MRI Imaging of Neuromyelitis Optica

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Our Patient: Initial Presentation

- J.H. is a 29 year-old woman who presents with acute vision loss and pain in the right eye.
  - Monocular central vision loss and “fuzziness” in the right eye.
  - Colors are “less bright” through the right eye.
  - Pain in the right eye with movement in all directions.

- Past medical history: uncomplicated vaginal delivery one month prior to presentation; no other significant medical, neurological or surgical history.

- Neurologic exam:
  - Visual acuity OD 20/400, OS 20/20.
  - Visual field testing: right eye central scotoma.
  - Right eye red desaturation.
Causes of Optic Neuropathy

1. Optic Neuritis:
   - inflammatory, demyelinating condition of the optic nerve
   - most common in younger adults (ages 18-40)

2. Ischemic Optic Neuropathy:
   - ischemic insult to the optic nerve head
   - most common in patients over the age of 50

3. Infectious/Post-infectious
   - viral, Bartonella, Toxoplasmosis, Lyme, Syphilis

4. Inflammatory Optic Neuropathy:
   - manifestation of Sarcoidosis, Systemic lupus erythematosus (SLE), Sjogren’s syndrome, Wegener’s granulomatosis

5. Compressive
   - Neoplasm (optic glioma, meningioma, lymphoma), carotid-ophthalmic artery aneurysm

6. Genetic
   - Leber’s hereditary optic neuropathy, Kjer type autosomal dominant optic atrophy

7. Toxic
   - Drugs, toxins, radiation

8. Trauma
   - closed head trauma causing contusion or hemorrhage
Anatomy of the Orbit

Axial T2-weighted MRI

- Lens
- Medial Rectus Muscle
- Lateral Rectus Muscle
- Optic Nerve
- Orbital Fat
- Vitreous Body

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Menu of Tests: Imaging the Optic Nerve

**MRI**
- Primary modality for imaging the optic nerve and orbital soft tissues
- Useful in the evaluation of:
  - compressive lesions
  - inflammatory and demyelinating lesions
  - infarction and ischemia
  - infection

**CT**
- Able to detect bony detail, calcifying lesions (e.g. meningiomas), early hemorrhage
- Useful in the evaluation of acute trauma for orbital fractures and hemorrhage
Imaging the Optic Nerve: MRI

- Imaging the optic nerve presents many challenges:
  - Small size requires high spatial resolution
  - Surrounding fat, CSF, and bone can produce artifacts
  - Eye movements can cause motion artifact

- T1: used to evaluate anatomy
  - Fat tends to be bright
  - CSF is dark

- T2: used to evaluate edema resulting from pathologic processes
  - CSF is bright
  - Fat tends to be dark

- Fat Saturation:
  - Short Tau inversion Recovery (STIR): suppresses the fat signal allowing for better detection of optic nerve lesions
  - T1 post-contrast with Fat Sat - suppresses fat signal allowing for better visualization of contrast uptake
Because our patient presented with monocular vision loss, dyschromatopsia, and eye pain, an MRI was performed to evaluate the optic nerve.
Sequential STIR images show:

- Abnormal T2 hyperintensity within the right optic nerve
- Enlarged right optic nerve
Our Patient: Axial T1 FSE with Contrast

- Following contrast administration, there is enhancement of the right optic nerve.

- Diagnosis:
The clinical presentation and MRI findings are compatible with the diagnosis of right acute optic neuritis.
Optic Neuritis: The Basics

- Acute inflammatory demyelinating disorder of the optic nerve.

- Typically presents with monocular vision loss, dyschromatopsia (loss of color vision), and eye pain.

- More common in women (two-thirds) and typically affects younger patients between the ages of 20 and 40.

- Diagnosis can usually be made based on clinical features but MRI of the orbits (STIR, gadolinium contrast-enhanced) provides confirmation.
Optic Neuritis: Prognosis

- Vision typically improves spontaneously over a period of weeks to months and 90% of patients have at least 20/40 vision after one year.

- Longer lesions in the optic nerve are associated with poorer visual recovery.

- The Optic Neuritis Treatment Trial (ONTT) found that there was recurrence in 35% of patients at 10 years and that patients with recurrent optic neuritis had a greater risk of developing MS.
  - Optic neuritis is the presenting symptom in 15-20% of patients diagnosed with MS
  - Optic neuritis occurs in 50% of patients with MS during the course of their illness
Optic Neuritis: Risk of MS

- In ON, MRI is used to assess the brain for asymptomatic lesions.

