“Mind-Bending” Neuro-Oph Grand Rounds:  
“From the Chiasm & Beyond”

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Disclosure Statement:
Mind-Bending Neuro-oph Grand Rounds:  
From the Chiasm and Beyond  
Leonard V. Messner, OD

- King Devick Technologies (scientific advisory board)  
- Heidelberg Engineering (professional advisory board)

Anatomy slides courtesy of  
Lorraine Lombardi, PhD

Key Points

- Neuroanatomical planes of the body  
- Imaging techniques and scan selection  
- Correlative neuro-anatomy and neuroradiology for visual pathway lesions
  - Chiasm  
  - Retro-chiasm

Planes of the Body

- Axial  
- Sagittal  
- Coronal

Axial

right  
left
Neuroimaging Studies

- Computed tomography (CT)
- Magnetic resonance imaging (MRI)

Ordering a Scan

- Scan selection (e.g. MRI, CT) and testing protocol:
  - Brain
  - Orbits
  - Pituitary/chiasm
- With / without contrast
- Clinical impression/question to be answered
- Medical history

Background

- Increased absorption of x-rays by atoms of higher atomic # (Ca, I, Fe)
- Axial & coronal image planes
- Iodinated IV contrast
  - contraindicated for px’s with hx of allergic rxn to previous contrast studies or shellfish, pregnancy or renal disease
CT “Windows”
- Brain / Soft Tissue
  - 50-350 HU (narrow window)
- Bone
  - 400-2000 HU (wide window)

7 y/o WM
- Hit in left eye with baseball bat
- + ecchymosis & sub conj hem
- No subjective diplopia or motility restriction
- Exoph = 17mm OU

27 y/o Man
- c/o vertical diplopia following blunt trauma
- Diplopia:
  - Near > Dist.
  - Alleviated on left head tilt
PROS & CONS OF CT
- CHEAP
- QUICK
- ADAPTABLE FOR ANGIOGRAPHY (CTA)
- ACUTE BLOOD
- BONE DETAIL & ORBITS
- SOFT TISSUE DIFFERENTIATION
- “BEAM-HARDENING” ARTIFACTS
- RESTRICTED IMAGING PLANES (AXIAL & CORONAL)
- IONIZING RADIATION

Polling Question #1
Which of the following is an indication for CT scanning?

a. High resolution of soft tissue
b. Identification of acute blood
c. Easy imaging of all anatomical planes
d. Absence of beam-hardening artifacts

MAGNETIC RESONANCE IMAGING (MRI)

Background
- Px in strong magnetic field
- Alignment vector for hydrogen atoms (protons)
- Radiofrequency (RF) pulse
- Energy absorbed / released
- Released signal (“echo”) analyzed by receiver coils
- Computed image construction
MRI Sequencing

• T1-weighted
• T2-weighted
• Fluid attenuated inversion recovery (FLAIR)
• Fat suppression
• Diffusion-weighted imaging (DWI)

T1-Weighted Imaging

• Short TR (≤ 600 ms)
• Short TE (≤ 30 ms)
• Good resolution of anatomical detail
• Adaptable with contrast infusion

T2-Weighted Imaging

• Long TR (≥ 2000 ms)
• Long TE (≥ 80 ms)
• Good identification of pathology (fluid)
  – Edema
  – Demyelination
  – Infarction

Signal Intensity (T-1 vs. T-2)

<table>
<thead>
<tr>
<th>Structure</th>
<th>T-1 weighted</th>
<th>T-2 weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>bright/gray</td>
<td>dark</td>
</tr>
<tr>
<td>CSF/H2O</td>
<td>dark</td>
<td>bright</td>
</tr>
<tr>
<td>Vitreous/aqueous</td>
<td>dark</td>
<td>bright</td>
</tr>
<tr>
<td>Fat</td>
<td>very bright</td>
<td>less bright</td>
</tr>
<tr>
<td>Rared blood</td>
<td>black</td>
<td>black</td>
</tr>
<tr>
<td>Bone/air</td>
<td>black</td>
<td>black</td>
</tr>
</tbody>
</table>
30 y/o AA Woman

