MRI Case Studies: Multiple Sclerosis and MS Mimics

Jill Conway, MD, MA, MSCE
Director, Carolinas MS Center
Clerkship Director, UNCSOM-Charlotte Campus
Charlotte, NC
DISCLOSURES

• Speaking, consulting, and/or advisory boards for Biogen, Genzyme, Novartis, Questcor, and Teva.

• Institutional research support from Avanir, Biogen, Novartis, Roche, Teva.
OUTLINE

• Introduction to MRI
  • T1/T2/FLAIR/gado – what does it mean?
• Typical MRI findings in MS
• Differential diagnosis of MS on MRI
• Case studies
  • Common and uncommon MS mimics
  • MS spectrum on MRI
MRI: HOW DOES IT WORK?

• The human body contains many protons (hydrogen nuclei)
• When exposed to a magnetic field, these protons align
• In MRI, magnetic fields are pulsed, causing protons to move and spin
• Observing how protons react to the magnet allows the creation of an image based on proton behavior in tissues
MRI: TYPES OF IMAGING

• The MRI sequences result from different relaxation and pulse times, oriented at different angles

• Differences in speed and pulse sequences highlight different tissue properties
MRI: TYPES OF IMAGING

- T1: good for brain anatomy
- T2: highlights pathology
- Fluid Attenuated: suppresses CSF signal
- T1 + gado: shows BBB breakdown
MRI: T1 IMAGING
MRI: T2 IMAGING
TYPICAL MS: SAGITTAL FLAIR
SPINAL CORD MRI
MRI IN DIAGNOSIS:

- Periventricular, ovoid lesions
- Cerebellum frequently involved
- Corpus callosum lesions common
- MRI is highly variable
MRI IN MS DIAGNOSIS

**TABLE 1: 2010 McDonald MRI Criteria for Demonstration of DIS**

DIS Can Be Demonstrated by \( \geq 1 \) T2 Lesion\(^a\) in at Least 2 of 4 Areas of the CNS:

<table>
<thead>
<tr>
<th>Periventricular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juxtacortical</td>
</tr>
<tr>
<td>Infratentorial</td>
</tr>
<tr>
<td>Spinal cord(^b)</td>
</tr>
</tbody>
</table>

Based on Swanton et al 2006, 2007.\(^{22,27}\)

\(^a\)Gadolinium enhancement of lesions is not required for DIS.

\(^b\)If a subject has a brainstem or spinal cord syndrome, the symptomatic lesions are excluded from the Criteria and do not contribute to lesion count.

MRI = magnetic resonance imaging; DIS = lesion dissemination in space; CNS = central nervous system.

**TABLE 2: 2010 McDonald MRI Criteria for Demonstration of DIT**

DIT Can Be Demonstrated by:

1. A new T2 and/or gadolinium-enhancing lesion(s) on follow-up MRI, with reference to a baseline scan, irrespective of the timing of the baseline MRI

2. Simultaneous presence of asymptomatic gadolinium-enhancing and nonenhancing lesions at any time

Based on Montalban et al 2010.\(^{24}\)

MRI = magnetic resonance imaging; DIT = lesion dissemination in time.
DIFFERENTIAL DIAGNOSIS OF MS

**MS forms and mimics**
- Neuromyelitis optica
- ADEM
- Balo’s concentric sclerosis
- Marburg variant

**Autoimmune disease**
- Systemic lupus erythematosus
- Sjögren’s syndrome
- Antiphospholipid antibody syndrome
- Behcet’s disease
- Neurosarcoid

**Infectious**
- HIV and HTLV
- Herpes viruses
- VZV
- JC virus
- Measles virus
- Toxoplasmosis
- Histoplasmosis
- Syphilis

**Genetic**
- Adrenoleukodystrophy
- Leber’s optic atrophy
- Mitochondrial diseases
- Canavan’s
- CADASIL

**Other**
- B12 deficiency
- Complicated migraine
- Nonspecific WM lesions
- SVID
MS Mimics on MRI
NONSPECIFIC WM LESIONS

- 32 yo diagnosed with MS in 2006
  - MRI done for recurrent headache
  - Pain in multiple locations refractory to treatment
- Cervical and thoracic spine MRI: normal
- Lumbar puncture
  - No cells, normal protein, no oligoclonal bands
- Labs for other conditions normal
  - B12, ESR, ANA, SSA/B, ACE level
MRI: NONSPECIFIC WM LESIONS
MRI: NONSPECIFIC WM LESIONS
NEUROMYELITIS OPTICA

- 30 yo African-American woman with a history of optic neuritis and lupus since 2003
- Treated with Avonex and azathioprine
- Did very well and stopped treatment and no follow-up for years
NEUROMYELITIS OPTICA

• Presented with confusion in 2011
• Lumbar puncture done with 5 WBC, no oligoclonal bands
• Tested positive for NMO antibody
• Treated with plasmapheresis and monoclonal antibody
NEUROMYELITIS OPTICA: BRAIN MRI
NEUROMYELITIS OPTICA: 1/12
T-SPINE MRI, 1/13
NEUROMYELITIS OPTICA

• *Absolute Criteria:*
  1. Optic neuritis
  2. Acute myelitis

• *Supportive Criteria:*
  1. Negative brain MRI at disease onset
  2. Spinal cord MRI with longitudinally extensive lesion (3 segments)
  3. NMO-IgG seropositive status

