Visual Fields: An Interactive Approach
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Classification of Visual Field Defects
- Density
- Size / Extent
- Position
- Shape
- Location
- Laterality
- Equality

Perimetric Assessment
Kinetic vs. Static

**Kinetic Perimetry**
- Tangent screen
- Goldmann perimetry
- Humphrey kinetic testing - Automated
- Octopus kinetic perimeter - Automated

**Static Perimetry**
- Humphrey - Automated
- Dicon - Automated
- Octopus - Automated

Visual Field Testing: Reliability Indices

- **Fixation loss**:
  - Indicator of test fixation status
  - During initial testing, the blind spot is assessed
  - During the testing procedure, the blind spot is re-tested to assess for fixation losses
  - Greater than 20% fixation losses prompts concerns regarding test reliability

Visual Field Testing: Reliability Indices

**False Positive**
- Perimeter simulates the presentation of a stimulus without actual presenting a stimulus
- If patient responds to the lack of a stimulus, a false positive response is generated
- Trigger happy

**False Negative**
- Presentation of a higher threshold stimulus to a point previously thresholded
- The lack of a response results in a false negative
- Suggest test fatigue

Visual Field Plot: Automated static

**Grey scale**
- “Pictorial plot”
- Dark = Greater defect

**Decibel sensitivity plot**
- Plot with actual threshold sensitivity values
- Permits point by point analysis
Visual Field Plot: Automated Static

- **Total deviation**
  - Numerical plot:
    - Considered value plot
    - Adjusted overall changes in the height of the measured hill of vision caused by:
      - Cataracts
      - Small pupils
  - Probability plot:
    - Probability symbols
    - Darker = less likely that the field is normal

- **Pattern deviation**
  - Numerical plot:
    - Probability symbols
    - Darker = less likely that the field is normal

Automated Visual Field Test Strategies

- Full threshold → Staircase strategy
- SITA (Swedish Interactive Threshold Algorithm)
  - Threshold determination by forecasting procedures
  - Utilizes prior information derived from normal & glaucoma populations to establish probability density functions for visual field sensitivity
  - Serves as basis for determining initial stimulus presentations at each location which are then dynamically modified by the participant’s responses
  - Testing continues until 95% confidence limits of the threshold estimate are determined

Retinal Anatomy and Visual Field Defects

- Lesions affecting the optic nerve, disc or nerve fiber layer will demonstrate patterns of visual field loss that parallel the arrangement of these nerve fibers
- Defects frequently have sharp borders and typically respect the horizontal meridian

Optic Chiasm: Anatomy of Visual Pathway Fibers

- Images from the left visual space fall on the temporal retina in the right eye and the nasal retina in the left eye
- Images from the right visual space fall on the temporal retina of the left eye and the nasal retina of the right eye
- At the chiasm, the axons become resorted:
  - Axons representing the temporal visual fields cross to the contralateral optic tract
  - Axons representing the nasal visual fields remain ipsilateral within the chiasm

Optic Chiasm

- Optic nerve and tract length, and chiasm anatomy will determine the type of field defect with a chiasm lesion
- Chiasm directly over pituitary hypophysis typically will cause classic bitemporal defect
- When the optic nerves are short, the optic tract fibers are more at risk for damage
  - Visual field defect bilateral, consistent with optic tract
- When the optic nerves are long, the optic nerve fibers are more at risk for damage
  - Visual field defect more likely to follow optic nerve or anterior chiasm anatomy

Optic Tract: Corresponding Visual Field Defects and Ocular Findings

- Homonymous, incongruous hemianopsia (less commonly, complete hemianopsia)
- Temporal optic atrophy in the ipsilateral eye and bow tie atrophy in the contralateral eye.
- Possible small RAPD in the eye contralateral to the lesion.
Lateral Geniculate Nucleus: Corresponding Visual Field Defects

- Isolated lesions to the LGN are rare
  - Damage to the LGN is usually due to vascular disease
- Field defects may be congruous or incongruous and may be sector or wedge shaped.