- Clinical concern for papilledema
- Chronic daily Headache
- BMI = 41
- BVA:
  - 20/20 OD
  - 20/20 OS

T-2 Likes $\text{H}_2\text{O}$
66 y/o man

- Long standing history of proptosis OD
- BVA:
  - LP OD (band keratopathy)
  - 20/20 OS

37 y/o man

- Hx of recent auto accident with whiplash injury
- Transient monocular blindness, OD
- Right side neck pain with intracranial noise
Fluid Attenuated Inversion Recovery (FLAIR)
- T2WI with suppression of CSF signal
- Increased sensitivity for paraventricular lesions:
  - Ischemic foci
  - Demyelinating plaques

42 y/o Hispanic Woman
- Previous bout of optic neuritis, OS
- H/o RR-MS
43 y/o AA Woman

- c/o progressive left proptosis
- h/o chronic sinusitis

Fat Suppression

- Short tau inversion recovery (STIR)
- Fat saturation (FS)
  - Orbits
  - Neck
  - Bone marrow
Polling Question #2

Which of the following conditions shows a hyperintense appearance on FLAIR imaging?

a. Bone  
b. Air  
c. Paraventricular demyelinating plaques  
d. High-speed blood flow

Paramagnetic Contrast Enhancement

- Gadolinium (Gd-DTPA)  
- Breakdown of blood-brain barrier  
  - Edema  
  - Vascularization  
- Hyperintensity on T1 (shortens T1 signal)

FLAIR T1 Post Gad

55

56

57

58

59

60
71 y/o AA Man

- Progressive vision loss OD > OS (months to years?)
- BVA:
  - LP OD
  - 20/60 OS
74 y/o AA Woman

- Consult for optic atrophy OU
- S/P thyroidectomy for thyroid CA (Rx Tyrosint® (levothyroxine) for hypothyroidism)
- + HTN / DM (advanced renal disease)
- c/o progressive vision loss OS > OD (x 2-3 months)
- Notices left eye protruding (x 2-3 months)
One thing you should never do is drink a few glasses of Ciroc vodka at an open bar event and then have a glass of straight Hennessy afterwards on a school night.

**Diffusion-Weighted Imaging**

- Variant of T2WI
- Assessment of the ability of water molecules to freely move (diffuse) within biological tissue (“Brownian motion”)
- Within white matter, water molecules show a linear diffusion parallel to axonal fibers

**DWI (cont.)**

- Immediate detection of cerebral ischemia
  - Increased signal intensity *within minutes*
  - Maximal signal intensity within 2-4 days
  - Slow return to baseline

**Apparent Diffusion Coefficient “ADC Map”**

- Chronicity of stroke:
  - Acute infarct (cytotoxic edema) = low ADC
  - Subacute/chronic infarct (vasogenic edema) = high ADC

  “T2 Shine Through”
**46 y/o Hispanic Man**
- Evaluation of optic atrophy OU
- H/o diabetes and hypertension
- BVO:
  - 20/20 OD
  - 20/20 OS
- Recent-onset tremor, confusion, depression, lower left facial weakness and eye tracking problems (impaired saccades greater looking to left)

**66 y/o AA Woman**
- Recent complaint of recent vision loss on her left side
- H/o hypertension
- BVO:
  - 20/20 OD
  - 20/20 OS
12 y/o AA Male

- C/o decreased vision, OS x 1 week
- BVA:
  - 20/20 OD
  - 20/60 OS
- RAPD OS
- Pain on eye movement

Metallic implants can substantially degrade MRI image quality or in certain instances, render the procedure unsafe (e.g. guide wires, aneurysmal clips, pacemakers)

PROS & CONS OF MRI

- SOFT TISSUE
- POSTERIOR FOSSA
- SAGITAL PLANE
- DEMYELINATION / MS
- CHRONICITY OF STROKE
- $$$
- LONGER TIME
- CONTRAINDICATED WITH METAL, PREGNANCY & OBESITY
Polling Question #3

Which of the following is true of diffusion-weighted imaging (DWI)?

a. Immediate identification of acute cerebral infarction
b. Hyperintensity with long-standing cerebral infarcts
c. Superior identification of demyelinating plaques
d. Optimal visualization of vascularized tumors

“The chiasm lives in a rough neighborhood.”

