Visual Fields in Neuro-Ophthalmology

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Visual Sensory Function: 4 Measurable Parameters

- Visual acuity
- Color vision
- Contrast sensitivity
- Visual field**

“W e live on an island of vision surrounded by a sea of blindness”*

- Peak of island hill has highest sensitivity:
  The Fovea
- Sensitivity not uniform
  - As you go downhill (i.e., further away from fovea), sensitivity of retina gradually drops
  - Isopters are concentric ovals down hill of vision
  - same retinal sensitivity
  - Gradient steeper nasally than temporally

*Traquair

Examples of Hill of Vision Erosion and Loss of Corresponding Visual Field

Central scotoma involving fovea
Cecocentral scotoma involving fovea and blindspot

Types of Visual Field Tests

- Confrontation
- Amsler grid
- Kinetic perimetry
- Static perimetry

Confrontational Field Testing**

- Finger counting in 6 areas
  - upper right and left
  - middle right and left
  - lower right and left
- Monocular test
- Use 1, 2, or 5 fingers
- Must be at eye level with patient
- Hand comparison to right and left of fixation

**Will pick up >75% of neurologic field defects with this technique
Confrontational Red Testing

- Red object
  - Intereye: test in center
  - Intraeye: test to right and left of fixation
    - consider paracentral upper and lower, right and left

Amsler Grid

- Monocular test
- Hold at 33 cm
- Evaluates central 10 degrees of field
  - Each box represents 1 degree, so 20 degrees across

Amsler Grid

- Have patient draw what (s)he sees for permanent record and place in chart
- Scotomas
  - Lines wavy
  - Helpful in distinguishing most cases of retina vs optic nerve disease
  - If metamorphopsia present, then retinal problem

Kinetic vs Static Perimetry

- Kinetic
  - Target moved from non-seeing area to seeing area
  - Stimulus may be varied in size and luminance
  - Location at which patient first sees object recorded
  - Threshold established at a particular location
  - Isopters can be mapped
  - Performed manually
- Static
  - Stationary object presented at different locations
  - Intensity increased or decreased to establish threshold* value
  - Usually light intensity increased from subthreshold value to that which is discernible to patient
  - Can be manual or automated
  - Automated more common

Kinetic Perimetry

- Most common way to test entire 180 degrees of visual field
- Goldmann perimeter most common instrument used; BUT results very dependent on interaction of perimetrist and patient
Goldmann Perimetry

- Key:
  - Roman numeral (I through V)
  - Size of target (on logarithmic scale)
  - I is small (.25 mm²), V is largest (64 mm²)
  - Number (1 through 4)
    - 1 is dimmest, 4 is brightest
    - Gradation is 5 dB
  - Lower case letter (a through e)
    - a is dimmest, e is brightest
    - Gradation is 1 dB

Kinetic Perimetry: Common Mistakes

- Speed: Too fast, too slow, too predictable
- Jumps: Too wide
- Size of test object: Inappropriate
- Not enough attention to “normal” eye
- Not enough thought to what is being asked (technician must communicate with physician)

Static (Automated) Perimetry

- Most common technique used since 1980s
- More sensitive than kinetic perimetry
- Provides useful comparison fields
- Humphrey most common instrument
  - Octopus also available

**REMEMBER:**
Test may be automated but patient is not!

Humphrey Automated Perimeter: Types of Tests

- Full Threshold 30-2, 24-2, or 10-2
- FASTPAC
- SWAP
  (Short Wavelength Automated Perimetry)
- SITA Standard
  (Swedish Interactive Threshold Algorithm)
- SITA Fast
- Humphrey Matrix
  - Frequency doubling

Threshold vs Suprathreshold Testing

- Threshold defined as the light sensitivity at which a given stimulus of given size and duration is seen 50% of the time:
  - corresponds to the dimmest spot seen during testing
- Suprathreshold defined as stimulus intensity greater than threshold
  - On screening test, stimulus 6 dB > expected threshold
  - If not seen then location retested with stimulus intensity maximized
    - If seen, then relative defect
    - If not seen, then absolute defect

Humphrey Automated Perimetry

- Threshold established via a staircase strategy:
  - Stimulus luminance is altered in ascending or descending intervals until threshold luminance is crossed
    - 4, 3, or 2 decibel steps
- Accuracy increases as:
  - smaller steps
  - multiple crossings of threshold
  - increase in number of staircases
Humphrey Full Threshold 30-2

- **Stimulus**
  - Size III spot size (4 mm²)
  - White stimulus on white background
  - Usually starts at 25 dB

