Stereotactic Body Radiation Therapy: QA, Safety, and Other Practical Aspects.

Tues, July 14, 2015: 7:30-8:30AM: AAPM Therapy Educational SAM Session: "Imaging, Treatment Planning, and QA for SBRT"

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Department of Radiation Oncology, University of California at Davis

Disclosures

- The UC Davis Radiation Oncology Department receives research funding from NIH/National Cancer Institute, National Lung Cancer Partnerships, and RSNA
- The Radiation Oncology Department has research and development agreements with Varian Medical Technologies, Sun Nuclear, Elekta, AlignRT, and iRT Systems GmbH

References:


References (cont’d):

5. The Canadian Association of Radiation Oncology scope of practice guidelines for lung, liver and spine stereotactic body radiotherapy.


7. AAPM TG132: Quality Assurance for Image Registration (K. Brock)

8. AAPM TG 155: Small Field Dosimetry (Indra Das)

9. AAPM WG-SBRT: Radiobiological Effects of Hypofractionation (J. Grimm)

* TG132, TG155, and WGSBRT NOT PUBLISHED...Yet
• Published in Aug 2014
• Most SRT books have chapters dedicated to clinical sites
• This book focuses on technology, biology, physics... With only one summary chapter on clinical experience (and results of clinical trials)

Table of Normal Tissue Tolerances

TG 101: Table 3

Some Caveats:

• There is sparse long-term follow-up for SBRT.
• Data in table 3 should be treated as a first approximation!
• Doses are mostly invalidated, and they are based mostly on observation and theory.
• There is some measure of educated guessing!

R. Timmerman, 10/26/09, pers. comm.
AAPM WGSBRT: Radiobiological Effects of Hypofractionation.

A WG with 74 Physicians, Physicists, and radiobiologists

John Adler, MD
Stacy Benayed, PhD
Sonneh Berardes, PhD
Ian Bolwell, PhD
Steven Bova, MD
Jenny Caswell, MD
Ronald Chen, MD
Andrew Clamp, MD
Sara Coitius, MD
Louis Conlowe, MD
Shive Das, PhD
Laura Dawson, MD
Joseph Deasy, PhD
George Ding, MD
Isean El Nage, PhD
John Flinkinger, PhD
Jack Fowler, PhD
Donald Fuller, MD
Martin Fuss, MD
Iris Gibbs, MD
Karyn Goodman, MD
Mary Martel, MD
Nathan Sheehan, MD
John Grima, PhD
Panayiotis Mavroidis, PhD
Ronald Chen, MD
Shaneen John, MD
Michael Joiner, PhD
Brian Kavanagh, MD
John Karpinski, MD
Feng-Ming Spring Kong, MD
Tamer LaCasce, MD
Peter Lee, MD
Young Lee, MD
Allen LI, PhD
Sunny Liu, MD
Zhengping Liu, MD
Michael Low blossom
Luan Wu, PhD
Lawrence Marks, MD
Tigran Saghatelyan, MD
Jesus Sanchez, MD

Planning Aspects for New SBRT Program

Table 1. Essential planning aspects for developing a new SBRT program and/or considering new disease sites.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Duration Or Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify clear program goals, search for sites, identify program specialists, develop guidelines for treatment, follow-up, and assessment.</td>
<td>Initially 13 - 34, 36</td>
</tr>
<tr>
<td>Identify key inclusion criteria, develop protocols for clinical trials, determine outcomes, determine outcomes, determine outcomes.</td>
<td>Initially 13 - 34, 36</td>
</tr>
<tr>
<td>Refine technology, assess for clinical trials, identify key inclusion criteria for trials, determine outcomes, determine outcomes, determine outcomes.</td>
<td>Initially 13 - 34, 36</td>
</tr>
<tr>
<td>Implement changes in treatment, develop guidelines for treatment, follow-up, and assessment.</td>
<td>Initially 13 - 34, 36</td>
</tr>
<tr>
<td>Develop and communicate guidelines for the use of SBRT.</td>
<td>Initially 13 - 34, 36</td>
</tr>
</tbody>
</table>

QA and Safety in SRS/SBRT

(Executive Summary and Supplemental Material)

Quality and Safety Considerations in Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy

Thomson D. Solberg, PhD, J. James M. Hamburgh, MD, Stanley W. Kondo, MD, Michael F. B. A. Feinm, PhD, Stephen M. H. Kone, MD, Robert R. M. F. Tobin, PhD, Lewis Potrero, M.D., Yongshin Yokota, M.D., Ph.D.

