SBRT: QA and Safety Considerations

SESSION: Therapy 4:
Current Advantages and Safety Considerations in SBRT
Presented at the AAPM Spring Clinical Meeting
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and
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University of Chicago, Department of Radiation Oncology

DISCLOSURES

The University of Virginia Health Systems
and the UVa Department of Radiation Oncology
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TomoTherapy (Accuray).

References

• Cunningham J, Coffey M, Knööö T, Holmberg O. Radiation Oncology Safety Information System (ROSIS): profiles of participants and the first 1074 incident reports. Radiother Oncol. 2010;97:601–607

What is SBRT?

• A single fraction treatment?
• A treatment with “n” fractions (n is your choice)?
• Whenever you are treating a “small” target?
• Any treatment that uses image guidance?
• Any treatment that uses a stereotactic frame?
• Any treatment on a machine claiming “stereotactic” capability?
Conventional RT vs. SBRT (I)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Conventional RT</th>
<th>SBRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose / Fraction</td>
<td>1.8 – 3 Gy</td>
<td>6 – 30 Gy</td>
</tr>
<tr>
<td>No. of Fractions</td>
<td>10 – 30</td>
<td>1-5</td>
</tr>
<tr>
<td>Target definition</td>
<td>CTV / PTV gross disease + clinical extension: tumor may not have a sharp boundary.</td>
<td>GTV / CTV / ITV / PTV well-defined tumors: GTV=CTV</td>
</tr>
<tr>
<td>Margin</td>
<td>Centimeters</td>
<td>Millimeters</td>
</tr>
<tr>
<td>Physics / dosimetry monitoring</td>
<td>Indirect</td>
<td>Direct</td>
</tr>
<tr>
<td>Required setup accuracy</td>
<td>TG40, TG142</td>
<td>TG40, TG142</td>
</tr>
<tr>
<td>Primary imaging modality used for tx planning</td>
<td>CT</td>
<td>Multi-modality: CT/MR/PET-CT</td>
</tr>
</tbody>
</table>

Conventional RT vs. SBRT (II)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Conventional RT</th>
<th>SBRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redundancy in geometric verification</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Maintenance of high spatial targeting accuracy for the entire treatment</td>
<td>Moderately enforced (moderate patient position control and monitoring)</td>
<td>Strictly enforced (sufficient immobilization and high frequency position monitoring through integrated image guidance)</td>
</tr>
<tr>
<td>Need for respiratory motion management</td>
<td>Moderate – Must be at least considered</td>
<td>Highest</td>
</tr>
</tbody>
</table>

Conventional RT vs. SBRT (III)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Conventional RT</th>
<th>SBRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Training</td>
<td>Highest</td>
<td>Highest + special SBRT Training</td>
</tr>
<tr>
<td>Technology implementation</td>
<td>Highest</td>
<td>Highest</td>
</tr>
<tr>
<td>Radiobiological understanding</td>
<td>Moderately well understood</td>
<td>Poorly understood</td>
</tr>
<tr>
<td>Interaction with systemic therapies</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

So…What is SBRT?

Image Guidance

Stereotactic Radiosurgery

IMRT and Conformal 3D Delivery

SBRT

1. History and Rationale for SBRT
2. Current status of SBRT patient selection criteria
3. Simulation Imaging and Treatment Planning
4. Patient Positioning, Immobilization, Target localization, and Delivery
5. Special Dosimetry Considerations
6. Clinical Implementation of SBRT
7. Future Directions

A few brief TG101 topics in this talk..

1. Participation in SBRT clinical trials
2. Normal Tissue Tolerances
3. Normalized Tumor Doses
4. Patient Immobilization

SBRT Participation In Trials

Recommendation: The most effective way to further the radiation oncology community’s SBRT knowledge base is through participation in formal group trials

• Single- or multi- institution
• Ideally NCI-sponsored or NCI-cooperative groups (e.g. RTOG)
• If no formal trial, look to publications
• If no publications, structure as internal clinical trial
What is the most effective way to further the radiation oncology community’s SBRT knowledge base?

