Why visual fields lecture
- Old technology- going through lot of changes

Outline of the lecture
- ABC's of perimetry
- ABC's specific to Humphrey Field Analyzer
- Single Field Analysis- Humphrey and Octopus
- Staging of Visual field
- Progression and visual fields
- Targeting specific ganglion cells –M or K-cells

Visual fields background
Do we still need visual fields in glaucoma management ???
- Octopus was the first automated visual field analyzer.
- Humphrey Field Analyzer is the accepted universal “gold standard”
- Are some perimeters superior than other?
Automated static perimetry

Why automate perimetry?

Drawback?

Advantages?

Hill of Vision:

Central vision greatest
Vision decreases as one moves away from center to periphery.

Low threshold = high sensitivity = weak stimulus (dim light) is also seen.

High threshold = low sensitivity = strong stimulus (bright light) is needed to be detected or seen.

Best perimetry

If threshold is performed in all possible locations that can see in retina but it is not possible.

Other points

Color of stimulus

Attentiveness

Moving versus non-moving

Moving targets are more visible than non moving targets (Riddoch phenomenon)

Duration of stimulus (1/100 of second compared to 2/100 of a second)

Beyond a certain critical period duration of stimulus has little effect on visibility (approx 1/3 second)

Units of light intensity

Apostilib (asb) european unit for luminance is the standard for perimetry for a long time

Absolute unit does not change from one perimeter to another

HVF max luminosity (intensity) 10,000 asb

Goldmann 1000 asb

Octopus (original) 1000 asb, all new ones 10,000 asb

So if all perimeters reported Apostilib for all points tested it will be great!

When dimmer light is required a neutral density filter is used to dim the light.

Decibel (dB) is the logarithmic unit that is used for convenience

10 dB stimulus = 1/10 as intense of max stimulus

20 dB stimulus = 1/100 as intense of max stimulus

30 dB stimulus = 1/1000 as intense of max stimulus

40 dB stimulus = 1/10,000 as intense of max stimulus
Threshold

- Threshold is defined as the intensity that is just marginally visible.
- An infrathreshold (weaker stimuli) for a point will not be visible
- A suprathreshold stronger stimuli

If measured multiple number of times there are bound to be slight variations.

This is the test retest variability or short term fluctuation.

Reasons for test retest differences?

- Because physiologic frequency-of-seeing curve has a some short term fluctuations
- Locations with reduced sensitivity has greater or broader seeing curve.
- Patients responses are not the most reliable (inattentiveness or inconsistent).
- Fatigue has a role to play.

Troxler’s effect

- When one fixates a particular point, after about 20 seconds or so, a stimulus away from the fixation point, in peripheral vision, will fade away and disappears.

- The effect is enhanced if the stimulus is small, is of low contrast or equiluminant, or is blurred.
Sources of error

- Miosis: decreases threshold peripherally, increases variability centrally
- Lens opacities
- Uncorrected refractive error – decrease in contrast sensitivity
- Spectacles – lens artefact
- Ptosis
- Inadequate adaptation: if VF performed soon after ophthalmoscopy

Why do we need perimetry?

- To diagnose if there is problem (diagnosis)
- Once diagnosed to see if the intervention doing its job (progression)

SITA

- Factors that contribute to time saving
  - Visual field modeling
  - Information index to determine threshold endpoints
  - Test paced to patients needs
  - Post test recomputation of threshold values
  - Reduction in "catch trials " needed to determine reliability indices

Visual field modeling

- Starts with a prior probability models of normal and abnormal fields
- This model is
  - age corrected normative data of normals and glaucoma patients
  - Frequency of seeing curves around threshold
  - Correlations between adjacent test points
  - Testing is adjusted continuously based on the patient responses.
Reaction time

- SITA determines continuously the average and standard deviation of time required to respond and alters the duration between two stimuli.
- This speeds up test for fast responder and slows it down if responses are slower.
- Most importantly the "patient runs the test not vice versa"

Fixation monitoring - in HFA

- Perimetrist observation
- Heijl-Krakau blind spot method
- Gaze monitor

Heijl-Krakau blind spot method

- A bright stimulus is presented where the blind spot is identified
- 5% of the stimulus presented are used to check for fixation
- Depends on the accuracy of the presumed location of blind spot

Problems with blind spot

- Head tilt during the test.
- Other eye not patched properly
- Remember size of stimulus is not an issue!

The gaze monitor

- Uses two image analysis method to loactate center of pupil.
- Infrared light source to get corneal reflexes
- Gaze monitor initialization at the beginning of the test is used for calibration and adjusting the system for individual patient.
- Patient has to look at the fixation and not blink.
- Procedure takes approximately 20 seconds.

Schematic of gaze tracking
Examples of gaze tracking

Gaze monitor cont...2
- Upward line full (max length) represents a fixation error of 10 degrees
- Downward line represents a situation when information on the position of eye is not available
  - Blinks
  - Gaze tracking is not recorded when stimulus is not presented.

