SPINE SBRT

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**Clinical Presentation**

- 62-year-old gentleman with a history of metastatic follicular thyroid cancer with bony metastasis, diagnosed 11y ago.
- S/p thyroidectomy as well as multiple courses of radioactive iodine therapy
  - Now with rising thyroglobulin level
  - Known to have a lesion in T7 which had been stable up until recent MRI, when there was evidence of epidural progression
  - Clinically, he denied any problems with bladder or bowel control, back pain, weakness and numbness of the extremities or numbness in the torso
Pearls

- Metastases are diagnosed in ~40% of cancer patients and are the most common spine tumors.
  - Autopsy studies suggest 30-90% of cancer pts may have metastasis in the spine (1)
- Most common presenting symptom is pain,
  - Also possible are upper/lower extremity weakness, numbness, or incontinence of bladder or bowel.
- Local anatomy - based on Intl. Spine Radiosurgery Consortium anatomic classification (2):
  - Vertebra divided into 6 sectors:
    - 1- Vertebral body
    - 2- L pedicle
    - 3- L transverse process
    - 4- Spinous process
    - 5- R transverse process
    - 6- R pedicle
Workup

• H&P focused on pain and neurologic function
• Basic Labs: CBC, CMP
• Imaging workup:
  • MRI of the spine w/wo contrast, and/or CT myelogram
    • MRI- Sagittal T1 and STIR, Axial T2 for evaluation of epidural disease, Volumetric T1 and T2 for treatment planning, and post-Gad T1 for evaluation of leptomeninges
    • CT myelogram to evaluate epidural disease, especially in postoperative patients with spinal hardware

• Consider biopsy to confirm metastases in pts w/o prior pathologic diagnosis
  • Tissue can be obtained at the time of surgical decompression if planned.
History and Physical

• **PMH:**
  - 1. History of hypertension.

• **Fam. Hx:**
  - No FHx of cancer

• **Soc. Hx:**
  - No smoking, drinking, drug use

• **Meds:**
  - 1. Pravastatin.
  - 4. Stool softener.
  - 5. Allegra.
  - 6. Ranitidine.
  - 7. Centrum Adult Silver.

• **Allergies:**
  - 1. Fish.
  - 2. Sulfa Drugs

• **Physical Exam:**
  - General:
    - General condition was good. KPS is 90. No pallor or jaundice.
  - HEENT:
    - Normocephalic. No abnormal masses in the head or neck region.
  - Vital signs:
  - Extremities:
    - No ankle edema or calf swelling.
  - Neurological:
    - No focal neurologic in the upper or lower extremities. Cranial nerves were intact. No sensory level in the torso.
  - Mental status examination:
    - Alert and oriented x3. Speech was coherent.
  - Abdomen:
    - No organomegaly or ascites.
  - Musculoskeletal:
    - No spinal tenderness or tenderness in the pelvis.
  - Chest:
    - Good air entry to both lungs. No crepitation.
  - Cardiovascular:
    - First and second heart sounds were normal. No murmurs, rubs.
  - Lymphatic:
    - No cervical, supraclavicular, or axillary adenopathy.
Imaging Studies - CT
Imaging Studies - MRI
General Principles - Criteria for SBRT

**Inclusion:**
- Spinal or paraspinal metastasis
  - Radioresistant histology
  - Failure of prior EBRT
  - Oligometastatic or bone-only metastatic disease
- 3 or fewer involved spine segments
- Stable spinal column
  - Calculate Spinal Instability Neoplastic Score (SINS score)
- Low grade epidural disease
  - Utilize Bilsky grade
- Limited extra-spinal systemic disease
- Life expectancy >3 months
- KPS > 40-50

**Exclusion:**
- Unstable spine requiring stabilization
- Previous SBRT to lesion
- EBRT within 90 days
- Worsening neurologic deficit
- Inability to lie flat on table
- <3-month life expectancy
- Spinal canal compromise >25%
- Inability to have MRI
- Receiving radiosensitizing chemotherapy

Adapted from ASTRO guidelines(3)
### Bilsky Grading

<table>
<thead>
<tr>
<th>Bilsky Grade</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Absence of epidural disease</td>
</tr>
<tr>
<td>1a</td>
<td>Impingement without deformation of thecal sac</td>
</tr>
<tr>
<td>1b</td>
<td>Impingement and deformation of the thecal sac</td>
</tr>
<tr>
<td>1c</td>
<td>Deformation of the thecal sac with abutment of the spinal cord</td>
</tr>
<tr>
<td>2</td>
<td>Epidural spinal cord compression with visible cerebrospinal fluid (CSF)</td>
</tr>
<tr>
<td>3</td>
<td>Epidural spinal cord compression without visible CSF</td>
</tr>
</tbody>
</table>