1. Industry research to improve the technology and delivery
2. Attendance at national and regional meetings
3. Participation in SBRT clinical trials, ideally NCI sponsored or NCI cooperative groups
4. Using the internet to promote the sophisticated features and capabilities.
5. Developing theoretical and computer based radiobiological models

Answer: 3

• Participation by clinicians in SBRT clinical trials, ideally NCI sponsored or NCI cooperative groups (ie, RTOG), but also single or multi-institutional protocols.

• Although industry research making improvement to our equipment, attendance at meetings by clinicians, and research into radiobiological modeling will advance our knowledge base – the most effective way to truly further our SBRT clinical knowledge base is by participation in clinical trials and communicating the analysis of the data to our clinicians. There is no evidence that promoting the features of medical equipment on the internet furthers our knowledge base of SBRT at all.

• Reference:

Normal Tissue Tolerances

Recommendation: Normal tissue dose tolerances in the context of SBRT are still evolving. So…. CAUTION!

• If part of an IRB-approved phase 1 protocol, proceed carefully

• Otherwise, the evolving peer-reviewed literature must be respected!

<table>
<thead>
<tr>
<th>Normal Tissue Tolerances</th>
<th>Table of Normal Tissue Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG 101: Table 3</td>
<td>SOMECAVEATS!</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table of Normal Tissue Tolerances

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

R. Timmerman, 10/26/09, pers. comm.

Normal Tissue Tolerances – Serial Tissue

<table>
<thead>
<tr>
<th>Normal Tissue Tolerances (Parallel)</th>
<th>One Fraction</th>
<th>Five Fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel Tissue</td>
<td>Threshold dose (Gy)**</td>
<td>Max point dose (Gy)**</td>
</tr>
<tr>
<td>Lung (right &amp; left)</td>
<td>≥0.2 cc</td>
<td>8 Gy</td>
</tr>
<tr>
<td>Liver</td>
<td>≤0.2 cc</td>
<td>16 Gy</td>
</tr>
<tr>
<td>Renal cortex (right &amp; left)</td>
<td>≤0.2 cc</td>
<td>16 Gy</td>
</tr>
</tbody>
</table>

Threshold dose (Gy)**: 25 Gy (5 Gy/fx) for serial tissue. 23 Gy (5 Gy/fx) for Parallel tissue.


Normal Tissue Tolerances – Serial Tissue

<table>
<thead>
<tr>
<th>Normal Tissue Tolerances – Serial Tissue</th>
<th>One Fraction</th>
<th>Five Fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Tissue</td>
<td>Max point dose (Gy)**</td>
<td>Threshold dose (Gy)**</td>
</tr>
<tr>
<td>Lung Pathway</td>
<td>8 Gy</td>
<td>10 Gy</td>
</tr>
<tr>
<td>Heart</td>
<td>16 Gy</td>
<td>22 Gy</td>
</tr>
<tr>
<td>Brainstem</td>
<td>&lt;0.5 cc</td>
<td>10 Gy</td>
</tr>
<tr>
<td>Spinal Cord and medulla</td>
<td>≤0.3 cc</td>
<td>10 Gy</td>
</tr>
<tr>
<td>Liver</td>
<td>&lt;20 cc</td>
<td>14 Gy</td>
</tr>
</tbody>
</table>

Threshold dose (Gy)**: 25 Gy (5 Gy/fx) for serial tissue. 23 Gy (5 Gy/fx) for Parallel tissue.

Biological Effects

• NOT the same as traditional radiation therapy!!!!
• Cannot extrapolate from the linear quadratic model!!!!
### Biological Dose Equivalents

