Masses of the Corpus Callosum

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Agenda

• Corpus Callosum Development and Anatomy
• Our Patient: Clinical Presentation
• Differential Diagnosis of Masses in the Corpus Callosum
  → Companion patients to illustrate imaging findings
• Our Patient’s Clinical Course
• Take Home Points
• Acknowledgements
• References
Corpus Callosum: The Basics

• Largest white matter structure in the brain
• Major inter-hemispheric pathway of association fibers
• Rich vasculature from the anterior cerebral, anterior communicating, and posterior cerebral arteries
Embryology of Corpus Callosum

- Corpus callosum forms in a ventral to dorsal fashion:
  - During 8\textsuperscript{th} week, the lamina reuniens of the neural tube forms a median groove named sulcus medianus telencephali medii (SMTM) starting ventrally and progressing dorsally
  - SMTM is infiltrated with cells in the 9\textsuperscript{th} week to form massa commisuralis
  - By 11-12 weeks, initial callosal fibers are induced to enter massa commisuralis
  - Definite CC formed by 12-13 weeks with continued growth from genu to splenium
  - Rostrum forms last at 18-20 weeks

Representative cross-sections of neural tube depicting corpus callosum development

Barkovich, AJ and David Norman. “Anomalies of the corpus callosum: Correlation with further anomalies of the brain.”
Corpus Callosum Anatomy on Sagittal View

Sagittal illustration of midline of brain

C- sagittal head MRI T1WI

Salzman, Karen L. “White matter tracts.”

Baumgardner, TL et al. “Corpus callosum morphology in children with Tourette syndrome and attention deficit hyperactivity disorder”
Corpus Callosum Anatomy on Axial View

Axial illustration of corpus callosum

C- axial head MRI T1WI

Salzman, Karen L. “White matter tracts.”
Our Patient: Clinical History

• Our patient is a 79yo female with history of lung cancer status-post left lobectomy 12 years ago who presents to outside hospital with 5-day history of increasing confusion, disorientation, and unsteady gait
• Reports 5 month history of weight loss; denies headache, vision changes, or hearing changes
• Some improvement in confusion with UTI treatment
• Non-contrast head CT was concerning for mass in the corpus callosum
Before viewing the head CT of our patient, let’s look at the ACR Appropriateness Criteria for imaging of a patient presenting with unexplained acute confusion or altered level consciousness
### Variant 5: Unexplained acute confusion or altered level of consciousness.

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<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
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<tr>
<td>MRI head without and with contrast</td>
<td>8</td>
<td>Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses. See statement regarding contrast in text under &quot;Anticipated Exceptions.&quot;</td>
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<td>MRI head without contrast</td>
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<td>CT head without contrast</td>
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<td>NRA head and neck without and with contrast</td>
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<td>See statement regarding contrast in the text below under &quot;Anticipated Exceptions.&quot;</td>
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<td>NRA head and neck without contrast</td>
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<td>For suspected vascular abnormality.</td>
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<td>CTA head and neck with contrast</td>
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<td>If MRI is unavailable or contraindicated. Consider CT perfusion.</td>
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<td>CT head without and with contrast</td>
<td>5</td>
<td>If MRI is unavailable or contraindicated. Consider CT perfusion.</td>
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<td>CT head with contrast</td>
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<td>O</td>
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<td>MRI functional (fMRI) head without contrast</td>
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<td>MR spectroscopy head without contrast</td>
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<td>FDG-PET/CT head</td>
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<td>Tc-99m HMPAO SPECT head</td>
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<td>Thallium-201 SPECT head</td>
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<td>CT head perfusion with contrast</td>
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<td>MRI head perfusion with contrast</td>
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<td>Arteriography cervicocerebral</td>
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**Rating Scale:** 1, 2, 3 Usually not appropriate; 4, 5, 6 May be appropriate; 7, 8, 9 Usually appropriate

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Now that we know the imaging recommendations for a patient presenting similar to our patient, let’s view our patient’s initial head CT
Our patient: Initial Head CT