Lawrence G. Gray

Visual field loss
- Bitemporal hemianopia
- Denser above than below
- Progression to entire hemifield
- Classic for pituitary adenoma

Posterior chiasmal lesions (pressure from above) denser below than above
- Produce bitemporal hemianopia with highest density pointing toward fixation
Lesions of the Chiasm

49 y/o AA woman

- "blurry vision" x 2 weeks
- Dull headache (treated for sinusitis but with no improvement in HA)
- Recently diagnosed with hypothyroidism (treated with Synthroid)
- Elevated prolactin
- BCVA: 20/20 OD, 20/25 OS
Epidermoid Cysts

- < 2% of all intracranial tumors
- Peak incidence 2nd to 5th decades
- Predilection for sellar/parasellar region (emanation from third ventricle)
- Cystic with no enhancement
- Recommended Tx = surgical resection if symptomatic/endocrine dysfunction
- 24% recurrence rate


Discharge & Follow-up

- BCVA: 20/20 OU
- Normalization of visual fields
- Normalization of endocrine function

Pituitary Adenomas
Pituitary Adenoma

- Benign tumors of pituitary origin
- Third most common intracranial tumor (25% prevalence at autopsy/MRI)
- Micro vs. macroadenoma (>10mm)
- Secretory (prolactin) vs. non-secretory
- Localized (2/3) vs. invasive (1/3)
- Do not produce papilledema

Pituitary Adenoma (cont.)

- MRI findings:
  - Iso-intense to brain
  - Homogeneous staining with gadolinium (highly vascularized)

Pituitary Adenoma (cont.)

- Complications:
  - Endocrine dysfunction
  - Pituitary apoplexy
  - Vision!!

61 Y/O Hispanic Woman

- C/o progressive vision loss, both eyes
- Approx. 2 years duration
- BVA:
  - 20/40 OD
  - 20/70 OS
40 Y/O Caucasian Man

- C/o progressive side-vision loss, both eyes
- Several months duration
- BVA:
  - 20/20 OD
  - 20/20 -2 OS

GCC analysis:
Bi-nasal GCC thinning

Blanch RJ, et al. Pituitary 2018
18 Y/O AA Man

- C/o vision loss OS 1-2 years ago
- Vision OD is “perfect”
- BVA:
  - 20/20 OD
  - 20/500 OS
Not all bitemporal defects are due to chiasmal disease...

27 Y/O Caucasian Man
- Suspicion of chiasmal compression
- Moderate-high myopia
- BVA:
  - 20/20 OD
  - 20/20 OS
Polling Question #4

Which of the following OCT findings is most significant in the identification of chiasma compression?

a. Bitemporal ganglion cell thinning  
b. Binasal ganglion cell thinning  
c. Arcuate ganglion cell thinning  
d. Altitudinal ganglion cell thinning

Anterior Chiasmal Syndrome

61 Y/O Hispanic Man

- C/o progressive vision loss, OS  
  - Several months duration  
- Long-standing history of DM / HTN  
- Conf fields:  
  - Temp field loss denser above, OD  
  - Complete temp field loss, OS  
- BVA:  
  - 20/20 OD  
  - 20/400 OS
S/P Trans-sphenoidal Resection of Tumor

- BVA:
  - 20/20 OD
  - 20/20 OS
79 y/o AA Man

• C/o progressive vision loss OS x several years
• BVA:
  – 20/20 OD
  – 20/60 OS

Rathke’s Cleft Cyst

• Benign, cystic tumors from embryonic remnant of Rathke pouch (33% of autopsy specimens)
• Often with mucin-derived nodule (iso/hyperintense to brain)
• Amenable to transphenoidal drainage
• Variable recurrence
Invasive Pituitary Adenomas