<table>
<thead>
<tr>
<th>Total Physical Dose (Gy)</th>
<th>NTD&lt;sub&gt;3&lt;/sub&gt; (Gy)</th>
<th>Log&lt;sub&gt;10&lt;/sub&gt; Cell Kill</th>
<th>Estimated 30 mo local progression-free survival</th>
<th>NTD&lt;sub&gt;3&lt;/sub&gt; (Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 x 2 = 60° (in 6 weeks)</td>
<td>65</td>
<td>9.9</td>
<td>17.7 % (w. repopulation)</td>
<td>65</td>
</tr>
<tr>
<td>35 x 2 = 70° (in 7 weeks)</td>
<td>72</td>
<td>10.9</td>
<td>28.4 % (w. repopulation)</td>
<td>72</td>
</tr>
<tr>
<td>4 x 12 = 48</td>
<td>83</td>
<td>12.6</td>
<td>78.9 % (no repopulation)</td>
<td>144</td>
</tr>
<tr>
<td>3 x 15 = 45</td>
<td>94</td>
<td>14.2</td>
<td>90.8 % (no repopulation)</td>
<td>162</td>
</tr>
<tr>
<td>5 x 12 = 60</td>
<td>110</td>
<td>16.7</td>
<td>97.1 % (no repopulation)</td>
<td>180</td>
</tr>
<tr>
<td>3 x 20 = 60</td>
<td>150</td>
<td>22.7</td>
<td>&gt;99% (no repopulation)</td>
<td>276</td>
</tr>
<tr>
<td>3 x 22 = 66</td>
<td>176</td>
<td>26.7</td>
<td>&gt;99% (no repopulation)</td>
<td>330</td>
</tr>
</tbody>
</table>

* NTD = Normalized Tissue Doses estimated using an a/b of 10 (late) and 3 Gy (early).

### Managing Tumor Motion

**Dinkel et al. 2009, 3D time-resolved echo gradient echo technique combining parallel imaging with view sharing (TREAT) sequence, ~ 1 frame/sec; voxel size ~ 3 mm.**

**Simulation with Motion or Imaging Artifacts**

**Recommendation:** If target and/or critical structures cannot be localized accurately due to motion or metal artifacts…

**STOP!**

Do NOT pursue SBRT as a treatment option!

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

1. Utilize the deformable image registration features of the treatment planning system to develop a treatment plan
2. 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
3. Reduce the dose and/or fractionation from the standard protocol to account for the errors in localization
4. Use orthogonal (AP and lateral) kV planar imaging to develop a 2D plan for treatment and set-up.
5. Do not pursue SBRT as a treatment option.
Answer: 5

- 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:

Patient Positioning, Immobilization, Target Localization, and Delivery

Recommendation: For SBRT, image-guided localization techniques shall be used to guarantee the spatial accuracy of the derived dose distribution.

- Body frames and fiducial systems are OK for immobilization and coarse localization
- They shall NOT be used as a sole localization technique!

For thoracic and abdominal targets, a patient-specific tumor motion assessment is recommended for planning and delivery of SBRT. Which of the following is a suitable approach?

0% 1. Adoption of a body frame will allow the planning, localization, and delivery for all thoracic and abdominal targets.
0% 2. The use of external markers or fiducials will allow accurate assessment of tumor position and re-localization.
0% 3. Employing abdominal compression has been shown to eliminate the need for tumor motion assessment.
0% 4. Developing a standard protocol for all target margins in the treatment planning process will eliminate the need for a patient specific tumor motion assessment.
0% 5. The use of fiducials and body frames may be helpful for patient positioning in SBRT, but they are no substitute for employing IGRT technology, such as CBCT. SBRT requires IGRT.

Answer: 5

- For SBRT, image-guided localization techniques shall be used to guarantee the spatial accuracy of the derived dose distribution. Other techniques, such as body frames, fiducials, and abdominal compression may be employed but they are no substitute for IGRT technology.

Reference:
Patient Positioning, Immobilization, Target Localization, and Delivery

• It is crucial to maintain spatial accuracy throughout treatment delivery!
  • Integrated image-based monitoring
  • Aggressive immobilization

Development of Body Frames

Challenge: Creating a rigid external frame that will provide a repeatable reference for sites in the body.

What is frameless?

