Clinical Implementation of SRS/SBRT

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Disclosures

Speaker:

BrainLAB

Standard Imaging

Research collaboration:

RaySearch
Learning Objectives

- Physics Considerations
- SRS Program
- SBRT Program
Physics Considerations

- Equipment Selection
- System QA (Image, Plan and Treat)
- Beam Data Measurement
- Data Validation
- End-to-End Test (Process QA)
- Tips and Tricks
System QA
- Winston-Lutz Test
- Process QA
- Image-Fusion Test
Output/PDD/Profiles

- Beam Output Check: TG-51
- Send for IROC TLDs
- Beam Scans (PDD/Profiles) for MLC & cones
- Scatter(output) factors
Small Field Challenge: Output Factors

Total scatter factor from different institutions

12% diff

Das et al.
Large vs. Small Fields
If Wrong Detector....

- Dose Under-estimated
- Penumbra Broadened
- FWHM Unaffected
Which Detector to Use?

- Ensure detector size < (¼ * Field Size)
- Small ion chamber (<0.1cc): stem effect/leakage.
- Medium ion chamber (0.1 – 1.0 cc): volume averaging
  - CA is under-dosed, penumbra broadened
- Recommend:
  - Unshielded diode for small fields and
  - Ion chamber for large fields
SRS Detectors

- CC13 (0.13cc active volume)
- A16
- Exradin D1H and D1V
- IBA SFD
- Edge detector
- PTW White diode (60018)
Beam Data Measurement:

Avoid Pitfalls
Beam Misalignment

F.S.: 6 x 6 mm
1 degree offset

Off-axis distance (mm)
Beam Misalignment

PDD
6 x 6 mm

- 1 deg
- 0.5 deg
- 2mm shift
- No_Angle

Dose (%) vs. Depth (mm)
In the measurement of very small fields (< 1x1 cm), variation in output factors caused by wrong detector and/or incorrect setup can be no more than
A. <2%
B. 2 - 5%
C. 5 – 10%
D. 10% +
E. There is no problem if you will use the smallest detector available.
In the measurement of very small fields (< 1x1 cm), variation in output factors caused by wrong detector and/or incorrect setup can be
A. <2%
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C. 5 – 10%
D. 10% +
E. There is no problem if you will use the smallest detector available.

Beam Data Measurement Tips

- Check water surface (use $d_{max}$ as reference)
- Correct for Effective point of measurement
- Align scanning system/ detectors with beam axis. Drive Up!
- Scan small field profile (< 2 cm) to verify detector centering & depth correction if needed
- Repeat with MLC and cones
Measurement Tips

- Verify 10x10 cm PDD/profiles
- Output factors with at-least two diode detectors + small volume ion chamber
- Apply correction factors (Francescon et al, MP 2011)
- Perform cross calibration before each measurement
- Daisy chain at ~4x4 cm: Perform measurements with large chamber for known MU and then deliver same MU to the small detector. Use charge ratio of output for large detector to adjust output with small detector.
More Tips

- For small fields, No ref detector
- Slow scan speed, 20+ points/meas.
- Watch for Penumbra asymmetry
- Check leakage and
- Subtract from Output if necessary
Detector Compare

PDD
6 x 6 mm

Dose (%)

Depth (mm)
Detector Compare

6 x 6 mm

Off-axis distance (mm)
Detector Compare

30 x 30 mm

Off-axis distance (mm)
## Detector Compare

### Penumbra Measurements

<table>
<thead>
<tr>
<th>F.S. (mm)</th>
<th>Detector</th>
<th>Vendor</th>
<th>100 x 100</th>
<th>30 x30</th>
<th>12x 12</th>
<th>6x6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Detector</strong></td>
<td><strong>Vendor</strong></td>
<td>100 x 100</td>
<td>30 x30</td>
<td>12x 12</td>
<td>6x6</td>
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<tr>
<td></td>
<td>CC13</td>
<td>IBA</td>
<td>5.2</td>
<td>4.9</td>
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<td>3.8</td>
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<td>A16</td>
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<td>3.3</td>
<td>3.1</td>
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<tr>
<td></td>
<td>Edge</td>
<td>Sun Nuclear</td>
<td>3.2</td>
<td>2.6</td>
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<td>2.1</td>
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<tr>
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<td>D1V</td>
<td>Std Imaging</td>
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<td>2.3</td>
<td>2.2</td>
<td>2.1</td>
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<tr>
<td></td>
<td>D1H</td>
<td>Std Imaging</td>
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<td>2.3</td>
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<td>1.9</td>
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<td></td>
<td>PFD</td>
<td>IBA</td>
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<td>2.5</td>
<td>2.5</td>
<td>2.3</td>
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<tr>
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<td>IBA</td>
<td>3.1</td>
<td>2.4</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>TN 60018</td>
<td>PTW</td>
<td>3</td>
<td>2.2</td>
<td>2.3</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Detector size impacts all of the following SRS measurements except:

A. Output factors
B. PDD
C. Beam Profile
D. MU calculations
E. FWHM
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A. Output factors
B. PDD
C. Beam Profile
D. MU calculations
E. FWHM

TPS Validation

- Independent MU to Dose Calc.
- TG-119 (Planar Array/ ion-chamber/film)
- MU vs. Measurement for MLC and Cone plans
- Heterogeneity Correction vs. Field size
- Verify Dose/MU for select fields
- RPC/RTOG credentialing
Results:

CT/CT: 0.48 ± 0.07 mm

CT/MR: 1.09 ± 0.65 mm
Process QA: Hidden Target Test

Scan, Plan, Treat, and Verify!
HTT for SRS/SBRT

Results

Position: 1.14 mm

Dose: < 2%
SAM_Q3

Good practice recommendation to ensure accuracy of small field output factors measured in your clinic is to use

A. One Ion Chamber
B. Any one ion chamber + one diode
C. Two ion chambers + one diode
D. One ion chamber + two diodes
E. Trust your instincts!
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A. One Ion Chamber
B. Any one ion chamber + one diode
C. Two ion chambers + one diode
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Summary

• Select **appropriate set of detectors** for small fields
• Ensure **positioning** and **alignment** with respect to central axis
• **Redundancy** of measurements
• **Cross check** with standard data
• RTP commissioning/verification: for typical treatment fields
• **System QA**: Imaging/TPS/Linac
SRS Treatment Planning
SRS Rx Dose

- Target Volume, Type, and Location

- SRS Rx dose (RTOG 95-08) max tolerable vs. GTV diameter:
  - < 2cm: 24 Gy
  - 2.1 - 3cm: 18 Gy
  - 3.1 - 4cm: 15 Gy

- Mets/AVM typically treated with SRS

- Malignant lesions with SRT
SRS Treatment Planning

- Follow RTOG guidelines (www.rtog.org)
- Use DVHs to get
  - target Rx Dose or $D_{\text{min}}$
- Volume of healthy tissue irradiated
  - Conformality index
- Target dose homogeneity (max/min target dose)
  - homogeneity index
- *SRS dose homogeneity is relaxed in favor of dose Conformality*
SRS Treatment Planning

- Draw separate GTVs on CT & MR
  - PTV = GTV (SRS)
  - PTV = GTV + 2mm (SRT)
- Use composite GTV (CT + MR) for planning
- OARs (auto segmentation but verify)
SRS Treatment Planning

- Target size,
- location,
- proximity to OARs
- dose fractionation.
- 3-4 VMAT Arcs
- Can also use conformal fixed fields or circular arcs
## Dose constraints

<table>
<thead>
<tr>
<th>Structure</th>
<th>Dose (Gy)</th>
<th>Endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optic chiasm</td>
<td>10</td>
<td>Neuritis</td>
</tr>
<tr>
<td>Cochlea</td>
<td>12</td>
<td>Hearing loss</td>
</tr>
<tr>
<td>Brainstem</td>
<td>15</td>
<td>Cranial neuropathy</td>
</tr>
<tr>
<td>Cord</td>
<td>14</td>
<td>Myelitis</td>
</tr>
</tbody>
</table>

Optic, auditory < trigeminal < motor CN

Ref.: QUANTEC (Red J. 2010); Mayo, (Red J. 2009); SBRT TG101 (Med Phys 2010)
SRS Plan Evaluation

- Draw “Irradiated_OARs” for long structures such as cord, brain stem for accuracy.
- Examine DVHs, Rx Isodose coverage, and OAR sparing
- Conformality index (V100/PTV)
- Homogeneity index (D5/D95)
Case 1: Brain Met DVH

Min. Dose : 98.8 % = 19.97 Gy
Mean Dose : 118.3 % = 26.16 Gy
Max. Dose : 125.6 % = 27.84 Gy