- The risk of developing MS is strongly related to the presence of demyelinating lesions on MRI at the time of optic neuritis onset.

- In the ONTT, the 15-year risk of developing MS was:
  - 72% with one or more lesions present
  - 25% when no lesions were present

MS Lesions on MRI

- MS is an autoimmune inflammatory demyelinating disease of the CNS characterized by attacks and lesions disseminated in space and time.

- MRI is the test of choice for evaluating MS lesions.
  - Lesions: typically ovoid in shape and found in the periventricular region, corpus callosum, subcortical white matter, brainstem and optic nerves.
  - T1:
    - Most lesions are isointense.
    - Some are hypointense (“Black Holes” – may represent axonal loss and may correlate with disease progression).
  - T2 and Proton Density: lesions are hyperintense.
  - Gadolinium-enhanced: active lesions enhance due to disruption of the blood-brain barrier.
  - Fluid Attenuated Inversion Recovery (FLAIR): suppression of the CSF signal allows for better detection of lesions along the corpus callosum.
Because of the increased risk of MS associated with optic neuritis, our patient underwent an MRI of the brain to look for demyelinating lesions.
Our Patient: Axial FLAIR MRI

- A series of images show no foci of abnormal signal within the brain parenchyma.
- The corpus callosum appears normal.
- Following contrast administration, there is no abnormal enhancement.
Our patient had no findings indicative of MS on MRI. The following companion patient illustrates the characteristic appearance of MS lesions on MRI.
Companion Patient #1: MS
Lesions on Axial T2-weighted MRI

There are multiple T2 hyperintensities representing characteristic MS lesions.
Companion Patient #1: Multiple MS Lesions on Sagittal FLAIR MRI

These images illustrate Dawson’s Fingers, characteristic MS lesions radiating outward from the corpus callosum.
Recap: J.H. was diagnosed with acute optic neuritis of the right eye based on clinical and radiologic findings. MRI of her brain showed no lesions suggestive of MS.

Must now decide on an appropriate treatment option:

1. No treatment: without treatment, vision typically begins to improve over a period of weeks and continues to improve over a period of months.
2. Corticosteroids: according to the ONTT, IV methylprednisolone followed by oral prednisone accelerates the recovery of visual function but does not impact long-term visual function.
3. Plasma Exchange: for patients with severe ON who are unresponsive to corticosteroid treatment.
4. Chronic Immunomodulatory therapy: in patients with a high risk of developing MS (as evidenced by demyelinating lesions on MRI), treatment with interferon beta may delay the development of clinical MS.

J.H. received two days of IV methylprednisolone but stopped treatment prematurely due to severe flushing. She noted very slight improvement in vision and decreased pain after treatment.
Our Patient: Second Presentation

- J.H., a 29 year-old woman with a history of optic neuritis in the right eye 2 months ago, now presents with acute vision loss and pain in the left eye.
  - Vision loss and “fuzziness” in the lower half of left eye visual fields.
  - Pain in left eye with movement in all directions.
  - Decreased color vision

- J.H. still has visual loss in the right eye but no other new symptoms.

- Neurologic exam:
  - Visual acuity: OD 20/200, OS 20/25 when viewing through left superior quadrant only.
  - Funduscopic exam: right optic disc pallor and slight obscuration of disc margins, left optic disc appears normal.
  - Visual field testing: right central scotoma, left inferior altitudinal scotoma.
  - Relative Afferent Pupillary Defect (RAPD) present on the right.
Our patient presented a second time with monocular vision loss, dyschromatopsia, and eye pain now in the left eye. An MRI was performed to evaluate the optic nerves.
Our Patient: Coronal STIR Images

First Presentation: 3/23/09

Second Presentation: 5/31/09

There is now abnormal increased T2 signal and enlargement of both the right and left optic nerves.

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Our Patient: Coronal T1 FSE with Contrast

First Presentation: 3/23/09
Second Presentation: 5/31/09

• There is enhancement of the right optic nerve, right aspect of the optic chiasm (not seen on this image), and left optic nerve, demonstrating progression from the prior imaging studies.
• Findings are compatible with a diagnosis of bilateral optic neuritis.

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Bilateral Optic Neuritis: Prognosis

- Optic neuritis may represent an isolated event or it may precede the onset of a demyelinating syndrome such as MS or neuromyelitis optica (NMO).

- Bilateral optic neuritis is relatively uncommon but occurs more commonly in children younger than 12-15 years old.