- Single irregularly lobulated, hypodense mass in the body and splenium of the corpus callosum and septum pellucidum.
- No fat density, high density blood, or calcifications are seen.
Let’s continue to view a differential diagnosis for a mass in the corpus callosum
Mass in Corpus Callosum: Differential Diagnosis

- Glioblastoma Multiforme
- Anaplastic Astrocytoma
- Primary CNS lymphoma
- Secondary Brain Metastasis
- Lipoma
- Tumefactive Multiple Sclerosis
- Infarct (rare)
Now that we have a list of differential diagnoses, let’s continue to learn about each of the entities listed on our differential (except for infarction) and their imaging findings with the help of companion patients.
Glioblastoma Multiforme: The Basics

• Rapidly growing, malignant astrocytic tumor (WHO grade IV) with poorly defined borders
  – Necrosis and neovascularity are hallmarks
  – Often see hemorrhage and cysts
  – Primary origin (90%) or secondary origin (10%, degeneration from lower grade tumor)
  – Frequently found in supratentorial white matter
    • Disseminates along white matter tracts

• Epidemiology and Natural History:
  – Most common primary brain tumor
    • ~15% of all intracranial neoplasms
    • Peak incidence at 45-75 years old
  – Symptoms vary depending on tumor location
  – Median survival of 1.6 months (>80 years) and 8.6 months (<50 years)

Rees, JH et al. “Glioblastoma multiforme: Radiologic-pathologic correlation.”
Zhang, X et al. “Glioblastoma multiforme: Molecular characterization and current treatment strategy (Review).”
Glioblastoma Multiforme: Imaging Findings

• CT characteristics:
  – Irregular isodense or hypodense mass with areas of hypodense necrosis and surrounding vasogenic edema
  – Hemorrhage may be seen
  – Heterogenous ring-enhancement

• MRI Characteristics:
  – T1-weighted
    • Irregular isointense to hypointense mass
    • Necrosis and thick irregular margins are common
    • Hemorrhage and cysts may be visualized
  – T1-weighted with contrast
    • Irregular enhancement with ring enhancement around central necrosis
  – T2-weighted
    • Heterogenous and hyperintense mass with surrounding vasogenic edema
    • Necrosis, hemorrhage, cysts, and flow-voids may be seen
  – DWI
    • Cellular components of the mass can show restricted diffusion

Rees, JH et al. “Glioblastoma multiforme: Radiologic-pathologic correlation.”
Zhang, X et al. “Glioblastoma multiforme: Molecular characterization and current treatment strategy (Review).”
Companion Patient 1: Glioblastoma on Sagittal MRI

- Poorly circumscribed, heterogeneous hypointense mass in splenium
- Adjacent vasogenic edema

Gaillard, F et al. “Glioblastoma multiforme.”
Companion Patient 1: Glioblastoma on Axial MRI

C⁻ axial head MRI T1WI
  - High signal intensity
  - Surrounding vasogenic edema

C⁺ axial head MRI T1WI
  - Irregular enhancement

Gaillard, F et al. “Glioblastoma multiforme.”
Companion Patient 1: Glioblastoma
Diffusion Restriction

Gaillard, F et al. “Glioblastoma multiforme.”
Anaplastic Astrocytoma: The Basics

• Diffusely infiltrating astrocytoma (WHO grade III)
  – No necrosis or microvascular proliferation
  – Cysts and hemorrhage are rare
  – Can progress to secondary glioblastoma multiforme
  – Commonly in frontal or temporal lobe white matter
    • Spreads along white matter

• Epidemiology and Natural History:
  – 1/3 of all astrocytomas
    • Peak incidence at 40-50 years old
  – Symptoms vary depending on tumor location
  – Median survival is 2-3 years

Weerakkody, Y and Gaillard, F et al. “Anaplastic Astrocytoma.”
Anaplastic Astrocytoma: Imaging Findings