• 35% of all pituitary adenomas
• Invasion of parasellar regions:
  – Vascular (cavernous sinus)
  – Neural tissues
  – Bone
• Rapid growth/early recurrence (within 6 months of removal)


44 y/o AA Man

• Progressive vision loss OD x 4 years
• s/p transphenoidal resection of “pituitary mass” in 2014
• BVA:
  – HM OD
  – 20/30 OS

3 months s/p surgical resection of tumor

• BVA:
  – 20/25 OD
  – 20/20 OS
70 y/o AA Woman

- C/o progressive difficulty seeing objects to her right x 4 months
- BVA:
  - 20/20 OD
  - 20/20 OS

Lesions behind the chiasm cause binocular visual field defects... homonymous, contralateral

Retro-chiasmal lesions result in binocular visual field defects... homonymous, contralateral
Temporal lobe lesion
- Inferior retinal quadrants
- Related neurologic problems: Memory/auditory dysfunction, seizures

Parietal lobe lesion
- Superior retinal quadrants
- Related neurologic problems: Neglect of non-dominant side, agnosia, apraxia, math difficulty, abn. saccades

Blood Supply to Occipital Lobes
- P3/P4 branches of the posterior cerebral artery (medial aspect)
  - Calcarine branch
  - Posterior lateral PCA branch
- Middle cerebral artery (lateral aspect)
  - deep optic branches

Posterior Cerebral Artery Segments:
- P1/P2: Brainstem / cortical
- P3/P4: Only cortical including calcarine
- Calcarine
- Middle Cerebral Artery (deep optic branches)
Posterior Cerebral Artery Infarction

- 5-10% of cerebral infarcts
- 5% stroke-related death (P1 & P2 segments)
- 84% chronic visual field defects (P3 & P4 segments)


A 58-y/o Man

- C/o recent onset vision loss on left side
- BVA: 20/20 OU
- PMI: HTN x 20 years
Polling Question #5

What is the most likely visual field defect associated with a right posterior cerebral artery infarct?

a. Right homonymous hemianopia
b. Left homonymous hemianopia
c. Bitemporal hemianopia
d. Binasal hemianopia

56 y/o Latino Man

- C/o difficulty seeing objects up & to his right
- BVA:
  - 20/20 OD
  - 20/20 OS
The Rest of the Story...

- Treated for gonorrhea 30 yrs. ago
- Serology:
  - + FTA-Abs
- CSF:
  - Protein (86.7 mg/100 ml)
  - IgG (14.7 mg/100 ml)
  - IgM (2.0 mg/100 ml)
  - + VDRL

CNS Syphilitic Vasculitis

- Positive FTA-Abs / CSF VDRL
- Elevated protein and pleocytosis
- Commonly along distribution of middle cerebral artery (less often with basilar artery distribution)

46 y/o AA Man

- C/o difficulty seeing objects to his right (approx. 6 mos)
- Right side hemiparesis
- + HIV & syphilis
- BVA:
  - 20/20 OD
  - 20/20 OS
44 y/o AA Man

- C/o difficulty seeing objects down & to his right ("scintillating" quality)
- + seizures
- BVA:
  - 20/20 OD
  - 20/20 OS

Occipital Lobe Arteriovenous Malformations

- Occipital epilepsy
  - Flashes of light
  - Homonymous field defects (dimming)
- Occipital apoplexy (acute hemorrhage)
  - Sudden onset headaches
  - Homonymous field loss
- Confusion with migraine


- Retrospective analysis of 68 patients with occipital lobe AVMs
  - Homonymous visual field loss: 57%
  - Headache: 57%
  - Seizures: 29%
Treatment Options

- 30% natural risk of hemorrhage (highest risk with thalamic, basal ganglia & brainstem AVMs)
  - Resection
  - Radiosurgery
  - Embolization
  - Observation


Key Points

- Imaging techniques and scan selection
- Correlative neuroanatomy and neuroradiology for visual pathway lesions
  - Chiasm
  - Retro-chiasm

Thank you!