Meningiomas
Qateeb Khan, M.D.
Introduction to ACRODeck

- The goal of ACRODeck is to introduce standard treatments of oncologic malignancies for early radiation oncology residents.

- Please note that there is often considerable variation in standard treatment recommendations.

- Moreover, the landscape of oncology is ever-changing; for practice changing landmark studies and feedback, please email: resident@acro.org.
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Clinical Presentation and Differential Diagnosis

- As with any CNS lesion, the location of the lesion will determine the clinical presentation
  - Meningiomas are commonly found in supratentorial areas of dural reflection
  - While they can be found incidentally and be asymptomatic, symptoms may include neurologic deficits, headaches, altered mental status, motor and sensory deficits, nausea and vomiting

- Differential Diagnosis:
  - Glioma
  - Ependymoma
  - Lymphoma
  - Brain metastasis
  - Intracranial abscess
  - Empyema
  - Multiple sclerosis

Meningiomas are the most common primary brain tumor, accounting for about 40% of cases
Initial Workup

- H/P
- CBC and CMP
- CT Head with contrast
- MRI brain with and without contrast (obtain one within 48 hours after surgery as well)
  - Classic findings: **Well-circumscribed, homogenously contrast enhancing, dural based, extra-axial mass with a dural tail**

<table>
<thead>
<tr>
<th>MRI Sequence</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Usually isointense</td>
</tr>
<tr>
<td>T1c</td>
<td>Intense homogeneous enhancement</td>
</tr>
<tr>
<td>T2 / FLAIR</td>
<td>Usually isointense</td>
</tr>
</tbody>
</table>

- If symptomatic, consider steroids and anti-epileptics
- If symptomatic and/or concern for a higher grade, a maximal safe resection may be indicated

Meningiomas are a radiologic diagnosis: if there is uncertainty, an octreotide scan can be considered.

Radiopaedia

**MRI Sequence Appearance**

- T1 Usually isointense
- T1c Intense homogeneous enhancement
- T2 / FLAIR Usually isointense
Staging

- Primary CNS tumors are graded, not staged

<table>
<thead>
<tr>
<th>WHO Grade</th>
<th>Example of Subtypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Meningothelial and Fibrous</td>
</tr>
<tr>
<td>2</td>
<td>Atypical, Chordoid, Clear Cell</td>
</tr>
<tr>
<td>3</td>
<td>Anaplastic, Papillary, Rhabdoid</td>
</tr>
</tbody>
</table>
Pathology

- Per CNS WHO 2021, a total of 15 subtypes of meningioma are recognized
  1. Meningothelial meningioma
  2. Fibrous meningioma
  3. Angiomatous meningioma
  4. Lymphoplasmacytic-rich meningioma
  5. Metaplastic meningioma
  6. Microcystic meningioma
  7. Psammomatous meningioma
  8. Secretory meningioma
  9. Transitional meningioma
  10. Atypical meningioma
  11. Chordoid meningioma
  12. Clear cell meningioma
  13. Anaplastic meningioma
  14. Papillary meningioma
  15. Rhabdoid meningioma

The meningothelial subtype accounts for 60% of all meningiomas.
Treatment Summary: Meningiomas

- **Radiographic Diagnosis of a Meningioma**
  - Small, Asymptomatic, Slow Growing
  - Others (surgically inaccessible)
  - Others (surgically accessible)

- **Observation**

- **Surgery**
  - Maximal Safe Resection

- **Radiotherapy**
  - Fractionated EBRT or SRS

- **Radiotherapy**
  - 54 – 60 Gy / 30 fx

Dependent on grade and extent of resection
Observation

- Observation can be done for WHO grade 1 meningiomas that are:
  - Asymptomatic
  - In a non-eloquent location
  - Less than 3 cm in size

- Growth rate is estimated at 1 – 2 mm / year
Surgery

If definitive treatment is preferred, surgery is the mainstay

- A maximal safe resection is typically indicated

- The extent of resection has been graded via the Simpson System

<table>
<thead>
<tr>
<th>Grade</th>
<th>Extent of Resection</th>
<th>Recurrence Rate at 5 Years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>GTR, including dural attachment and bone plus stripping of 2-4-cm dura</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>GTR, including dural attachment and any abnormal bone</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>GTR, with coagulation instead of resection of dural attachment</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>GTR of meningioma without resection or coagulation of dural attachment</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>Subtotal resection</td>
<td>44</td>
</tr>
<tr>
<td>5</td>
<td>Tumor debulking or decompression only</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Chemotherapy

