Meningiomas: Update on Treatment and Care

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Overview

- Incidence
- Risk Factors
- Classification
- Presenting Symptoms
- Imaging Modalities
- Surgery
- Radiotherapy
- Medical Therapy
- Future Advances
Origin

Meningiomas arise from the dura (the outer-most protective layer of the brain)
Incidence

- Meningiomas represent 36% of all primary brain tumors (25,610 per year)
- More common in women (3:1)
- Average age = 63 years
## Incidence

<table>
<thead>
<tr>
<th>Age</th>
<th>Most Common Brain Tumor</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>Embryonal Tumors</td>
<td>1.23</td>
</tr>
<tr>
<td>5-9</td>
<td>Pilocytic Astrocytoma</td>
<td>0.96</td>
</tr>
<tr>
<td>10-14</td>
<td>Pilocytic Astrocytoma</td>
<td>0.85</td>
</tr>
<tr>
<td>15-19</td>
<td>Tumors of the Pituitary</td>
<td>1.50</td>
</tr>
<tr>
<td>20-34</td>
<td>Tumors of the Pituitary</td>
<td>2.97</td>
</tr>
<tr>
<td>35-44</td>
<td>Meningioma</td>
<td>4.66</td>
</tr>
<tr>
<td>45-54</td>
<td>Meningioma</td>
<td>8.79</td>
</tr>
<tr>
<td>55-64</td>
<td>Meningioma</td>
<td>14.35</td>
</tr>
<tr>
<td>65-74</td>
<td>Meningioma</td>
<td>25.08</td>
</tr>
<tr>
<td>75-84</td>
<td>Meningioma</td>
<td>37.49</td>
</tr>
<tr>
<td>85+</td>
<td>Meningioma</td>
<td>49.48</td>
</tr>
<tr>
<td><strong>OVERALL</strong></td>
<td><strong>Meningioma</strong></td>
<td><strong>7.61</strong></td>
</tr>
</tbody>
</table>
Risk Factors

- **Definite**
  - Higher level radiation (Israeli experience)
  - Genetic disorders (Neurofibromatosis 2)

- **Possible**
  - Lower level radiation (dental X-rays, cell phones)
  - Head trauma (concussion)
  - Breast cancer association
  - Allergies (protective effect)
Classification: *By Distribution*

<table>
<thead>
<tr>
<th>Location</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convexity</td>
<td>30%</td>
</tr>
<tr>
<td>Midline</td>
<td>27%</td>
</tr>
<tr>
<td>Skull Base</td>
<td>43%</td>
</tr>
</tbody>
</table>

Incidence of multiple meningiomas = 8%
# Classification: By Pathology

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Benign</td>
</tr>
<tr>
<td>II</td>
<td>Atypical</td>
</tr>
<tr>
<td>III</td>
<td>Malignant</td>
</tr>
</tbody>
</table>
Classification: By Genetics

- Loss of the NF2 gene is found in ~50% of sporadic meningiomas
**Presenting Symptoms**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>70%</td>
</tr>
<tr>
<td>Seizure</td>
<td>54%</td>
</tr>
<tr>
<td>Cognitive</td>
<td>52%</td>
</tr>
<tr>
<td>Weakness</td>
<td>43%</td>
</tr>
<tr>
<td>Speech</td>
<td>27%</td>
</tr>
<tr>
<td>Sensation</td>
<td>14%</td>
</tr>
<tr>
<td>Vision</td>
<td>6%</td>
</tr>
</tbody>
</table>
External Signs
Imaging Modalities: CT Scan

Calcium
Imaging Modalities: MRI Scan

Imaging in multiple planes
Imaging Features: Location

Inside the skull but outside the brain
Imaging Features: *Enhancement*

Strong enhancement with intravenous dye
Imaging Features: *Brain Edema*

Tumor and surrounding edema increase brain pressure
Imaging Features: *Blood Supply*

Meningiomas have a rich blood supply
Angiography and Embolization

Tumor arteries can be occluded prior to surgery to reduce blood loss

Pre-embolization

Post-embolization
Treatment Options

- Observation
- Surgery
- Radiation
- Medical Therapy
Observation

- Appropriate for patients w/o symptoms
- Regular MRI scans every 6 – 12 months
- Natural history of meningiomas
  - No change 70%
  - Tumor growth 30%
Rationale for Surgery

- **Pathology**
  - Confirms diagnosis and grade of tumor
  - Special studies (hormone receptors)

- **Neurologic**
  - Improves neurological status
  - Prevents future deterioration

- **Outcome**
  - Complete removal can be curative
What Factors Influence the Decision to Undergo Surgery?

