Stereotactic Body Radiation Therapy (SBRT)

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Outline

1. SBRT From SRS
2. SRS Review
3. Emerging SBRT
4. Issues related SBRT
5. RTOG Protocols
6. Treatment Plans

Historical Perspective I

We should recognize and acknowledge that Stereotactic Body Radiation Therapy (SBRT) is an extension or evolution of Stereotactic Radiosurgery (SRS)

Why ?
Historical Perspective II

If we acknowledge this evolution, we should also provide EXTRA-ORDINARY CARE for SBRT as demanded in Stereotactic Radiosurgery (SRS)

Questions: Why is EXTRA-ORDINARY CARE necessary?

References:
SRS Review II

Stereotactic radiosurgery (SRS) of an intracranial lesion, or radiosurgery, combines the use of a **stereotactic apparatus** and energetic radiation beams to irradiate the lesion with a **single treatment**.

Stereotactic Radiotherapy (SRT) utilizes the stereotactic apparatus and radiation beams for multiple fractions or treatments.

AAPM Report No. 54

SRS Review III

Stereotactic apparatus is an **external device** commonly used in surgery to guide biopsy needle to the target.

Figure: Benedict SH, et al. Med Phy 35:4262; 2008

SRS Review IV

Radionics CRW Stereotactic System
(From Integra Radonics Website)
SRS Review V
Radionics CRW Stereotactic System
(From Integra Radionics website)

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SRS Review VI
Leksell Stereotactic System
(From Elekta Website)

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SRS Review VII
Leksell Stereotactic System - Software

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SRS Review VIII

Leksell Stereotactic System – Biopsy System

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SRS Review IX

Summary:
1. Stereotactic apparatus are precise instrument
2. Use for stereotactic biopsy
3. Modified for stereotactic radiosurgery

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SRS Review X

Gamma Knife (Perfexion and 4C)
- is radiosurgery unit
- limited to intracranial treatment
- Elekta product

Top: Model 4C
Bottom: Perfexion

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SRS Review XI
Gamma Knife (Perfexion and 4C)
- Perfexion is the latest product
- capable of performing treatment to the cervical spine

SRS Review XII
Gamma Knife (Perfexion)
- Physical feature
- During treatment, the door opens and couch moves into the system and latched
- Radiation begins

SRS Review XIII
Gamma Knife (Perfexion)
- System works by rotating a specific collimator size in alignment with the cobalt-60 source for treatment
SRS Review XIV

Gamma Knife (Perfexion)

By design, the system delivers the target dose from many directions.

By rotating the collimators, appropriate size is used for dose delivery.

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SRS Review XV

Gamma Knife (Perfexion and 4C)

Fixation
Localization
Treatment Planning
Dose Delivery

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SRS Review XVI

Cyberknife – Physical Characteristics

It is a robotic dose delivery system capable of delivering the dose from many directions.

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SRS Review XVII

Cyberknife:

Dose delivery is performed by shooting the small amount of radiation from many directions to the target.

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SRS Review XVI

Cyberknife:

By the design, the system delivers the target dose from many directions.

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SRS Review XVIII

Linac Based System:

- Internal component
- Irradiation is performed by moving the collimator assembly
- Cylindrical collimators are commonly used

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SRS Review XX

Beam entry delivery pattern from linac-based radiosurgery
(AAPM Report No. 54)

Summary:
Delivery of highly collimated beam
Use of stereotactic device
Precisely aim at the target
Arc Fields or Many Static Fields
Delivery of high doses

SBRT I

Stereotactic Body Radiation Therapy (SBRT) is an extension of SRS and SRT.

Although SRS and SRT have been used for decades, SBRT is considered emerging and evolving technology.

Why?
SBRT II

We do not know the impact of high radiation dose on the extracranial region.