LGN: Corresponding Ocular Findings

- Optic atrophy often accompanies LGN lesion:
  - If the entire LGN is damaged, the optic atrophy will be similar to optic tract lesion.
  - With partial LGN lesion (sectoral hemianopia), optic atrophy may be subtle.
- *No RAPD with an LGN lesion.

Retrochiasmal Pathway

- Lesions involving the geniculostriate pathway produce field defects that are homonymous, with increasing congruity the more posterior the lesion
- Typically do not affect visual acuity

Optic Radiations: Temporal Lobe

- The optic radiations follow a very wide arc around the lateral ventricles forming Meyer’s loop in the temporal lobe.

Temporal Lobe Visual Field Defects

- The fibers in Meyer’s loop carry lower retinal projections and result in superior homonymous visual field defects or at least defects that are denser above the horizontal meridian

Temporal lobe: Functional Overview

- Responsible for hearing, memory, meaning, and language
- Plays a role in emotion and learning
- Integrate interpretation and processing of auditory stimuli
- Visual perception
Basic Signs of Dominant and Non-Dominant Temporal Lobe Dysfunction

- **Non-Dominant side:**
  - Neglect
  - Visual memory loss
  - Difficulty recognizing faces, drawings
  - Decreased recognition of tonal sequences and musical abilities
  - Loss of speech inhibition

- **Dominant side:**
  - Language dysfunction/speech perception
  - Receptive aphasia
  - Verbal and visual memory loss
  - Difficulty recognizing words

Parietal Lobe: Two Main Functional Regions

1. Integration of sensory information to form a single perception (cognition)
2. Constructing a spatial coordinate system to represent the world around us
   - Integration of sensory input, primarily with the visual system
   - Individuals with parietal lobe damage often show striking deficits, such as abnormalities in body image and spatial relations.

Optic Radiations: Parietal Lobe

- The optic radiations passing through the parietal lobe carry upper retinal projections which can result in homonymous visual field defects that are denser below than above

Basic Signs of Dominant and Non-Dominant Parietal Lobe Dysfunction

- **Non-Dominant Side**
  - Particularly important for visual spatial function
  - Can be thought of as our “3D Center”
    - Contralateral neglect (neglect of body parts or space)
    - Constructional apraxia (difficulty making things)
    - Anosagnosia (denial of deficits)
    - Impaired drawing ability

- **Dominant Side**
  - Right-left confusion
  - Agraphia
  - Acalculia
  - Receptive aphasia
  - Agnosia
  - All or most of these symptoms together comprise Gerstmann’s syndrome

Parietal Lobe and OKN

- Deep parietal lobe lesions may cause an abnormal OKN response
- The abnormal response consists of defective slow and fast phases when targets are moved TOWARD the side of the lesion

Occipital Lobe Visual Field Defects

- Homonymous and highly congruous; always respect the vertical meridian
- The central visual field is represented at the occipital tip
  - The more peripheral field is represented deeper in the central sulcus
- The calcarine fissure separates the upper projections above (inferior fields) from the lower projections below (superior fields) – so they may respect the horizontal meridian
**Occipital Lobe: Functional Overview**

- Processes visual information
- Responsible for visual reception and contains association areas that help in the visual recognition of shapes and colors

**Occipital Lobe: Signs of Dysfunction**

- Achromatopsia (color blindness)
- Visual agnosia: inability to combine individual parts of an object together to recognize the entire object
- Associative agnosia: inability to recognize objects despite perception of overall shape
- Visual-form agnosia: inability to recognize objects based on drawings
- Prosopagnosia: inability to recognize faces including their own

**Imaging and the Visual Pathway**

- Orbital ultrasound
- X-ray
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)

**Computed Tomography (CT)**

- Utilizes X-rays (Radiation)
- Images can only be in the coronal and axial planes
- Useful to assess tissue density
- Orbital Disorders:
  - Thyroid
  - Bone
  - Trauma
  - Infection
  - Tumor
  - Sinus
  - Lacrimal
  - Brain – Acute hemorrhages
  - Contraindication to MRI