Adapted from Bilsky et al. (4)
## SINS scoring

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td><strong>Junctional</strong> <em>(Occiput-C2, C7-T2, T11-L1, L5-S1)</em></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>C3-C6, L2-L4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>T3-T10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>S2-S5</td>
<td>0</td>
</tr>
<tr>
<td><strong>Pain</strong></td>
<td>Yes, positional or load-bearing</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Yes, non-mechanical</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td><strong>Bony Lesion Type</strong></td>
<td>Lytic lesion</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Mixed lytic/blastic</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Blastic lesion</td>
<td>0</td>
</tr>
<tr>
<td><strong>Radiographic spinal appearance</strong></td>
<td>Subluxation/translation</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>De novo kyphosis/scoliosis/lordosis</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Normal alignment</td>
<td>0</td>
</tr>
<tr>
<td><strong>Vertebral Body Collapse</strong></td>
<td>&gt;50% collapse</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>&lt;50% collapse</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>No collapse, but &gt;50% of VB involved</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Absence of above</td>
<td>0</td>
</tr>
<tr>
<td><strong>Posterolateral involvement of spinal canal</strong></td>
<td>Facet / Pedicle / costovertebral joint fracture or replacement with tumor</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Bilateral</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Unilateral</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td></td>
</tr>
<tr>
<td><strong>Summation</strong></td>
<td>Stable</td>
<td>0-6</td>
</tr>
<tr>
<td></td>
<td>Potentially stable – Neurosurgical consultation</td>
<td>7-12</td>
</tr>
<tr>
<td></td>
<td>Unstable – Neurosurgical consultation</td>
<td>13-18</td>
</tr>
</tbody>
</table>

Adapted from Fisher et al. (5)
Simulation*:

- Immobilization using long head and neck thermoplastic mask for lesions above T4
- Utilize dual vacuum system (Body FIX) for LINAC, or vacuum cushion for CyberKnife for lesions T4 or below
- Obtain diagnostic Volumetric MRI for fusion with planning CT scan
- Obtain CT myelogram if metallic hardware hinders visualization of the spinal cord
- Planning CT performed w/o contrast, 1.0 - 1.25mm slices

* Per institutional preferences and standards
Target Delineation

CTV is defined as whole vertebral body +/- pedicles +/- posterior elements
  Exception is tumors located primarily in the posterior elements

Need to include all epidural and paraspinal involvement

Postoperative cases should take into account the pre-operative extent of involvement

Utilize the consensus contouring guidelines published in IJROBP by Cox et al. (2) and Redmond et al. (6).
  The entire vertebral body, pedicle, transverse process, lamina, or spinous process was included in the CTV if any portion of these regions contained the GTV. Additionally, the next adjacent normal marrow space was typically included in the bony CTV

PTV = CTV + 2-3mm, minus PRV cord

PRV cord is spinal cord as defined on myelogram or MRI +1.5-3mm, can also use thecal sac
Fig. 2. Consensus clinical target volume contours for spinal stereotactic radiosurgery. Red indicates individual contours and orange indicates consensus contours.
Treatment Planning

- 4-8 MV photons, using MLC
- IMRT: 7+ static, coplanar beams
- VMAT: 2-4 rotational arcs
- Common Dose/Fractionation schema:

<table>
<thead>
<tr>
<th>Dose/Fx</th>
<th>Number of Fx</th>
<th>Total Dose</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-24 Gy</td>
<td>1</td>
<td>16-24 Gy</td>
<td>Jabbari et al. 2016 (7) / Sahgal et al. 2008 (8)</td>
</tr>
<tr>
<td>10-12 Gy</td>
<td>2</td>
<td>20-24 Gy</td>
<td>Jabbari et al. 2016 / Sahgal et al. 2008</td>
</tr>
<tr>
<td>9 Gy</td>
<td>3</td>
<td>27 Gy</td>
<td>Jabbari et al. 2016 / Sahgal et al. 2008</td>
</tr>
</tbody>
</table>

- Dose prescribed to PTV.
  - Goal $\geq 80\%$ of PTV, and $\geq 90\%$ of CTV covered by prescribed IDL
  - Typical coverage: $\sim 75\% - 85\%$
# Normal Tissue Tolerances