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Table 2. Personnel qualifications of a stereotactic program

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Duration Or Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>All personnel must demonstrate normal levels of knowledge and experience in their respective discipline, current practice, and their current level of training.</td>
<td>Initially 32 - 33</td>
</tr>
<tr>
<td>All personnel must be current with current medical literature and be able to provide updated information.</td>
<td>Initially 32 - 33</td>
</tr>
<tr>
<td>All personnel must be able to provide evidence of their knowledge of current medical literature and be able to provide updated information.</td>
<td>Initially 32 - 33</td>
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</table>

Personnel Qualifications for an SRT Program

"Quality and Safety Considerations in SRS and SBRT", Solberg et al. Practical Rad Onc 2011

"Quality and Safety Considerations in SRS and SBRT", Solberg et al. Practical Rad Onc 2011

"Quality and Safety Considerations in SRS and SBRT", Solberg et al. Practical Rad Onc 2011
Commissioning of a SRS Program

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Duration</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquire necessary specialized equipment, personnel time, must be evaluated and available prior to initiating clinical SRS program.</td>
<td>2-10 weeks</td>
<td>22-35</td>
</tr>
<tr>
<td>Independently assess machinery at the beginning of a clinical SRS program.</td>
<td>1 week</td>
<td>32-37</td>
</tr>
<tr>
<td>Independent verification of all equipment calibration must be performed prior to initiating a clinical SRS program.</td>
<td>1 week</td>
<td>32-37</td>
</tr>
<tr>
<td>Comprehensive treatment planning system commissioning incorporating a variety of stereotactic delivery parameters and techniques, and specifically addressing use of imaging guidance systems with specific tool algorithms, must be performed prior to initiating a clinical SRS program.</td>
<td>2-4 weeks</td>
<td>33-38</td>
</tr>
<tr>
<td>Independent verification of all commissioning including appropriate equipment and systems such as those from the Radiological Physics Centers, must be performed prior to initiating a clinical SRS program and prior to acquiring clinical data and treatment techniques.</td>
<td>2-4 weeks</td>
<td>33-38</td>
</tr>
<tr>
<td>Management of optional routines is an essential element of SRS simulation, planning and delivery. Measures must be developed to ensure effective and safe operation of these technologies.</td>
<td>2-4 weeks</td>
<td>33-38</td>
</tr>
<tr>
<td>Evaluation of individual and overall image guidance systems must be performed prior to initiating a clinical SRS program and prior to initiating new clinical sites and in treatment technique.</td>
<td>2 weeks</td>
<td>33-38</td>
</tr>
<tr>
<td>Test of commissioning procedures, incorporating simulation, treatment planning and delivery, imaging guidance and motion management systems, must be performed prior to initiating a clinical SRS program and prior to initiating new clinical sites and in treatment technique.</td>
<td>2 weeks</td>
<td>33-38</td>
</tr>
</tbody>
</table>

Recommendations to guard against catastrophic failures:
- Principals
- Primary Reviews
- 2nd Reviews

Sample Checklist for SRS Program: Lung

The 52-page document represents an intensive collaboration among 31 specialists from all of the major societies in the radiation oncology field, representing physicians, medical physicists, radiation therapists, medical dosimetrists, nurses and administrators to ensure safe and effective radiation therapy treatment for patients.
Staffing…from ASTRO, Safety is No Accident

Doctors jailed in French radiation scandal

At least 24 people treated between May 2004 and August 2005 received 20 per cent more radiation than recommended due to a calibration error linked to the introduction of new machines in 2004.