There is no upfront role for systemic therapy in meningiomas

- Sunitinib, bevacizumab, bevacizumab + everolimus, and somatostatin analogues (octreotide) may be useful in certain progressive and treatment refractory situations
Radiation

Simulation
- CT head without contrast
- Brain MRI with and without contrast
- Face mask

Volumes
- **GTV** = tumor + post-op bed
  - Seen best on the T1c MRI; no edema is included
- **CTV** = 0.5 – 3 cm expansion
  - NCCN states 0.5 – 2 cm for grade 2 meningiomas, and 2 – 3 cm for grade 3 meningiomas
  - Recent NRG trials have trended towards smaller expansions
- **PTV** = 0.3 – 0.5 cm expansion

Inclusion of the dural tail and/or hyperostotic bone is of some debate
- Recent protocols do not specify inclusion of the dural tail
- Inclusion of hyperostosis is often done due to high rate of bone involvement

PMID: 33309848 (ESTRO ACROP)
- Cavernous sinus meningioma (red)
- Left optic nerve (lime green)
- Right optic nerve (yellow)
- Right hippocampus (purple)
- Left hippocampus (gold)
Fractionated Radiation Dosing Example

Modern radiation techniques (IMRT, VMAT, SRS, and protons) are often utilized to minimize toxicities.

<table>
<thead>
<tr>
<th></th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTR</td>
<td>Observation</td>
<td>54/30</td>
<td>60/30</td>
</tr>
<tr>
<td>STR</td>
<td>Observation</td>
<td>60/30</td>
<td>60/30</td>
</tr>
<tr>
<td>Recurrent</td>
<td>54/30</td>
<td>60/30</td>
<td>60/30</td>
</tr>
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</table>
SRS Dosing Example

If OAR dose constraints cannot be met for a single fraction approach, occasionally a 5-fraction treatment can be utilized.

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<tr>
<th></th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Fraction Dose</td>
<td>12 - 16 Gy</td>
<td>16 – 20 Gy</td>
<td>N/A</td>
</tr>
<tr>
<td>Five Fraction Dose</td>
<td>25 – 30 Gy</td>
<td>27.5 – 30 Gy</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Selected CNS Dose Constraints

<table>
<thead>
<tr>
<th>Organ at Risk (OAR)</th>
<th>Fractionated Radiation Dose Constraint (Gy)</th>
<th>1 Fraction Radiation Dose Constraint (Gy)</th>
<th>5 Fraction Radiation Dose Constraint (Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optic Nerves and Chiasm</td>
<td>Max &lt; 54 – 60</td>
<td>Max &lt; 8 – 10</td>
<td>Max &lt; 25</td>
</tr>
<tr>
<td>Brainstem</td>
<td>Max &lt; 54 - 60</td>
<td>Max &lt; 12 - 14</td>
<td>Max &lt; 30</td>
</tr>
</tbody>
</table>

PMID: 33864823
Radiation Toxicities

- **Acute:**
  - Fatigue
  - Alopecia
  - Nausea
  - Skin erythema

- **Chronic:**
  - Swelling
  - Radionecrosis
  - **Location-Dependent:** for example, meningiomas of the cavernous sinus (located just medial to the hippocampus) may carry a higher risk of cognitive decline
Prognosis

- Meningiomas have a prolonged natural history
  - Many can be observed; those that are treated either with surgery and/or radiation have excellent rates of local control
  - However, higher-grade tumors (i.e.: anaplastic meningiomas) can be quite devastating in terms of their local growth
Review
Review #1: Imaging

What is the most appropriate MR imaging study to visualize a meningioma?

(A) T1
(B) T1c
(C) T2
Review #2: Pathology

Which histological variant is classified as a grade 3 meningioma?

(A) Clear cell
(B) Choroid
(C) Rhabdoid
Review #3: Systemic Therapy

Which systemic agent has shown efficacy in a phase II trial and has a NCCN category 2B recommendation for meningiomas?

(A) Sunitinib
(B) Imatinib
(C) Temozolomide
(D) PCV
Review #4: SRS Dosing

Which of the following is an appropriate marginal dose for single fraction SRS for a WHO Grade 1 meningioma?

(A) 8 Gy  
(B) 14 Gy  
(C) 18 Gy  
(D) 24 Gy
Review #5: Fractionated Radiation Dosing

Which of the following is a reasonable dose range for a recurrent grade 1 meningioma?

(A) 12 – 16 Gy  
(B) 30 – 36 Gy  
(C) 50.4 – 54 Gy  
(D) 60 – 66 Gy
NRG BN-003 is exploring omission of radiation following a GTR of a WHO Grade 2 meningioma