Dose : 100.1 % = 22.07 Gy
L. front net comp : 99.4 % = 2.87 Gy
Conformity Index : 1.29

CI = 1.29

22Gy @ 80% isodose volume
Case 2: Rt Occipital Met

4 VMAT arcs, 4 table angles, 18Gy, single fraction
Tips: Conformity Index vs. Target size

Dosimetric Parameters by PTV Volume

- PTV Index
- PTV Volume (cc)

Legend:
- SI
- CI
- HI
SBRT Planning
4DCT Scanning

- Free breathing (FB) scan
  - 3x3mm slices
- 4D scan with Varian’s RPM
  - ROI: (±5 cm around PTV)
  - 2-3 mm slice width.
- Create MIP (maximum intensity projection) data set.
- Transfer FB images & 4D sets (0%, 50%, MIP & Ave. Int. projection) to TPS
Image Fusion
SBRT OARs

- Rt + Lt lung (pulmonary window)
- Heart, Trachea, Carina
- Esophagus_irrad. (± 3cm sup/inf around PTV)
- Spinal cord_irrad. (± 3cm sup/inf around PTV)
- Liver, kidneys, Small bowel, Pancreas
- *Do not include GTV/PTV in lung definition
SBRT Targets

- GTV on FB, 0%, 50% CT sets; ITV on MIP
- PTV = ITV + 3 - 5mm
- Create D2cm = PTV + 2cm (high dose spillage)
SBRT Dose Rx.

Loyola:

- For lung patients:
  
  10 - 12Gy/fx x 5 fractions = 50-60Gy
  
  BED ~ 100-150 Gy
  
  M-W-F treatments
SBRT Treatment Planning

- 6 – 10 MV X-rays,
- VMAT: 3 – 4 VMAT non-coplanar arcs or
- 3DCRT: 8 – 12 non-coplanar, non-opposing fields.
SBRT Plan Evaluation

- **Target Coverage:** 95% of PTV and 100% of GTV
- **Hot spot must be** less than ~10-15% & within PTV.
- **Target Dose Homogeneity:** < 15-20%
- **Dose spillage:** V50/PTV (see RTOG table)
SBRT Plan Evaluation

- **Dose Conformality:** $V_{100}/PTV = 1.2 - 1.5$ (higher values for smaller targets)
- Tighten up PTV - MLC margin or adjust beam parameters to achieve better Conformality index (CI).
- Ensure **small calc. grid** (1mm) for small structures.
# SBRT Plan Evaluation

## Table 1: Conformality of Prescribed Dose for Calculations Based on Deposition of Photon Beam Energy in Heterogeneous Tissue

<table>
<thead>
<tr>
<th>PTV Volume (cc)</th>
<th>Ratio of Prescription Isodose Volume to the PTV Volume</th>
<th>Ratio of 50% Prescription Isodose Volume to the PTV Volume, R_{50%}</th>
<th>Maximum Dose (in % of dose prescribed) @ 2 cm from PTV in Any Direction, D_{2cm} (Gy)</th>
<th>Percent of Lung Receiving 20 Gy Total or More, V_{20} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deviation</td>
<td>Deviation</td>
<td>Deviation</td>
<td>Deviation</td>
</tr>
<tr>
<td></td>
<td>None</td>
<td>Minor</td>
<td>None</td>
<td>Minor</td>
</tr>
<tr>
<td>1.8</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;5.9</td>
<td>&lt;7.5</td>
</tr>
<tr>
<td>3.8</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;5.5</td>
<td>&lt;6.5</td>
</tr>
<tr>
<td>7.4</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;5.1</td>
<td>&lt;6.0</td>
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<tr>
<td>13.2</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;4.7</td>
<td>&lt;5.8</td>
</tr>
<tr>
<td>22.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;4.5</td>
<td>&lt;5.5</td>
</tr>
<tr>
<td>34.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;4.3</td>
<td>&lt;5.3</td>
</tr>
<tr>
<td>50.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;4.0</td>
<td>&lt;5.0</td>
</tr>
<tr>
<td>70.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;3.5</td>
<td>&lt;4.8</td>
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<tr>
<td>95.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;3.3</td>
<td>&lt;4.4</td>
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<tr>
<td>126.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;3.1</td>
<td>&lt;4.0</td>
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<tr>
<td>163.0</td>
<td>&lt;1.2</td>
<td>&lt;1.5</td>
<td>&lt;2.9</td>
<td>&lt;3.7</td>
</tr>
</tbody>
</table>

