance (TD and PD)
Deviation Plots

- Pattern Deviation
  - Adjusts TD plot by 7th highest threshold value for general height value
    - Subtracted from every location on TD plot
  - Removes noise from media opacities
    - New “hill” considered normal

Deviation Plots

- Pattern Deviation-Underlying glaucoma
  - Hill of vision created by TD plot is “normalized” up by the “general height value”
    - Depressed hill is elevated
    - Localized defects uncovered
Deviation Plots

- Pattern Deviation- Suprathreshold
- Hill of vision created by TD plot is “normalized” down by the ‘general height value’
  - Supranormal hill (with normal “scotoma”) is lowered
  - White field defects= artifacts

Glaucoma Hemifield Test (GHT)

- Glaucoma causes asymmetric RNFL loss across the horizontal raphe → HVF changes
  - GHT → 5 zones in each hemisphere on PD plot
    - Each zone scored and compared to mirror zone across midline
    - Assymetry is suggestive of glaucoma
Glaucoma Hemifield Test (GHT)

- 5 Possible results of GHT
  - General Reduction of Sensitivity
    - Most normal 15% of VF is below pop. avg, p<0.5%
  - Abnormally High Sensitivity
    - Most normal 15% is above pop. avg, p<0.5%
  - Borderline
    - Difference bet. upper and lower zone, p< 3%
  - Outside Normal Limits
    - Difference bet. upper and lower zone, <1%
  - Within Normal Limits
    - None of the above criteria are met

Global Indices

- Mean deviation (MD)
- Average of all values on TD numeral plot
  - Overall height of hill
    - Worse than -2.0 (abnormal p<5%)
    - Worse than -3.5 (abnormal p<1%)
- Pattern Standard Deviation (PSD)
- PSD of all Values on PD numerical plot
  - Surface contour of hill
    - >2.0 abnormal, p<5%
    - >3.0 abnormal, p<1%
Global Indices

• Additional indices on Full Threshold algorithm
  – Short term fluctuation (STF)
    • SD of repeat measurements at 10 predetermined loci
    • Measure of single test attentiveness and locus stability
  – Corrected Pattern Standard Deviation (CPSD)
    • PSD corrected for STF

Recognizing Artifacts

• Peripheral dropout
  – May be caused by corrective lens rim
  – May be due to RP or optic neuropathy
• Eyelid and Nose Defects
• “White Out”
• Head or Eye Movement
• Pupil Size
Glaucoma Visual Fields

• Mainstay of determining whether glaucoma therapy is adequate
• Purpose of therapy is to prevent further loss
• Final interpretation must always be done by MD, since only they can correlate results with the clinical exam

Visual Fields and Cataracts

• Refractive changes (affects lens selection)
• Worsens the mean deviation across all tests including SAP, FDP, and SWAP
• May affect the visual field index/glaucoma progression index as well as the characterization of scotomas
• May affect the decision to monitor rather than operate on a glaucomatous eye
Humphrey 24-2 visual field showing (A) pre-cataract visual field, (B) field with cataract and visual field defect, (C) visual field after cataract removal.

- Br J Ophthalmol 2003;87:1045-1046 doi:10.1136/bjo.87.8.1045

**Multifocal Intraocular Lenses (IOLs)**

- Multifocal IOLs cause significant non-specific reduction in MD values that does not improve with time or neuro-adaptation.

- Cautious in considering multifocal IOLs in eyes that require regular VF testing such as glaucoma and where central visual disease already exists like AMD.
PEARLS FOR OBTAINING OPTIMUM RESULTS

Facilities

• Comfort of patient very important to obtaining accurate visual field
• Take at least 10 minutes per eye
• Quiet enough to concentrate
• Dimly lit room
• Out of the way of normal practice traffic
• Adjustable, motorized table and comfortable chair
Communication is Key

- Physician must know what information is being sought to order appropriate test and parameters
- Perimetrist must know how to properly set-up and administer test
- Patient must be prepared to take the test to perform optimally

Perimetrist’s Responsibilities

- Be positive, patient, and compassionate
- Ensure patient understands test
- Ensure test runs smoothly
- Ensure fixation remains aligned
- Encourage and reassure patient during test
- Give patient a break or re-instruct when fatigue is being observed
Preparing the Patient

- Greatest source of error:
  - PATIENT NOT KNOWING WHAT TO EXPECT!
- Instruct and inform patient:
  - Won’t see light every time/ignore shutter noise, have fixation monitor, can take break, etc.
- Determine if patient is fresh and alert
  - Reschedule if necessary

Patient Set-Up

- Maximize patient’s understanding of test:
  - What it’s for
  - How it’s performed
  - What he/she is supposed to do
    - Ability to rest
  - What to expect
    - Sometimes won’t see a light
Patient Setup

• Patient comfort very important for accuracy
  – Place pillow or pad behind lower back
  – Have somewhere to rest their arms
  – Keep forehead touching headrest
• Careful patching
• Tape lids when necessary
• Determine which eye first

Determine Best-Correction

• Measure visual acuity and record best corrected refraction
• Check your calculations, but use full add for
  – Dilated patients
  – Aphakic or pseudophakic
• Check trial lens power and sign (use thin rimmed lenses)
• Look for smudges on lens
• Note if lens is sphere or cylinder (use spherical equivalent if <1D, check axis)
• Place lens holder to barely clear eyelashes
• Contact lens preferred for high powers (+/- 6.00)
Determine Best Correction

- If patient wears contact lenses, be sure to ask if they are corrected for distance or monovision (which may still need additional near correction if set at intermediate focal point)

Patient Instructions

- Look straight at all times (will be monitoring)
- Light might be very dim, still respond
- Sometimes no light, which is normal
- Only respond when see a light
- Blink normally (right after pushing button)
- Hold button down to stop test and take break
Don’t Leave Patient Alone for Test

• Constantly monitor fixation
  – Failure to fixate centrally, greatly alters results
• Check head position
  – Forehead touching
  – Not tilting to the side
• Periodic coaching and encouragement
  – “Over halfway done” “just a few more minutes”

Assessing Reliability

• Fixation Losses (realign)
• False Positives (trigger-happy)
• False Negatives (quick break)
• Short-term fluctuations/Double determination points (consistency)
• Gaze tracking
Predicting Success

• More a function of personality than IQ
• Give clear instructions; joke, but don’t criticize
  – High IQ, but anxious
  – Mentally slow patients
  – Children under 12
  – Physical disabilities (arthritis, deaf)
  – Definite learning curve (2\textsuperscript{nd}/3\textsuperscript{rd} time a charm)!

Instrument Maintenance

• Daily
  – Calibration (automatic)
• Monthly
  – Clean filter (located on back of machine)
  – Back-up data onto optical disk
• Annually (depending on use)
  – Change bulb
THANK YOU!

Instructional Objectives

• Identify the common visual field defects that may occur in the various parts of the visual pathway.

• List the different types of testing protocols available and their application.

• Describe several methods for obtaining optimal visual field results in patients.
Instructional Objectives, cont.

• Identify problems with machine and patient setup and methods to correct these problems.
• Assess patient performance using the machine’s indicators.
• Identify appropriate methods to correct errors.
• Recognize artifacts and their causes.

Summary

• Automated perimetry is here to stay
• Key component is still the technician (not the computer or sophisticated software)
• Fears that computer would replace trained technicians are unfounded
• Automation eases many aspects of testing while allowing more time for guiding and encouraging patient
Any questions?
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