- 76 locations tested
- 2 near blindspot disregarded to give 74 total
- Each location spaced six degrees apart to cover central 30 degrees of field

Staircase method: 4-2 to find threshold
- Light intensity dimmed by 4 dB until threshold reached (stimulus is no longer seen)
- Light intensity then increased by 2 dB until threshold crossed again (reversal)

Initially, threshold determined in "seed point" in each of 4 quadrants
- Threshold of seed point used to determine threshold of adjacent points in each quadrant

Problems
- Long testing time
- High variability in testing peripheral points
- High test-retest variability
  - especially in pts with pre-existing optic nerve disease
- Since seedpoints used to determine threshold, entire quadrant may have artificially high or low thresholds if seed point threshold is high or low

Humphrey Full Threshold 24-2

- To reduce test-time, outer ring of points eliminated
  - Central 54 locations (minus 2 near blindspot) used within central 24 degrees of field
  - Reduces test time by 30% and also decreases variability

Humphrey Fastpac

- Developed in early 1990's to shorten test time of Humphrey 30-2
- Uses one threshold crossing with 3 dB steps instead of 4-2 staircase
- Reduces test time by 30-40%...
- but has decreased sensitivity and increased variability!
Humphrey SITA Standard

- Threshold measured at 4 primary points in each quadrant, 12.7 degrees from fixation
- Staircase method used 4-2 dB like FT
- Last seen stimulus intensities in neighboring points used to calculate starting values for new points, presented in a pseudo-random order

Humphrey SITA Fast

- Same as SITA, but analogous to FASTPAC staircase strategy, with one reversal/crossing of threshold for most locations
- Threshold values for 4 points used to determine adjacent points where only one reversal with 4 dB steps performed
- If estimated threshold value departs from expected value (based on neighboring points) by > 12 dB, then second staircase initiated

Humphrey SWAP (Short-wavelength automated perimetry)

- “Blue on yellow”
  - Blue stimulus (440 nm) on yellow background (500 nm)
  - Stimulus Goldmann size V (64 mm²)
- May detect VF damage earlier
  - Targets magnocellular photoreceptors susceptible to early damage
  - Studies done on glaucomatous eyes, optic neuritis

Humphrey SWAP (Short-wavelength automated perimetry)

- Strategies similar to FT and FASTPAC
- Good correlation with NFL defects, but…
  - Increased variability
    - both long and short-term (SF)
  - Increased testing time by 15%
  - Affected by ocular media, i.e. cataracts

Comparison of testing times

- Full threshold: 13 minutes/eye
- SWAP: up to 20 minutes/eye
- SITA Standard: 6.5 minutes/eye
- SITA Fast: 2-3 minutes/eye

HVF Reliability Indices

- Fixation Losses
  - Stimuli presented in patient’s blindspot
  - < 20%
- False Positives
  - Projector makes noise but no stimulus presented
  - “trigger happy” patient
  - < 33%
- False Negatives
  - Failure to respond to stimulus > 9 dB from previously determined threshold
  - May indicate that patient is fatigued or inattentive
  - < 33%
Humphrey 24-2 Visual Field

HVF Visual Field Indices
- Pattern Standard Deviation (PSD)
  - Standard deviation of all differences between each threshold value and age-corrected normal
  - Adjusts for generalized decreased sensitivity, i.e. from ocular media opacities
- Corrected Pattern Standard Deviation (CPSD)
  - PSD adjusted for short-term fluctuation

HVF Threshold Variability
- Short-term fluctuation (SF)
  - 10 locations tested twice
  - Normal variation: 1-2 dB
  - Medium fluctuation: 2-3 dB
  - High fluctuation: > 3 dB

Kinetic vs Static Perimetry
- Both techniques have distinct advantages and disadvantages
- One should use the technique that will provide the information needed

Left anterior clinoid meningioma with extension into optic canal
Right sided cavernous hemangioma

Visual Field Testing

- Static perimetry is more sensitive than kinetic perimetry
- Static perimetry is more precise in following defects in patients with chronic disease (eg, glaucoma, compressive optic neuropathies)

HOWEVER

- Most static perimeters test only the central visual field and will miss peripheral defects

Nomenclature of Monocular VF Defects

- Visual field defects associated with disease of papillomacular bundle
Nomenclature of Monocular VF Defects

- Cecocentral scotomas from toxic optic neuropathy

- Temporal nerve fiber bundles

Nomenclature of Monocular VF Defects

- Altitudinal Defects

- Nasal nerve fiber bundles: Temporal wedge off blind spot

Nomenclature of Binocular VF Defects

- Bitemporal hemianopia

- Macular bitemporal hemianopia
Nomenclature of Binocular VF Defects

- Right Homonymous Hemianopia

- Complete Homonymous Hemianopia
- Incomplete Homonymous Hemianopia

- Congruous (symmetric) Incomplete Homonymous Hemianopia
- Incongruous (asymmetric)
- Incomplete Homonymous Hemianopia