From: RTOG 0813 / 0915 / 0236
# OAR Dose Constraints

## FIVE-FRACTION TREATMENT

<table>
<thead>
<tr>
<th>Serial Tissue</th>
<th>Volume (mL)</th>
<th>Volume Max (Gy)</th>
<th>Max Point Dose (Gy)</th>
<th>Endpoint (≥ Grade 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optic pathway</td>
<td>&lt;0.2</td>
<td>20 (4 Gy/fx)</td>
<td>25 (5 Gy/fx)</td>
<td>Neuritis</td>
</tr>
<tr>
<td>Cochlea</td>
<td></td>
<td>27.5 (5.5 Gy/fg)</td>
<td>Hearing loss</td>
<td></td>
</tr>
<tr>
<td>Brainstem</td>
<td>&lt;1</td>
<td>26 (5.2 Gy/fg)</td>
<td>31 (6.2 Gy/fg)</td>
<td>Cranial neuropathy</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>&lt;0.25</td>
<td>22.5 (4.5 Gy/fg)</td>
<td>30 (6.6 Gy/fg)</td>
<td>Myelitis</td>
</tr>
<tr>
<td>Cauda equina</td>
<td>&lt;1.2</td>
<td>13.5 (2.7 Gy/fg)</td>
<td>34 (6.4 Gy/fg)</td>
<td>Neuritis</td>
</tr>
<tr>
<td>Sacral plexus</td>
<td>&lt;5</td>
<td>30 (6.6 Gy/fg)</td>
<td>32 (6.4 Gy/fg)</td>
<td>Neurophy</td>
</tr>
<tr>
<td>Esophagus</td>
<td>&lt;5</td>
<td>27.5 (5.5 Gy/fg)</td>
<td>35 (7.0 Gy/fg)</td>
<td>Stenosis/fistula</td>
</tr>
<tr>
<td>Ipsilateral brachial plexus</td>
<td>&lt;3</td>
<td>30 (6.6 Gy/fg)</td>
<td>32 (6.4 Gy/fg)</td>
<td>Neurophy</td>
</tr>
<tr>
<td>Heart/pericardium</td>
<td>&lt;15</td>
<td>32 (6.4 Gy/fg)</td>
<td>38 (7.6 Gy/fg)</td>
<td>Pericarditis</td>
</tr>
<tr>
<td>Great vessels</td>
<td>&lt;10</td>
<td>47 (9.4 Gy/fg)</td>
<td>53 (10.6 Gy/fg)</td>
<td>Aneurysm</td>
</tr>
<tr>
<td>Trachea and ipsilateral bronchus</td>
<td>&lt;4</td>
<td>18 (3.6 Gy/fg)</td>
<td>38 (7.6 Gy/fg)</td>
<td>Stenosis/fistula</td>
</tr>
<tr>
<td>Skin</td>
<td>&lt;10</td>
<td>30 (6.6 Gy/fg)</td>
<td>32 (6.4 Gy/fg)</td>
<td>Ulceration</td>
</tr>
<tr>
<td>Stomach</td>
<td>&lt;10</td>
<td>28 (5.6 Gy/fg)</td>
<td>32 (6.4 Gy/fg)</td>
<td>Ulceration/fistula</td>
</tr>
<tr>
<td>Duodenum</td>
<td>&lt;5</td>
<td>18 (3.6 Gy/fg)</td>
<td>32 (6.4 Gy/fg)</td>
<td>Ulceration</td>
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<td>Jejunum/ileum</td>
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<td>19.5 (3.9 Gy/fg)</td>
<td>35 (7.4 Gy/fg)</td>
<td>enteritis/obstruction</td>
</tr>
<tr>
<td>Colon</td>
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<td>25 (5.0 Gy/fg)</td>
<td>38 (7.6 Gy/fg)</td>
<td>colitis/fistula</td>
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<tr>
<td>Rectum</td>
<td>&lt;20</td>
<td>25 (5.0 Gy/fg)</td>
<td>38 (7.6 Gy/fg)</td>
<td>proctitis/fistula</td>
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<tr>
<td>Bladder wall</td>
<td>&lt;15</td>
<td>18.3 (3.65 Gy/fg)</td>
<td>38 (7.6 Gy/fg)</td>
<td>cystitis/fistula</td>
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<tr>
<td>Penile bulb</td>
<td>&lt;3</td>
<td>30 (6.6 Gy/fg)</td>
<td>50 (10 Gy/fg)</td>
<td>Impotence</td>
</tr>
<tr>
<td>Femoral heads (right and left)</td>
<td>&lt;10</td>
<td>30 (6.6 Gy/fg)</td>
<td>50 (10 Gy/fg)</td>
<td>Necrosis</td>
</tr>
<tr>
<td>Renal hilum/vascular trunk</td>
<td>&lt;2/3 volume</td>
<td>23 (4.6 Gy/fg)</td>
<td></td>
<td>Malignant hypertension</td>
</tr>
</tbody>
</table>