• CT Characteristics:
  – Poorly defined, hypodense mass
  – Typically non-enhancing

• MRI Characteristics:
  – T1-weighted
    • Heterogenously isointense and hypointense mass
  – T1-weighted with contrast
    • Typically no enhancement
  – T2-weighted
    • Heterogenously hyperintense mass
  – DWI
    • No typical diffusion restriction

Saizman, Karen L. “Anaplastic astrocytoma.”
Weerakkody, Y and Gaillard, F et al. “Anaplastic Astrocytoma.”
Companion Patient 2: Anaplastic Astrocytoma on T1 MRI

- Heterogenous hypointense mass involving left thalamus and splenium
- Increased signal likely due to hemorrhagic material

Weerakkody, Y and Gaillard, F et al. “Anaplastic Astrocytoma.”
Companion Patient 2: Anaplastic Astrocytoma on T2 MRI

- Predominantly increased signal intensity
- Cystic foci within the mass and
- No surrounding vasogenic edema

Secondary Brain Metastasis: The Basics

• Hematogenous spread of primary cancer outside CNS, most commonly lung, breast, and melanoma
  – Typically well-circumscribed lesions at gray-white junction
  – 20-30% of patients have solitary metastasis while ~70% have multiple metastases (some can have bony metastases)

• Epidemiology and Presentation
  – Brain metastasis in 25% of patients with systemic cancer
  – Symptomatic patients can have focal or nonfocal signs
    • Most common presenting symptom is headache and most common presenting sign is altered mental status

Chamberlain, Marc C. “Brain metastases: A medical neuro-oncology perspective.”
Secondary Brain Metastasis: Imaging Findings

- **CT Characteristics**
  - Hypodense lesion(s), typically at the gray-white interface, that enhance

- **MRI Characteristics**
  - T1-weighted
    - Isointense/hypointense lesions
  - T1-weighted with contrast
    - Variable patterns of strong enhancement
  - T2-weighted
    - Varied signal depending on nuclear to cytoplasmic ratio
    - Surrounding vasogenic edema

Khosla, A et al. "Brain metastasis imaging."
Companion Patient 3: Secondary Brain Metastasis on Axial MRI Findings

- Hypointense metastasis in corpus callosum in patient with lung cancer
- Thick, irregular enhancement of mass

Foster, KA et al. "Metastatic small cell carcinoma as a "butterfly" tumor of the corpus callosum."
Lipoma: The Basics

• Congenital, benign fatty lesion
  – Usually found in or near the midline
  – Often associated with other brain malformations, most commonly corpus callosum anomalies

• Typically asymptomatic presentation and incidentally discovered
  – Can be associated with seizures

Jabot, G et al. "Intracranial lipomas: clinical appearances on neuroimaging and clinical significance."
Lipoma: Imaging Findings

• CT Characteristics:
  – Non-enhancing fat density mass

• MRI Characteristics:
  – T1-weighted
    • Hyperintense mass
  – T1-weighted fat suppression
    • Hypointense mass
  – T2-weighted
    • Intermediate fat-intensity mass

Jabot, G et al. "Intracranial lipomas: clinical appearances on neuroimaging and clinical significance."
Companion patient 4: Lipoma on Axial MRI

- Anterior midline hyperintense mass
- Absent corpus callosum

Weerakkody, Y and Desai, PK et al. “Pericallosal lipoma.”
Primary CNS Lymphoma

• Malignant neoplasm, typically non-Hodgkin type with B-cell origin
  – ~80% have supratentorial, periventricular location and commonly involve the corpus callosum

• Epidemiology
  – 1-5% of all primary brain tumors
  – Age of onset typically >50 years old
  – Increased risk in immunocompromised patients

Haldorsen, IS et al. “Central nervous system lymphoma: Characteristic findings on traditional and advance imaging.”
Primary CNS Lymphoma

• CT characteristics:
  – Isodense to hyperdense lesion with moderate, uniform enhancement