• Non-invasive frames provide repeatable (relocatable) immobilization.
• Designed for single or multiple treatments: Stereotactic radiotherapy
• Can be used for cranial and body sites
Relocatable ‘Frameless’ Frames

Frame-based spinal SRS

- University of Arizona experience
  - 45 Gy external radiation
  - previous XRT
  - 8-10 Gy for recurrent tumor in single fraction
- Setup aided by surgically implanted device that docked into external frame
- 5 patients followed median 6 months
  - Good local control and palliation described


‘Frameless’ Immobilization Systems

Lax, Blomgren SBF (Elekta)

BodyFIX (Elekta) www.products.elekta.com

Respiratory Motion Management

Recommendation: For thoracic and abdominal targets, a patient-specific tumor motion assessment is recommended.

- Quantifies motion expected over respiratory cycle
- Determines if techniques such as respiratory gating would be beneficial
- Helps in defining margins for treatment planning
- Allows compensation for temporal phase shifts between tumor motion and respiratory cycle
Simulation with motion or Imaging Artifacts

- **Recommendation:** If target and radiosensitive critical structures cannot be localized on a sectional imaging modality with sufficient accuracy because of motion and/or metal artifacts, SBRT should not be pursued as a treatment option.

SBRT Target Margins

Recommendation: At the current time, it remains difficult to base target margins directly on clinical results. The adequacy of ICRU definitions depend on:

- Understanding of how high absolute doses and sharp dose falloffs affect accuracy
- Limitations on in-house localization uncertainty
- Guidance from current peer-reviewed literature

Make an effort to gather and analyze your own clinical results to improve margin design!

Physicist Presence

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Fraction SRS</td>
<td>Physicist present for entire procedure</td>
</tr>
<tr>
<td>Multiple-Fraction SRS</td>
<td>Physicist present for 1st fraction and at setup of remaining fractions</td>
</tr>
<tr>
<td>SBRT</td>
<td>Physicist present for 1st fraction, and setup for every fraction to verify imaging, registration, gating, immobilization</td>
</tr>
</tbody>
</table>

SRS Event in the News...

Making a Complex Machine Even More Complex

1) Working with the Conference of Radiation Control Program Directors (CRCPD) and other stakeholders to create a database for the reporting linear accelerator and computed tomography-based medical errors.

2) Launching a significantly enhanced practice accreditation program, and beginning the development of additional accreditation modules specifically addressing new, advanced technologies such as IMRT, SBRT and brachytherapy.

3) Expanding our educational training programs to include specific courses on quality assurance and safety, and adding additional content to other educational programs.

4) Working with patient support organizations to develop tools for cancer patients and caregivers for use in their discussions with their radiation oncologist to help them understand the quality and safety programs at the centers where they are being treated. These tools will include questions to ask their treatment team, such as, “Do you have daily safety checks?” and “What kinds of safeguards do you have to make sure I’m given the right treatment?”

5) Further developing our Integrating the Healthcare Enterprise – Radiation Oncology (IHE-RO) connectivity compliance program to ensure that medical technologies from different manufacturers can safely transfer information to reduce the chance of a medical error.

6) Providing our members’ expertise to policymakers and advocating for new and expanded federal initiatives to help protect patients, including support for immediate passage of the Consistency, Accuracy, Responsibility and Excellence in Medical Imaging and Radiation Therapy (CARE) Act to require national standards for radiation therapy treatment team members; additional resources for the National Institute of Health’s Radiological Physics Center to evaluate the safety of treatments; and funding for a national reporting database.

ASTRO has committed to a six-point patient protection plan that will improve safety and quality and reduce the chances of medical errors… which of the following is not part of the plan?

0% 1. Working with the Conference of Radiation Control Program Directors (CRCPD) and other stakeholders to create a database for the reporting Therapists

0% 2. Developing new accreditation modules specifically addressing new technologies, such as SBRT

0% 3. Expanding our educational training programs to include specific courses on quality assurance and safety.

0% 4. Working with patient support organizations to develop tools for cancer patients and caregivers for use in their discussions with their radiation oncologist to help them understand the quality and safety programs.

0% 5. Committing to a single manufacturer for each specialized treatment delivery and thereby eliminating problems associated with combining different technologies transferring erroneous information between systems.