<table>
<thead>
<tr>
<th>Tumor</th>
<th>Patient</th>
<th>Surgeon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Age</td>
<td>Ability</td>
</tr>
<tr>
<td>Size</td>
<td>Neurologic status</td>
<td>Experience</td>
</tr>
<tr>
<td>Brain swelling</td>
<td>Medical condition</td>
<td>Resources</td>
</tr>
<tr>
<td>Eloquent areas</td>
<td>Patient choice</td>
<td></td>
</tr>
<tr>
<td>Invasiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presumed grade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Surgical Pre-Planning

Provides a preoperative roadmap for the neurosurgeon

Foot Movement

Hand Movement

Tumor
Computer-Guided Surgery
Craniotomy for Meningioma Removal

Burr hole

Craniotomy

© Mayfield Clinic
Meningioma Surgery Case Study

- 59 year-old woman with a long history of migraines headaches. Headaches increased in frequency and severity which prompted an MRI scan.

- Neurologic Exam: normal
Preoperative MRI
Meningioma Exposure

- Skull
- Tumor
- Dura

- Skull
- Tumor
Meningioma Removal

Brain

Tumor

Vein

Tumor Cavity
Meningioma Specimen

Tumor

Dura
Limitations of Surgery

- **Vascular structures**
  - Arteries
  - Veins

- **Eloquent areas**
  - Optic nerve
  - Cranial nerves
  - Motor/Sensory/Language/Visual

- **Highly Invasive or Multiple Meningiomas**
Risks of Surgery

- **Neurologic**
  - Bleeding
  - Brain swelling
  - Seizures
  - Stroke

- **Regional**
  - Wound infection
  - Wound breakdown

- **General**
  - Anesthetic complications
  - Heart/Lungs
  - Urine infection
  - Blood clots
Types of Radiation

ENERGY LEVEL

High

Low

Meningioma Radiation
Tumor DNA is the Target of Radiation
Radiation delivers energy to the tumor cell DNA.

Radiation

H₂O

free radical

American Brain Tumor Association
Providing and pursuing answers®
Which damages the DNA
Radiation damages both normal and tumor cells.
Tumor cells are unable to repair damage (normal brain cells are able)

- Repaired: Normal brain cell
- Unrepaired: Tumor cell
Common Radiation Machines

True Beam

Novalis

Cyberknife

Gamma Knife
Radiosurgery

- High dose
- 1-5 sessions
- Tight treatment area

Radiotherapy

- Low dose
- 6-33 sessions
- Margin of normal brain
Indications for Radiation

- Inoperable meningiomas
- After surgery for incompletely removed meningiomas
- After surgery for malignant meningioma
- Recurrent tumors after previous surgery
- Co-existing medical problems that preclude surgery
- Patient choice
Inoperable
Incomplete Removal
Malignant Meningioma
Recurrent Meningioma
Co-existing Medical Problems or Patient Choice
Results of Radiation for Meningioma

- 90% likelihood of controlling a meningioma with radiation

- **Rule of Threes**
  - Tumor unchanged 30%
  - Minor shrinkage 30%
  - Major shrinkage 30%

- May not reverse neurological symptoms (e.g., visual loss)
Tumor Response after Radiosurgery

Tumor Unchanged

Minor Shrinkage
Side Effects of Radiation

- Fatigue
- Hair Loss
- Scar Tissue
- Second Tumor
Medical Therapy: *Indications*

- Recurrent meningioma after previous surgery and radiation
- Multiple meningiomas
- Diffuse meningiomas
Recurrent Meningioma

2009

2012

2014
Multiple Meningiomas
Diffuse Meningioma
Approved Medical Therapies

Hydroxyurea
- Oral
- Promotes cell death pathway

Alpha Interferon
- Injection
- Inhibits tumor blood vessels

Sandostatin
- Injection
- Works through hormone receptors
**Future Advances: Clinical Trials**

- **Standard agents**
  - Hydroxyurea, Alpha Interferon, Sandostatin
  - Usually combined with another drug

- **Targeted biologic agents**
  - Everolimus (Afinitor)
  - Bevacizumab (Avastin)
  - Sunitinib (Sutent)
  - And more…
Future Advances: NovoTTF

- Alternating electrical currents disrupt tumor cell division
- Greater benefit for high-grade meningiomas
Questions?