- Rapid succession of optic neuritis episodes, especially in patients with normal brain MRI, is predictive of NMO conversion.
Neuromyelitis Optica

- NMO is an inflammatory, demyelinating syndrome of the CNS characterized by severe attacks of optic neuritis and myelitis, which, unlike MS, commonly spare the brain in the early stages.

- It is up to 9 times more common in women than men.

- The median age of onset is 39.

- Diagnostic Criteria:
  - Optic neuritis
  - Acute transverse myelitis
  - At least 2 out of 3 supportive criteria:
    - Contiguous spinal cord lesion extending over 3 vertebral segments on MRI
    - Brain MRI findings not satisfying diagnostic criteria for MS
    - NMO-IgG seropositive status
Neuromyelitis Optica on MRI

- Brain MRI at onset: typically normal or may show non-specific white-matter lesions that do not meet criteria for MS.

- Brain MRI (later): 10% of patients have white-matter lesions in the periependymal regions (enriched in aquaporin 4), including the hypothalamus and periaqueductal brainstem.

- Spinal Cord MRI: lesions are longitudinally extensive and span 3 or more contiguous vertebral segments.
Because of the association between bilateral optic neuritis and NMO, an MRI of the cervical and thoracic spine was performed to look for transverse myelitis.
Our Patient: Sagittal C-spine Proton Density Weighted Image

- There is questionable subtle increased signal of the cord at the level of C5-C6, though this is not definite.

- Following gadolinium administration, there is no abnormal enhancement of the cervical cord.

- MRI of the thoracic cord is normal.
There was no evidence of transverse myelitis in our patient. The following companion patient with diagnosed NMO illustrates the characteristic appearance of longitudinally extensive transverse myelitis on MRI.
Patient with diagnosed NMO presents with a flare.

Abnormal T2 hyperintensity throughout the spinal cord from C1-2 through T12-L1.

Associated spinal cord swelling from C6-T10.

Findings are consistent with an aggressive demyelinating process.
Back to Our Patient: Recap of Findings

**Presentation:**
- J.H. initially presented with acute vision loss and pain with movement in the right eye and was diagnosed with optic neuritis.
- Two months later, she presented with similar symptoms in the left eye and was diagnosed with bilateral optic neuritis.

**MRI:**
- Bilateral optic neuritis
- No brain lesions suggesting MS
- No longitudinally extensive transverse myelitis
Our Patient: Other Notable Findings

- **Serologic Work Up:**
  - NMO-IgG Serum: Negative*
    - *Suspicious, but not diagnostic. Recommend follow-up in 6 months if NMO spectrum disorder is suspected.
    - 76% sensitive and 94% specific for clinical diagnosis of NMO
  - HSV, HIV, Hep B surface AG, and Lyme: Negative

- **Rheumatologic Work Up:**
  - Positive ANA, Positive Anti-Ro/SSA, Positive RF, low C4
    - These lab features can be seen in patients with SLE or Sjogren’s syndrome
    - Optic neuritis can be seen in SLE and Sjogren’s syndrome
    - The patient has no other manifestations of these diseases

- **CSF Work Up:**
  - NMO-IgG CSF: Negative.
    - CSF test recommended when NMO is strongly suspected and NMO-IgG is negative.
  - No oligoclonal bands present.
    - Found in 85-95% of patients with clinically definite MS
Our Patient: Treatment and Follow-up

Treatment:
- Completed a 9-day course of IV methylprednisolone with no significant improvement of symptoms.
- After failing to respond to corticosteroids, she completed a 5-day course of plasmapheresis.

J.H. was released on oral prednisone and azathioprine.

One month follow-up with outpatient neurologist:
- Neurologic exam was unchanged. J.H. still has bilateral vision loss and continues to have pain in the left eye with movement.
- Assessment: 2 episodes of optic neuritis post-partum, possibly NMO or SLE.
- Plan:
  1. begin tapering prednisone.
  2. increase azathioprine dose.
  3. follow-up in one month.
Key Points

- **Optic Neuritis**: an acute inflammatory demyelinating disorder of the optic nerve that typically presents with monocular vision loss, dyschromatopsia, and eye pain.

- **MS**: an autoimmune inflammatory demyelinating disease of the CNS characterized by attacks and lesions disseminated in space and time.

- **NMO**: a severe, demyelinating disease of the CNS that preferentially affects the optic nerves and spinal cord.

- **MRI** is the best imaging modality for detecting lesions associated with these inflammatory, demyelinating conditions.
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