<table>
<thead>
<tr>
<th>OAR</th>
<th>Dmax</th>
<th>Volume</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brachial plexus</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 1Fx</td>
<td>• 17.5 Gy / 14 Gy</td>
<td>Max point / &lt;3cc</td>
<td>• RTOG 0631</td>
</tr>
<tr>
<td>• 3Fx</td>
<td>• 24 Gy / 20.4 Gy</td>
<td></td>
<td>• RTOG 1021</td>
</tr>
<tr>
<td>• 5Fx</td>
<td>• 32 Gy / 30 Gy</td>
<td></td>
<td>• RTOG 0813</td>
</tr>
<tr>
<td>Cauda Equina</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 1Fx</td>
<td>• 16 Gy / 14 Gy</td>
<td>Max point / &lt; 3cc</td>
<td>• RTOG 0631</td>
</tr>
<tr>
<td>• 3Fx</td>
<td>• 24 Gy / 20.4 Gy</td>
<td></td>
<td>• Extrapolated - RTOG 1021</td>
</tr>
<tr>
<td>• 5Fx</td>
<td>• 32 Gy / 30 Gy</td>
<td></td>
<td>• Extrapolated - RTOG 0813</td>
</tr>
<tr>
<td>Spinal Cord (no prior RT)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 1Fx</td>
<td>• 12.2 Gy</td>
<td>Max point dose</td>
<td>• Sahgal et al. IJROBP 2013 (9)</td>
</tr>
<tr>
<td>• 3Fx</td>
<td>• 20.3 Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 5Fx</td>
<td>• 25.3 Gy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esophagus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 1Fx</td>
<td>• 16 Gy / 11.9 Gy</td>
<td>Max point / &lt; 5cc</td>
<td>• RTOG 0631</td>
</tr>
<tr>
<td>• 3Fx</td>
<td>• 25.2 Gy / 17.7 Gy</td>
<td></td>
<td>• RTOG 1021</td>
</tr>
<tr>
<td>• 5Fx</td>
<td>• 105% of PTV prescription / 27.5 Gy</td>
<td></td>
<td>• RTOG 0813</td>
</tr>
</tbody>
</table>
## Cord tolerance – *Prior conventional RT*

<table>
<thead>
<tr>
<th>Prior RT</th>
<th>1 Fx SBRT – Max point dose</th>
<th>3 Fx SBRT– Max point dose</th>
<th>5 Fx SBRT– Max point dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>20Gy / 5Fx</td>
<td>9 Gy</td>
<td>14.5 Gy</td>
<td>18 Gy</td>
</tr>
<tr>
<td>30Gy / 10Fx</td>
<td>?</td>
<td>14.5 Gy</td>
<td>18 Gy</td>
</tr>
<tr>
<td>37.5Gy / 15Fx</td>
<td>?</td>
<td>12.5 Gy</td>
<td>15.5 Gy</td>
</tr>
<tr>
<td>40Gy / 20 Fx</td>
<td>?</td>
<td>14.5 Gy</td>
<td>18 Gy</td>
</tr>
<tr>
<td>50Gy / 25 Fx</td>
<td>?</td>
<td>12.5 Gy</td>
<td>15.5 Gy</td>
</tr>
</tbody>
</table>

Adapted from Saghal et al. 2012 (10)
Contours
Radiation Plan
Potential Toxicities:

**Acute**
- Dermatitis
- Esophagitis
- Nausea/vomiting
- Pain flare
- Fatigue

  *Consider premedication with medrol dose-pak or 4mg Dexamethasone*
  
  *Consider antiemetics if treating near stomach*

**Late**
- Skin discoloration/fibrosis
- Vertebral compression fracture
  - Higher risk if >20Gy per fraction
  - Peak incidence is 2-3 months after XRT
- Radiation myelopathy
- Radiation plexopathy
- Esophageal stricture / stenosis
Follow up:

- H/P and neuro exam Q3months for 1-2 years, Q6 months for years 3-5, and annually thereafter
- Spine MRI according to the same schedule
- For more details regarding response assessment, please see SPINO 2015 (11)
Conclusion:

- Patient was treated to 27 Gy in 3 fractions
  - Fractionation was used per our institutional preference, however single fraction approaches are also acceptable – See RTOG 0631.
    - There *may be* reduced risk of VB fracture with fractionation when compared to single fraction
  - He tolerated treatment well overall, He had minimal esophagitis that resolved after about a week
- MRI revealed gradual reduction in the epidural disease over the course of the following 18 months.
References