Learning Lessons from SRS/SBRT Accidents and Administrations

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Quick facts:

**Improper Jaw Size During SRS**
- **Location**: France
- **Year**: 2004
- **Issue**: Physicist told therapist to set a “40x40” for cone SRS treatment; therapist set 40x40 cm²
- **Consequences**: Some normal tissue received more dose than the target; developed “fibrosis and oeso-tracheal fistula” requiring surgery; patient died from “brutal haemorrhage” a few days after surgery
- **Lesson**: Have clear procedures/checklists in place

**Improper Jaw Size During SRS**
- **Location**: United States
- **Year**: 2009
- **Issue**: Collimator jaws for SRS treatment using cones were left open during treatment
- **Consequences**: Patient “is in a nursing home, nearly comatose…”
- **Lesson**: Interlocks needed, better communication, standardized procedures

**Commissioning**
- **Location**: France
- **Year**: 2007
- **Issue**: Large chamber used to make small field SRS measurements of output factors
- **Consequences**: Up to 200% overdose for some patients
- **Lesson**: Compare commissioning values with other institutions, look for guidance

**SRS Cone Left Out**
- **Location**: Texas
- **Year**: 2012
- **Issue**: Licensee notified the Agency that a medical event had occurred at its facility on June 5, 2012. A technician failed to insert a conical collimator prior to a stereotactic surgery procedure which resulted in a dose being delivered to a patient that varied greater than 10% from the prescribed dose. An investigation into this event is ongoing.

**This occurred in France in 2004!**
Same mistakes keep happening

This happened in France in 2007!

Miscalibration

- Location: Florida
- Year: 2004-2005
- Issue: Miscalibration of SRS linac
- Consequences: 77 patients received a 50% overdose
- Lesson: Get independent/second check of the output (RPC)

Small Field Output Factors

Small Field Dosimetry

- SBRT often uses small fields and beamlets (<1cm) in diameter
- This can cause a variety of dosimetric effects:
  - Loss of lateral electronic equilibrium
  - Volume averaging
  - Detector interface artifacts
  - Collimator effects
  - Detector positioning and orientation effects
Small Field Dosimetry

• Use detectors with a spatial resolution of 1mm or better (stereotactic detectors) for basic dosimetry measurements
• Be VERY careful with setup and detector positioning
• Remember that MLC-shaped fields have more uncertainty than circular cones
• When detector diameter is close to the FWHM of the field, the detector volume effect becomes significant

Detectors for small fields

Recommendation: the maximum inner diameter of a detector should be less than half the FWHM of the smallest beam measured in order for the deconvolution of the detector-size effect to work properly.
What About Localization Accuracy?

IGRT Accuracy

Must perform end to end tests!

Summary of Published QA Recommendations for SBRT (TG 101)

Recommends End-to-End localization accuracy at initial commissioning and annually thereafter.

RPC Lung Motion Phantom Benchmark

... learning from our mistakes by maintaining data on our experience... lots of experience...

lots of data!
**Question #1:** The use of procedural checklists can be particularly effective at ensuring compliance and minimizing error. Which of the following best describes the use of checklists for treatments:

A. Checklists are only helpful for the initial stages of an SBRT program

B. The adoption of the same site specific checklists from other institutions will usually suffice for initiating SBRT

C. Checklists are exclusively for the therapists to review and ensure that the patient has been set-up correctly.

D. Checklists used prior to daily treatment must be customized to the particular treatment planning and delivery systems.

**Answer Question #1**

D. Checklists used prior to daily treatment must be customized to the particular treatment planning and delivery systems.

Checklists should be used, and they should be customized to match the technology and treatment site. These checklists should also be updated regularly to reflect any changes in procedures or technological updates in the SBRT program.

**Reference:**


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**Question #2:** When target and/or critical structures cannot be localized accurately due to motion or metal artifacts which of the following applies...

A. Utilize the deformable image registration features of the treatment planning system to develop a treatment plan

B. Contour the target and critical structures as best you can and increase the margins on the target to a level that is necessary to account for the motion

C. Reduce the dose and/or fractionation from the standard protocol to account for the errors in localization

D. Use orthogonal (AP and lateral) kV planar imaging to develop a 2D plan for treatment and set-up.

E. Do not pursue SBRT as a treatment option.
ANSWER QUESTION #2

E. Do not pursue SBRT as a treatment option.

- If one is unable to localize the target and adjacent critical structures due to motion or metal artifacts SBRT should not be a treatment option.

- Deformation registration and other imaging tools may be instructive for targeting, but if the target and/or adjacent critical structures are not localizable than SBRT is not an appropriate delivery.

- Reference:

Thank You