---

## Parallel Tissue

<table>
<thead>
<tr>
<th>Parallel Tissue</th>
<th>Critical Volume (mL)</th>
<th>Critical Volume Dose Max (Gy)</th>
<th>Endpoint (≥ Grade 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung (right and left)</td>
<td>1,500</td>
<td>12.5 (2.5 Gy/fg)</td>
<td>Basic lung function</td>
</tr>
<tr>
<td>Lung (right and left)</td>
<td>1000</td>
<td>13.5 (2.7 Gy/fg)</td>
<td>Pneumonitis</td>
</tr>
<tr>
<td>Liver</td>
<td>700</td>
<td>21 (4.2 Gy/fg)</td>
<td>Basic liver function</td>
</tr>
<tr>
<td>Renal cortex (right and left)</td>
<td>200</td>
<td>17.5 (3.5 Gy/fg)</td>
<td>Basic renal function</td>
</tr>
</tbody>
</table>

*Avoid circumferential irradiation.

Ref: QUANTEC; RTOG
Dose Calculation Algorithms:
Impact on Txt. Planning and Validation
Depth dose, 6 MV

Problems with algorithms that do not model electron transport.
Electronic equilibrium? No problem.
Better agreement between Pinnacle CC and Monte Carlo than between Eclipse AAA and Monte Carlo.

Chopra et al.
Dual Lung Phantom

Dual Lung Target (30 x 30 mm)

Dose (cGy)

Off-axis distance (mm)
Challenging Cases - 1

Patient had 3D treatment for lung target 2 years ago and recurred. Prev Cord dose = 49 Gy, deliver minimum dose to cord. Beam arranged to not enter thru cord, exit only. Cord as OAR in optimization.
Challenging Case - 2

- Patient with LUL lesion. Significant left lung obstruction.
- Opened up after three fx. Re-planning required. Significant (~10%) change in PTV dose.
- Will impact MU validation as well as 2nd check are insensitive to density corrections.
Challenging Case - 2
Future Directions

PTV Rx:
55Gy in 5 fx
<table>
<thead>
<tr>
<th>METRIC</th>
<th>RESULT</th>
<th>MIN REQ</th>
<th>IDEAL</th>
<th>POINTS</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose (Gy) covering 98% of the PTV</td>
<td>54.534</td>
<td>52.25</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering whole PTV minus 0.03 (cc)</td>
<td>51.591</td>
<td>49.5</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Conformation Number [52.25 (Gy), PTV]</td>
<td>0.859</td>
<td>0.75</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Conformality Index [27.5 (Gy), PTV]</td>
<td>3.929</td>
<td>5</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Homogeneity Index [55 (Gy), PTV]</td>
<td>0.147</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum dose (Gy) to the ITV</td>
<td>56.856</td>
<td>52.25</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Structure(s) containing the global max dose point</td>
<td>3 values</td>
<td>PTV</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Volume (cc) of the HEART covered by 10 (Gy)</td>
<td>0.416</td>
<td>10</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 0.03 (cc) of the PRVSPINALCANAL</td>
<td>9.071</td>
<td>20</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 0.03 (cc) of the TRACHEA</td>
<td>8.245</td>
<td>40</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Volume (%) of the LUNG_MINUS_ITV covered by 10 (Gy)</td>
<td>11.366</td>
<td>15</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Volume (%) of the LUNG_MINUS_ITV covered by 5 (Gy)</td>
<td>23.988</td>
<td>30</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Mean dose (Gy) to the LUNG_MINUS_ITV</td>
<td>6.288</td>
<td>10</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Volume (%) of the RLUNG covered by 5 (Gy)</td>
<td>1.409</td>
<td>30</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Volume (cc) of the THORACIC_WALL covered by 30 (Gy)</td>
<td>0.000</td>
<td>10</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 4 (cc) of the ESOPHAGUS</td>
<td>8.874</td>
<td>32.5</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 0.03 (cc) of the ESOPHAGUS</td>
<td>12.320</td>
<td>40</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 0.03 (cc) of the VESSELS</td>
<td>51.993</td>
<td>57.75</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 4 (cc) of the PBT</td>
<td>26.655</td>
<td>50</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 1.5 (cc) of the PBT</td>
<td>43.208</td>
<td>55</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dose (Gy) covering 0.03 (cc) of the SKIN</td>
<td>16.462</td>
<td>30</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>
Stereotactic body radiation therapy: The report of AAPM Task Group 101