- Left Inferior Quadrantanopia

- Macular sparing

1. Visual field defects are opposite in location to the damaged fibers that have produced them
2. Monocular field defects are almost always caused by prechiasmal processes (refractive, media, retina, or optic nerve) or are nonorganic
3. The optic chiasm is the only location for bitemporal field defects that obey vertical midline
Visual Field Rules (Continued)

4. Lesions that affect the visual system posterior to the optic chiasm almost always produce visual field defects that are bilateral and homonymous (affect the same side of visual space in both eyes)
5. Complete homonymous hemianopias are nonlocalizing
6. Visual acuity is not affected in patients with homonymous field defects (one can see 20/20 with half a macula)

7. Lesions of the optic tract produce very incongruous (asymmetric) homonymous visual field defects that are often scotomatous
8. Temporal lobe lesions produce "pie-in-sky" homonymous defects
9. Parietal lobe lesions often produce incomplete homonymous defects associated with other evidence of neurologic dysfunction

10. Occipital lobe lesions produce homonymous defects that are often scotomatous and that can be distinguished from optic tract lesions by their significant congruity (symmetry)

10 Visual Field Rules

1. Visual field defects are opposite in location to the damaged fibers that have produced them

2. Monocular field defects are almost always caused by prechiasmal processes (refractive, media, retina, or optic nerve) or are nonorganic
2a. The visual field defects produced by retinal and optic nerve lesions are identical
2b. Monocular field defects may occur in each eye, masquerading as a chiasmal or retrochiasmal problem
• HVF 24-2
• Left eye
• Good reliability indices
• Inferior arcuate defect
  • Extends to blind spot
• What diseases could have caused this VF defect?

Glucomatous optic nerve cupping with supero-temporal thinning

Optic disc edema from anterior ischemic optic neuropathy (AION)

Chorioretinal scar along supero-temporal vascular arcade

• Amsler grid OS
• Central scotoma

Optic disc edema from optic neuritis
Macular scar from toxoplasmosis

Visual Field Rules (Continued)

3. The optic chiasm is the only location for bitemporal field defects that obey vertical midline.
• Beware of temporal defects that do NOT obey vertical midline!
• Not chiasmal lesion
  • Retinoschisis, retinal detachment
Lesions that affect the visual system posterior to the optic chiasm almost always produce visual field defects that are bilateral and homonymous (affect the same side of visual space in both eyes).

Complete homonymous hemianopias are nonlocalizing.
Visual Field Rules (Continued)

6. Visual acuity is not affected in patients with homonymous field defects (one can see 20/20 with half a macula)

Visual Field Rules (Continued)

7. Lesions of the optic tract produce very incongruous (asymmetric) homonymous visual field defects that are often scotomatous
Temporal lobe lesions, when incomplete, produce superior “pie-in-sky” homonymous defects.

Parietal lobe lesions often produce incomplete homonymous defects associated with other evidence of neurologic dysfunction.
10 Visual Field Rules (Continued)

Occipital lobe lesions produce homonymous defects that are often scotomatous and that can be distinguished from optic tract lesions by their significant congruity (symmetry).
Temporal Crescent Syndrome

- Extreme temporal visual field 150-180° (temporal crescent) represented monocularly by nasal retina
- These fibers project to anterior tip of calcarine cortex
- Area may be spared
- Area may be affected in isolation

Visual Field Examination “Tricks”

- Use tangent (Bjerrum) screen at different distances
- Must keep relationship between target diameter and distance from screen constant
  - i.e., 9 mm target at 1 meter and 18 mm target at 2 meters

Visual Field Examination “Tricks”

- “Saccade” test is best and fast
  - Patient is asked if it hurts to move eyes
  - Patient told to look at finger in peripheral field
  - If patient says can’t see finger, explain that is “expected because of your poor peripheral vision” and that is why “I want you to look directly at the finger.”

Visual Field Examination “Tricks”

- Binocular fields may help in some cases of monocular loss (automated static or kinetic)
Visual Field Examination “Tricks”

- Look for spiraling, concentric constriction, intersecting isopters, etc.

Summary

- The performance of a careful visual field is a crucial part of any ocular examination, regardless of the reason the patient has come for an assessment.
- Understanding the anatomy of the visual sensory system helps to understand the nature and appearance of visual field defects.