• MRI characteristics:
  – T1-weighted
    • Homogenously hypointense lesion
  – T1-weighted with contrast
    • Homogenously enhancing lesion
  – T2-weighted
    • Homogenous, hypointense signal in immunocompetent
    • Surrounding vasogenic edema
    • Heterogenous signal in immunocompromised
  – DWI
    • Restricted diffusion of lesion

Haldorsen, IS et al. “Central nervous system lymphoma: Characteristic findings on traditional and advance imaging.”
Companion Patient 5: Primary CNS Lymphoma on CT and MRI

C- axial head CT
- Hyperdense mass in the splenium
- Surrounding vasogenic edema

C- axial head MRI T1WI
- Homogenously hypointense mass
Companion Patient 5: Primary CNS Lymphoma on Axial MRI

C+ axial head MRI T1WI
-Homogenously intense enhancement

C- axial head MRI T1WI
-Fairly uniform, hypointense signal
Let’s continue to view the imaging characteristics of primary CNS lymphoma diffusion restriction with the help of a different companion patient with primary CNS lymphoma.
Companion Patient 6: Primary CNS Lymphoma Diffusion Restriction

- Homogenously restricted diffusion in mass

Weerakkody, Y and Gaillard, F et al. “Primary CNS Lymphoma.”
Tumefactive Multiple Sclerosis

- Solitary demyelinating lesions >2cm that mimic neoplasm on imaging
  - Typically supratentorial in white matter without mass effect or edema
- Epidemiology and Presentation:
  - Most common in females
  - Median age 37yo
  - Frequently have focal, sudden onset deficits

Given II, CA et al. “The MRI appearance of tumefactive demyelinating lesions.”
Tumefactive Multiple Sclerosis

- MRI Characteristics
  - T1-weighted
    - Hypointense, generally well-circumscribed lesion
  - T1-weighted with contrast
    - Partial ring-enhancement, often with central vessel
  - T2-weighted
    - Hyperintense lesion, often surrounding a vein

- Look for other lesions that may be indicative of MS

Given II, CA et al. “The MRI appearance of tumefactive demyelinating lesions.”
Companion Patient 7: Tumefactive Multiple Sclerosis on MRI

- Heterogeneously enhancing lesion in splenium
- High signal intensity of lesion
- Other white matter lesions supportive of demyelinating process

Now that we have learned about the imaging findings for the diagnoses listed on our initial differential, let’s return to our patient
Returning to Our Patient

• Our patient was transferred to BIDMC for workup of a corpus callosum mass that was hypointense on non-contrast CT

• Further characterization of the lesion was obtained using MRI with and without contrast
Our Patient: Findings on T1 MRI

- Heterogeneous, hypointense mass involving body and splenium of the corpus callosum and the septum pellucidum
Our Patient: Findings on Axial T1 and T2 MRI

C+ axial head MRI T1WI
- Heterogeneously intense enhancement
- Low intensity areas may be necrosis

C- axial head MRI T2 FLAIR
- Heterogeneous high signal intensity
- Surrounding vasogenic edema
Our Patient: Findings on Diffusion Restriction Imaging

C- axial head MRI DWI
-Moderately restricted diffusion

C- axial head MRI ADC
-Moderately restricted diffusion
Our Patient CS: Final Diagnosis

• Differential diagnosis based on the patient’s lesion location, imaging characteristics, clinical presentation, and age:
  – *Primary consideration* was glioblastoma multiforme.
  – *Secondary considerations* included primary CNS lymphoma and CNS metastasis

→ Biopsy confirmed **WHO grade IV Glioblastoma Multiforme**

• Patient passed away prior to treatment
Take Home Points

• Non-contrast head CT is appropriate initial imaging for patients presenting with unexplained acute confusion/altered consciousness and head MRI is appropriate for further evaluation

• CT and MRI, in conjunction with clinical history, help narrow differential for masses in the corpus callosum

• Definitive diagnosis of corpus callosum masses often requires biopsy
Acknowledgements

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References

References