Examples of gaze tracking

Examples of gaze tracking -2

Octopus Features: Fixation Control
- Correct fixation
- Fixation lost
- No stimuli during fixation loss
- Automatic repetition of stimuli after blinking or darting
- Most accurate test possible

Octopus Features: Auto Eye Tracking
- Correct fixation
- Eye movement
- Automatic readjustment
- The perimeter centers the patient automatically to the optical axis
- Less interrupts, less time to finish
### Catch trials - False positive
- A response when no stimulus was presented
- Trigger happy patient
- Older models made noise but no stimulus was presented
- SITA does not measure false positive but calculates false positives

### False positives issues
- Poorly instructed patient
- Expectancy of a stimulus to be present
- A noise of shutter in the machine may be perceived as a stimulus presentation
- Trigger happy patient
- “Education is the key” in threshold tests theoretically 50% of the stimulus presented should not be seen!!!

### False negative error
- Proportion of visible stimuli to which the patients fail to respond.
- Stimuli are presented at a location 9 dB brighter than previously “seen level” to which the patient response is “cannot see”

### Acceptable catch trial rate
- SITA acceptable rates are
  - <20% Fixation loss
  - <20% false positives
  - <20% false negatives
- Research studies varies on their criterion of acceptable levels
  - Generally
    - <25% Fixation loss
    - <35% false positives
    - <25% false negatives

### Other important consideration
- Mydriatics and pupil size
- Refractive error
- Testing environment

### Mydriatics and pupil size
- Hippus: No effect as both light intensity of stimulus and background changes with hippus
- Retinal adaptation: Amount of light reaching the retina, hence not totally independent of pupil
- Pupil size also determines which part of the crystalline lens is used.
  - With cataract the scatter increases
To dilate or not to dilate!
- Best not to dilate.
- Humphrey normative data was collected with undilated pupil
- Exceptions: cataract that severely affects vision
- Consistency in pupil size is most important so if patient examined dilated best to always dilate

Refractive correction
- Less than 1 D best ignored.
- Patients that under the effect of cycloplegia will need add HFA II is 30 cms

Testing environment
- Low to dark environment
- Machine does indicate if room illumination is too bright
- During calibration (turning the machine on) room should be the same illumination that is used for the testing.

Example of VF

Single field analysis

Parts of VF

HFA details

Octopus details
Grey-scale

Grey scale
- To be looked at for 2-3 seconds not more
- A overall idea of the field.
- Not all points showed on the field are tested.
- The interpolation of data is done

Grey scale- HFA
- The grey scale should be interpreted very carefully
- The grey scale is represented in gradations of 5 dB and range from 1-40 dB

Grey scale- Octopus
- Options to have either color or pure grey scale

Threshold sensitivity values – raw numerical data
- Very important to look at.
- Non manipulated or least manipulated data; so patients “true” response.
Raw data-2
- As seen before threshold data is greater centrally and lesser in the periphery
- 40 dB is the most that a trained observer in a laboratory can see
- If any threshold is seen greater than 40 in central is probably due to "trigger happy patient"

Raw data-3
- Centrally one expects a threshold of lower 30’s dB generally (rule of thumb).
- Peripherally one expects a threshold of upper 20’s dB generally (rule of thumb)

Total deviation plot
- Difference between each point of patients threshold and median age matched normal values.
- A rule of thumb 5 dB lesser values than age matched normal should be viewed “suspicious”

Probability plot Threshold deviation

Pattern Deviation
Pattern deviation numerical plot
- To expose localized defects which may be masked by
  - elevated hill of vision (some locations of abnormally high sensitivity)
  - Generalized depression (cataract)

Pattern Standard Deviation
- Degree to which the total deviation plot points are not similar to each other
- Pattern standard deviation quantifies localized loss as a single value
  - Measure of focal loss or variability within the field
  - Takes into account generalized depression of field

Global Indices

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<th>Octopus</th>
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<td>Mean deviation</td>
<td>mean defect</td>
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Mean deviation
- Measure of entire visual field loss (elevation or depression)
- Average of severity of loss
  - A positive number indicates an average sensitivity is above-average normal for age
  - A negative number indicates an average sensitivity is below-average normal value for age

Mean deviation cont...2
- Mean deviation which is an index of average severity is affected by
  - Degree of loss
  - Number of locations

Glaucoma hemifield test zones
Glaucoma hemifield test
- Plain language analysis
- Chooses points along the paths of nerve fiber bundle- test fine tuned for glaucoma not neurologic fields
- Test zones in superior hemifield compared to inferior hemifield

Results of Glaucoma hemifield test (GHT)
- Outside normal limits (p<0.01)
- Borderline (p<0.03)
- Generalized reduction in sensitivity (low sensitivity p<0.05)
- Abnormally high sensitivity (high sensitivity p<0.05)
- Within normal limits