Example – Skin Toxicity [From Timmerman]

Solution: Spread out entrance dose (more beams)

SBRT III

Need to consider these issues for SBRT:

- Stereotactic apparatus
- Organ motion relative to the stereotactic apparatus
- High dose irradiation of extracranial (abdominal) structures
- Ability to ablate extracranial targets

SBRT IV

Stereotactic apparatus:

- Stereotactic Body Frame
- Stereo Imaging Technology
**SBRT VIII**

Organ Motion – RPM System

On-Board Imager on Linac

In-Room Localizer

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**SBRT IX**

Organ Motion – Compression Technique

Reduce abdominal motion associated with respiration

Figure: Benedict SH – ACMP presentation 2005

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**SBRT X**

4D CT Simulator

A technique that allow an evaluation of the motion of the target

Figure: Christopher Willey, MD, PhD UAB
SBRT XI

4D CT Simulator

Prospective binning to create motion of the target

Figure: Christopher Willey, MD, PhD
UAB

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SBRT XII

4D CT Simulator

The trace of the target motion allows the creation of an internal target volume (ITV) for treatment planning

Figure: The relative motion of the target at three different phases.

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SBRT XIII

SBRT Procedures:
1. Immobilization
2. ConeBeam CT
3. Applied Shifts
4. Motion-Gated Technology
5. Verification
6. Dose Delivery

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Clinical Trials - 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

<table>
<thead>
<tr>
<th>Organ</th>
<th>Volume</th>
<th>Dose (cGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal Cord</td>
<td>Any point</td>
<td>18 Gy (3 Gy per fraction)</td>
</tr>
<tr>
<td>Esophagus</td>
<td>Any point</td>
<td>27 Gy (3 Gy per fraction)</td>
</tr>
<tr>
<td>Tracheal/Bronchial</td>
<td>Any point</td>
<td>24 Gy (2 Gy per fraction)</td>
</tr>
<tr>
<td>Heart</td>
<td>Any point</td>
<td>30 Gy (10 Gy per fraction)</td>
</tr>
<tr>
<td>Trachea and Bronchus</td>
<td>Any point</td>
<td>30 Gy (10 Gy per fraction)</td>
</tr>
<tr>
<td>Whole Lung (Right &amp; Left)</td>
<td>(See table in Section 6.4.2)</td>
<td>(See table in Section 6.4.2)</td>
</tr>
</tbody>
</table>
SBRT XV

• Clinical Trials - RTOG 0618: A Phase II Trial of Stereotactic Body Radiation Therapy (SBRT) in the Treatment of Patients with Operable Stage I/II Non-Small Cell Lung Cancer

SBRT XVI

• Clinical Trials - 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

SBRT XVII

• Clinical Trials - RTOG 0915: 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
SBRT XVIII

Various Lung Treatment Regimens

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sample Size</th>
<th>Total Dose of Fractions [cGy/fraction]</th>
<th>Local Control</th>
<th>Follow-up [month]</th>
<th>a Grade 3 Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babcock et al</td>
<td>30</td>
<td>60-70 Gy / 1.8 Gy</td>
<td>90%</td>
<td>60</td>
<td>0%</td>
</tr>
<tr>
<td>Regan et al</td>
<td>45</td>
<td>60 Gy / 3 Gy</td>
<td>80%</td>
<td>30</td>
<td>0%</td>
</tr>
<tr>
<td>Travers et al</td>
<td>37</td>
<td>60.4 Gy / 1.8 Gy</td>
<td>90%</td>
<td>24</td>
<td>0%</td>
</tr>
<tr>
<td>Department at U</td>
<td>123</td>
<td>30-40 Gy / 1.8 Gy</td>
<td>80%</td>
<td>20</td>
<td>16.7%</td>
</tr>
<tr>
<td>Department at U</td>
<td>68</td>
<td>37.5 Gy / 1.8 Gy</td>
<td>90%</td>
<td>36</td>
<td>3.0%</td>
</tr>
<tr>
<td>McCary et al</td>
<td>87</td>
<td>36-42 Gy / 1.8 Gy</td>
<td>80%</td>
<td>15</td>
<td>--</td>
</tr>
<tr>
<td>Hu et al</td>
<td>45</td>
<td>50 Gy / 3 Gy</td>
<td>80%</td>
<td>36</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

*Notes: the treated lesions were central in location, not peripheral, although the report does not clarify whether a central tumor location led to increased risk of treatment toxicity.

SBRT XIX

Status of SBRT as published in the red journal in November 2006

Various sites that have been treated using SBRT

SBRT XX

Additional Treatment Sites

- Lung
- Spine
- Liver and Pancreas
- Renal Cell Carcinoma
- Prostate
SBRT XXI
Extracranial Toxicity
(Figures from B. Hoppe and R. Timmerman)

SBRT XXII

SBRT XXIII
Treatment Planning Innovations