**Magnetic Resonance Imaging (MRI)**

- Hydrogen protons align in a strong magnetic field
- Grey matter consists largely of the bodies of nerve and glial cells
- White matter consists largely of the axons or fibers, glial cells and myelin (fat)
- MRI Planes:
  - Sagittal
  - Coronal
  - Axial / Transverse

**Imaging the Visual Pathway: Views**

- Axial or Transverse (x-y) plane
  - Slices from top to bottom, going down
- Coronal (x-z) plane
  - Slices lengthwise from front to back
- Sagittal (y-z) plane
  - Slices lengthwise from side to side
### MRI Imaging

#### T1 Signal vs T2 Signal

<table>
<thead>
<tr>
<th>Weighted</th>
<th>T1 Signal</th>
<th>T2 Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>Bright</td>
<td>Dark</td>
</tr>
<tr>
<td>Water</td>
<td>Dark</td>
<td>Bright</td>
</tr>
<tr>
<td>Muscle &amp; Nerve</td>
<td>Light grey</td>
<td>Dark grey</td>
</tr>
<tr>
<td>Grey Matter</td>
<td>Dark grey</td>
<td>Light grey</td>
</tr>
<tr>
<td>White Matter</td>
<td>Light grey</td>
<td>Grey</td>
</tr>
<tr>
<td>Visualization</td>
<td>Ocular anatomy</td>
<td>Pathology (Fluid)</td>
</tr>
</tbody>
</table>

#### Fat Suppression
- Deletes fat in orbit
- Increases visibility of small orbital lesions

- Beneficial for:
  - Orbit
  - Pituitary
  - Base of skull

#### FLAIR
- Fluid attenuated inversion recovery
- Diminishes CSF in T2 weighted images
- Good in demyelinating diseases

### Key Locations to Image When a Visual Field Defect is Present

- **Orbit**
- **Cavernous sinus**
- **Chiasm**
- **Visual pathway/cortex**

### Orbit

- Use useful imaging modalities
  - Ultrasound
  - CT
  - MRI (T1 with fat suppression or T2 with contrast)

### Cavernous Sinus

- **MRI**
  - Pre-contrast T1 of entire brain
  - T1 weighted with and w/o contrast, specified as <3mm thick
  - FLAIR T2 weighted
  - Axial and coronal planes from orbital apex through the pre-pontine cistern should be reviewed carefully

- **CT**
  - Best with contrast, <1mm thick axial and coronal sections
Chiasm: Key Anatomic Points

- Optic chiasm
- Pituitary stalk – connects to hypothalamus
- Pituitary gland
- Sella turcica
- Carotid arteries

Neuroimaging Summary

- Be sure to specify
  - Adequate history to radiologist
  - Type of scan
  - Location: Head, orbit, body or neck
  - Optimal view(s) (axial, sagittal, coronal sections), scan thickness, image sequence
  - Decide if contrast needed – MOST neuro-ophthalmic conditions require contrast to highlight the pathology from the background brain tissue unless it is contraindicated (as in severe kidney disease)

- Be sure to specify
  - Suspected location of the lesion
  - Urgency of the scan
  - Possible differential diagnoses tailored to the patient’s clinical symptoms and visual field
  - Indicate special sequences if needed, tailored to the differential diagnosis
    - For example: Fat suppression for any orbital lesion
    - FLAIR MRI for demyelinating lesions
    - DWI MRI for CVA

Imaging Key Points

- Clinicians should communicate with the radiologist for additional testing and recommendations, especially if imaging doesn’t match the clinical diagnosis
- Common errors when requesting imaging tests for neuro-ophthalmic disorders:
  - Failure to apply a dedicated study
  - Inappropriate application of a dedicated study
  - Omission of IV contrast
  - Omission of specialized sequences

Visual Field Take Home Points

- History is KEY
- Ensure all test parameters are correct
- Do not be afraid to REPEAT the test
- Consider more than 1 disease etiology
- Remember disease pathogenesis and disease course
- Understanding the visual pathway & anatomy facilitates localization of the lesion
- Neuro-imaging often confirms the diagnosis