HyTEC Spinal Cord Dose Limits for Spine SRS/SBRT

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* A total of ~40 spine SBRT papers reviewed

Historical Dose Limits: TD5/5 - TD50/5
Conventional 47 - 50 Gy 60-70 Gy

HyTec Dose Limit:  TD (1-5% Risk)

Single Fraction  12.4 Gy - 14.0 Gy

Reports of myelopathy from SRS to spinal lesions appear rare (<1%) when the maximum spinal cord dose is limited to the equivalent of 13 Gy in a single fraction or 20 Gy in three fractions. Long-term data are insufficient to calculate a dose–volume relationship for myelopathy when the partial cord is treated with a hypofractionated regimen.
Dosimetric Data

- Worldwide institutions
- 9 RM cases; 66 random control cases
- RM cases: Thecal Sac $D_{max} = 10.6$ to $16.2$ Gy /Fx; $25.6$ Gy /2Fx; $30.9$ Gy /3Fx
- EQD2 modeled ($\alpha/\beta = 2$ Gy)

Logistic Regression Curve for RM

[@5% Risk $\text{EQD2} = 44.6$ Gy](Int J Radiat Oncol Biol Phys, 2013, 85(2), 341-7)
### Estimated Dose Limits

<table>
<thead>
<tr>
<th>P</th>
<th>1Fx (Gy)</th>
<th>2Fx(Gy)</th>
<th>3Fx(Gy)</th>
<th>4Fx(Gy)</th>
<th>5Fx(Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>9.2</td>
<td>12.5</td>
<td>14.8</td>
<td>16.7</td>
<td>18.2</td>
</tr>
<tr>
<td>2%</td>
<td>10.7</td>
<td>14.6</td>
<td>17.4</td>
<td>19.6</td>
<td>21.5</td>
</tr>
<tr>
<td>3%</td>
<td>11.5</td>
<td>15.7</td>
<td>18.8</td>
<td>21.2</td>
<td>23.1</td>
</tr>
<tr>
<td>4%</td>
<td>12.0</td>
<td>16.4</td>
<td>19.6</td>
<td>22.2</td>
<td>24.4</td>
</tr>
<tr>
<td>5%</td>
<td>12.4</td>
<td>17.0</td>
<td>20.3</td>
<td>23.0</td>
<td>25.3</td>
</tr>
</tbody>
</table>

Int J Radiat Oncol Biol Phys, 2013, 85(2), 341-347
Dosimetric Data

- 2 RM cases; 228 patients; 259 lesions
- All are single fraction delivery
- RM cases: Cord $D_{\text{max}} = 13.4 \text{ Gy}$ and $13.6 \text{ Gy}$
- DVH atlas obtained for all cases published on-line in Supplementary Data

Median Cord $D_{\text{max}} = 13.85 \text{ Gy}$ for 2 RM cases out of 295 cases. Therefore 14 Gy/1Fx appears safe (<1% risk)
The logistic model of Gibbs 2007 (1/19) + Katsoulakis 2017 (2/259) data in single-fraction equivalent dose (GK model) is shown; since the confidence intervals extend all the way from 3% to 96% at high dose, the model itself was only plotted at lower dose.
Challenging Issues

- Cord vs. PRV (e.g. 1-2 mm margin or Thecal Sac)
- LQ formula (e.g. EQD2 to 1Fx dose conversion)
- Dmax Specifications (e.g. Plan vs. Delivered Dose)

Summary

- **De novo Treatment**: Point maximum doses (Dmax) as conservative thresholds for approximate 1-5% risk between 12.4 (Sahgal) - 14.0 Gy (Gibbs/Katsoulakis) @1Fx, via LQ the following limits at higher fx number:
  - 17.0 – 19.3 Gy/2Fx, 20.3- 23.1 Gy/3Fx, 23.0- 26.2 Gy/4Fx, 25.3 – 28.8 Gy/5Fx

- **Re-Irradiation**
  - (1) < 70 Gy in total EQD2
  - (2) < 25 Gy EDQ2 and < 50% for the SBRT portion
  - (3) > 5 months in minimum time interval