Stanley H. Benedict, Chairman
University of Virginia Health System, Charlottesville, Virginia 22908

Accelerator beam data commissioning equipment and procedures:
Report of the TG-106 of the Therapy Physics Committee of the AAPM

Indra J. Das
Department of Radiation Oncology, University of Pennsylvania, Philadelphia, Pennsylvania 19104

Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy:
Executive summary

Timothy D. Solberg PhD, James M. Balter PhD, Stanley H. Benedict PhD, Benedick A. Fraass PhD, Brian Kavanagh MD, Curtis Miyamoto MD, Todd Pawlicki PhD, Louis Potters MD, Yoshiya Yamada MD

AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS-SBRT

Per H. Halvorsen | Eileen Cirino | Indra J. Das | Jeffrey A. Garrett | Jun Yang | Fang-Fang Yin | Lynne A. Fairobent
REFERENCES:

RTOG 0813
SEAMLESS PHASE I/II STUDY OF STEREOTACTIC LUNG RADIOTHERAPY (SBRT)
FOR EARLY STAGE, CENTRALLY LOCATED,
NON-SMALL CELL LUNG CANCER (NSCLC) IN MEDICALLY INOPERABLE PATIENTS

RTOG 0915
(NCCTG N0927)
A RANDOMIZED PHASE II STUDY COMPARING 2 STEREOTACTIC BODY RADIATION
THERAPY (SBRT) SCHEDULES FOR MEDICALLY INOPERABLE PATIENTS WITH
STAGE I PERIPHERAL NON-SMALL CELL LUNG CANCER

RTOG 0236
A Phase II Trial of Stereotactic Body Radiation Therapy (SBRT) in the Treatment of
Patients with Medically Inoperable Stage I/II Non-Small Cell Lung Cancer
Summary

• Ensure adequate resources are available for:
  - Imaging,
  - Txt Planning and
  - Delivery

• Acceptance Testing/Commissioning
• Robust System QA (End-to-End Test)
• IMRT/VMAT QA
Summary

• Checklists + Independent MU calc
• Follow RTOG Guidelines
• Establish site specific protocols consistent with departmental resources
• Automate Planning and Evaluation methods for efficient and consistent planning
• Follow AAPM/ASTRO/RTOG guidelines
For lung SBRT of small targets, independent checks of TPS calculated monitor units (MUs)

A. Should never be done because they never agree with TPS
B. Will always produce same MUs as TPS because both account for heterogeneity corrections
C. Will produce lower MUs than TPS because independent calculations fail to account for reduced scatter conditions in TPS
D. Will produce higher MUs because scatter is missing in independent calculations
E. Will produce higher MUs because independent calculations are 2D and TPS is 3D.
SAM_Q4

For lung SBRT of small targets, independent checks of TPS calculated monitor units (MUs)

A. Should never be done because they never agree with TPS
B. Will always produce same MUs as TPS because both account for heterogeneity corrections
C. Will produce lower MUs than TPS because independent calculations fail to account for reduced scatter conditions in TPS
D. Will produce higher MUs because scatter is missing in independent calculations
E. Will produce higher MUs because independent calculations are 2D and TPS is 3D.

According to RTOG 0813 guidelines, the ratio of 50% isodose volume to planning target volume (PTV) should ____________ with increasing PTV size

A. Increase
B. Decrease
C. Stay the same
According to RTOG 0813 guidelines, the ratio of 50% isodose volume to planning target volume (PTV) should **decrease** with increasing PTV size.

A. Increase
B. Decrease
C. Stay the same

Reference: RTOG- 0813 - Seamless Phase I/II Study of Stereotactic Lung Radiotherapy (SBRT) for Early Stage, Centrally Located, Non-Small Cell Lung Cancer (NSCLC) in Medically Inoperable Patients
Thank you!