Bebie curve
- Diffuse defect – DD
- Local defects – LD
- Detection of false positives

Why is staging important?
- Treatment issues
- Management issues
- Prognosis
- Research
Staging based on MD
- Better than -6 dB - Mild
- Worse than -6.0 dB but better than -12 dB - Moderate
- Worse than -12.0 dB severe

Criteria for glaucomatous damage
- GHT outside normal limits in at least two occasions
- A cluster of three or more non-edge points (pattern deviation plot) all of which are depressed at a p<5% and one of which is depressed at a p<1% on two occasions (respecting horizontal meredian)
- PSD < 5% of normal individuals
- This criterion was written for 30-2, if 24-2 field is analyzed edge points are included.

Progression
- Consensus is limited
  - Early changes
  - Paracentral
  - Nasal step
  - Arcuate defects
  - Enlargement of scotomas
  - Deepening of scotomas
  - More than 4 point change in AGIS (later on considered too much)

Guided Progression analysis
- More advanced statistical analysis
- Makes clinical sense
Guided progression Analysis
cont...2
- Baseline:
- First two tests (automatic) are needed and average to make the baseline
- If you don't want to use the first two tests you can manually chose other tests
- For example: Learning curve, poor test taker
- Ocular intervention like, High IOP which was treated during first test

Guided progression Analysis
cont...3
- 30-2 and 24-2 can be used. If 24-2 is the follow-up fields then all field reports are used as 24-2 (extra points of 30-2 is not used)

GPA cont ...5
- Example of additional information with your single field printout

GPA cont -6
- Symbols used
  - Open triangle p<5%
  - Half filled p<5% two occasions
  - Solid triangle p<5% three occasions
  - X out of range
- Possible progression – three or more points show change at least two consecutive tests
- Likely progression – three or more points show change in at least three consecutive tests

Visual Field Index
- Percentage of normal age adjusted field
- Greater the number more normal
- Trend over time is given with a probability values as well
Cluster analysis

Why cluster analysis?

- Individual points may vary
- Overall clusters are more stable
- Also close representation to various bundles of RNFL
- So in some respect better structure function relationship.

Trend analysis

Global rate of progression

Color codes
- Worsening at the 5% level
- Improvement at the 5% level
- Fluctuation at the 5% level

Scale
- Grey: Normality
- 15dB: Seriously impaired vision
- 25dB: Considered legally blind

Global trends
Polar graph

- M cells 10%
- P cells 80%
- K cells 9%

This may explain why selective targeting of ganglion cells may be ideal method

Targeting specific ganglion cells

Frequency Doubling Technology

- Low spatial frequency sinusoidal grating
- Counterphase flicker
- It appears to have twice number of black and white bars

Heidelberg Edge Perimeter
Contour-Illusion Stimulus

Phase 1 + Phase 2 = Illusory "Edge" or Contour

FDT Matrix and similarly magno cell specific perimetry

- Is shown to detect glaucomatous damage early
- Why is it not used more often?
- Data cannot be interchanged!

SWAP

- High luminance (100 cd/m²) uniform yellow background
- Blue target size V
- These isolates koniocellular layer (blue cone system)

SWAP

- More difficult test
- Requires greater learning time
- SITA options are available
- Clinically useful in a good visual field taker
- Reported to detect glaucoma earlier than standard automated perimetry

SWAP

- Short Wavelength Automated Perimetry
- Isolates and measures the sensitivity of the short-wavelength-sensitive (blue-sensitive) visual pathways by presenting a large blue stimuli on a bright yellow background.
SWAP (cont 2)
- The bright yellow background:
  - DEPRESSES the sensitivity of the middle (green) and long (red) wavelength mechanisms
  - PERMITS the sensitivity of the short wavelength sensitive mechanisms to be evaluated

SWAP Deficits
- Are more prevalent in high-risk ocular hypertensives; less prevalent in medium to low-risk ocular hypertensives
- Precede visual field loss for SAP; but, are predictive of future deficits for SAP

SWAP Deficits (cont 2)
- Are more extensive than those found for SAP
- Progress at a higher rate than for SAP losses
- Are correlated with structural abnormalities of the optic disc

Disadvantages of SWAP
- Short-wavelength sensitivity is reduced by:
  - Age-related lens yellowing
  - Macular pigment
  - Cataract
  - Other ocular media opacities
- SWAP has greater inter- and intraindividual variation compared to SAP

Advantages of SWAP
- SWAP is more sensitive to change than standard perimetry. Progression is identified 1-3 years earlier.

Global Summary
- White on white perimetry is till gold standard in perimetry in glaucoma diagnosis and progression detection
- Newer perimetry techniques give additional insights into pathogenesis in glaucoma
- Newer algorithms help make structure function relationships become clearer and more clinically useful.