Wingerchuk 2006 proposed criteria
NEUROSARCOID: HISTORY

- 63 yo woman presents with recent MS diagnosis
  - Symptoms include vertigo, dragging right leg
  - LE pain and fatigue began many years ago

- MRI suspicious for demyelinating disease

- Lumbar puncture: many white cells (120), elevated protein, low glucose, and positive oligoclonal bands
NEUROSARCOID: MRI
NEUROSARCOID: MRI
NEUROSARCOID: FOLLOW-UP

- Extensive infectious disease workup was negative
- Meningeal biopsy normal
- Diagnosed with neurosarcoid
  - Autoimmune systemic inflammatory condition
  - Lesions may mimic MS
    - Often leads to meningeal enhancement
    - Optic chiasm and nerves often affected
    - May involve spinal cord lesions
- Patient stable on TNF-alpha blocker
MS Spectrum on MRI
### Table 1
Proposed diagnostic criteria for the radiologically isolated syndrome

A. The presence of incidentally identified CNS white matter anomalies meeting the following MRI criteria:

1. Ovoid, well-circumscribed, and homogeneous focal with or without involvement of the corpus callosum

2. T2 hyperintensities measuring >3 mm and fulfilling Barkhof criteria (at least 3 out of 4) for dissemination in space

3. CNS white matter anomalies not consistent with a vascular pattern

RIS: CASE EXAMPLE

- 16 yo female
- Identical twin
- Sister diagnosed with MS after multiple symptoms and MRI with changes consistent with MS
- Twin in NIH study and MRI done annually
- Report of minor MRI changes on recent research MRI
CLINICALLY ISOLATED SYNDROME

• Any other MRI lesion
  • Risk of MS conversion 80% at 15 years
• No other MRI lesions
  • Risk of MS conversion 20% at 15 years
• Other risk factors for MS conversion
  • Epstein-Barr virus, smoking, positive HLADRB1*1501
• 50-70% have other MRI lesions at CIS

CIS: BRAIN MRI AFTER ON
ESTABLISHED MS: TYPICAL MRI
RISKS FOR AGGRESSIVE DISEASE

- More relapses in first 2 years
- Male gender
- Spinal cord disease
- Number of T2 lesions at baseline
- Enhancing lesions on therapy

Coret, F et al. Multiple Sclerosis: 16(8) 935–941
AGGRESSIVE MS
AGGRESSIVE MS
Tumefactive MS

- Lesions larger than 2 cm
- May have edema, mass effect
- Enhancement typical
- 70% with MS at follow-up
- Median time to next event was 4.9 years
- Younger patients had more relapsing disease

Luchinneti, Brain (2008), 131, 1759^1775
TUMEFACTIVE MS
TUMEFACTIVE MS
TUMEFACITIVE MS: SOLITARY
Why MRI matters in treatment

Patients taking any interferon
MRI done after one year
Patients followed for EDSS up to 4 years

MRI lesions after one year predict future disability

<table>
<thead>
<tr>
<th>No. of New Lesions</th>
<th>Patients with Worsening Disability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5%</td>
</tr>
<tr>
<td>1</td>
<td>54%</td>
</tr>
<tr>
<td>2</td>
<td>73%</td>
</tr>
<tr>
<td>≥3</td>
<td>83%</td>
</tr>
</tbody>
</table>

Most lesions are clinically silent. MRI can show whether a medication is working. MRI recommended 6 months after medication change.
CASE I: STRAIGHTFORWARD

- 46 yo male
  - Noted red desaturation 6 years ago
  - Diagnosed 4 years ago after vertigo
- Started a DMT
- Full recovery from initial symptoms
- No further relapses
- No change on MRI
CASE I: POOR PROGNOSIS?

- Male
- Had spinal cord lesions at diagnosis and diagnosed with brainstem syndrome
- Despite some risk factors, no progression or relapses on first-line therapy
CASE II: MORE COMPLICATED

• 30 yo male
• Diagnosed after one week of bilateral hand weakness and numbness in his feet with L’hermitte’s sign
• History of blurry vision in the right eye 5 years previously
INITIAL MRI AT DIAGNOSIS
INITIAL SPINAL CORD MRI
TREATMENT HISTORY

• Started on a DMT but multiple steroid courses in the first year

• Switched to a second DMT, but MRI 6 months later showed multiple enhancing lesions

• Switched to another therapy and had good clinical response, but changed medications due to concern about risk
TREATMENT HISTORY

• On his 4th DMT, he again had breakthrough disease
• Changed to another medication, and again had significant breakthrough disease
• Starting his 6th DMT
BRAIN MRI ON 5TH DMT
MRI IN MONITORING

- It is easier to prevent than repair
- Gd+ lesions predict poor outcome
- MRI lesions 5-10 times more common than symptoms
- MRI 6 months after change of therapy to assess effectiveness
- Consider alternatives if active disease
CONCLUDING THOUGHTS

• MRI is a useful tool in diagnosis
  • There are many non-MS causes of WM lesions

• MRI can be useful in monitoring MS on treatment
  • New T2 lesions or enhancing lesions indicate disease activity
  • Disease activity predicts poor prognosis over time

• Initial MRI can help with treatment decisions
  • More aggressive MS may need more aggressive therapy
  • Spinal cord lesions, large lesion volume, and black holes indicate worse prognosis
QUESTIONS?