Answer: 2

• The majority of reported incidents were detected by the radiation therapists at the treatment unit and were found during a treatment appointment. Detection by the QC process was the next most common method of detection. Although QC checklists and checks by dosimetry and physicists are important, they are no substitute for vigilance at the machine, particularly on the first day of treatment.

• Reference:
  - Cunningham J, Coffey M, Knööö T, Holmberg O. Radiation Oncology Safety Information System (ROSIS)–profiles of participants and the first 1074 incident reports. Radiother Oncol. 2019;137:61–67
ASTRO, AAPM, ACR and other organizations have developed guidance documents aimed at understanding radiation risks.

- Several guidance documents aimed at understanding radiotherapy risks and mitigating radiotherapy errors have been forthcoming recently from national and international organizations; these include: the World Health Organization (WHO), the International Commission on Radiological Protection (ICRP), the National Health Service (NHS) of the United Kingdom and the Alberta Heritage Foundation for Medical Research.

- A list of some of the common factors contributing to radiotherapy incidents has been summarized from these documents and they include:

  - Lack of training, competence or experience
  - Inadequate staffing and/or skills levels
  - Fatigue and stress, staffing and skills levels
  - Poor design and documentation of procedures
  - Complexity and sophistication of new technologies
  - Over-reliance on automated procedures
  - Poor communication and lack of team work
  - Inadequate infrastructure and work environment
  - Changes in processes

The WHO has suggested a number of general preventative measures aimed at reducing radiotherapy errors:

- A thorough quality assurance program to reduce the risks of systematic equipment and procedural related errors;
- A peer review audit program to improve decision making throughout the treatment process;
- Extensive use of procedural checklists;
- Independent verification through all stages of the process;
- Specific competency certification for all personnel;
- Routine use of in-vivo dosimetry.

Common factors contributing to radiotherapy incidents

- Table 1: List of radiotherapy events reported to the NRC during the period 2005-2010

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Treatment Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient orientation entered incorrectly at MRT Scanner</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Technical error, not identified during CT imaging</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Malfunction of automatic positioning mechanism following re-localization</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Right trigeminal nerve was not visualized</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Facility not used in treatment (2 events)</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Machine not at setting for treatment</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Bead not secured to stereotactic device (2 events)</td>
<td>Wrong location treated</td>
</tr>
<tr>
<td>Selected calibration did not match planned</td>
<td>Wrong dose delivered</td>
</tr>
<tr>
<td>Physician mistakenly used 25 Gy instead of 18 Gy into planning system</td>
<td>Wrong dose delivered</td>
</tr>
<tr>
<td>Physician calculated prescription to 50% isodose instead of 40%</td>
<td>Wrong dose delivered</td>
</tr>
<tr>
<td>Microphone dislodged, causing stereotactic device to break</td>
<td>Treatment halted after 2 of 5 fractions</td>
</tr>
<tr>
<td>Couch moved during treatment</td>
<td>None, procedure interrupted</td>
</tr>
</tbody>
</table>

Radiation Oncology Safety Information System (ROSIS) – Profiles of participants and the first 1074 incident reports

Established in 2001, the aim of ROSIS is to collate and share information on incidents and near-incidents in radiotherapy, and to learn from these incidents in the context of departmental infrastructure and procedures.

A voluntary web-based cross-organizational and international reporting and learning system was developed.

ROSIS departments represent about 150,000 patients, 343 megavoltage (MV) units, and 114 brachytherapy units.

Discipline who detected the incident

- Therapist (n=117) 56%
- Dosimetrist 4%
- Other 3%
- Technical maintenance 0%
- Therapist (n=GT) 9%
- Oncologist 8%
- Physicist 9%
- Unknown 15%

Fig. 1. Discipline who detected the incident.

QA Incident Detection

Fig. 2. Quality assurance method by which the incident was detected.

A recent report by Cunningham et al on 1074 radiation oncology incident reports determined which discipline was most likely to detect an incident?

<table>
<thead>
<tr>
<th></th>
<th>1. Radiation Oncologists</th>
<th>2. Therapists</th>
<th>3. Physicists</th>
<th>4. Dosimetrists</th>
<th>5. Unknown, it has not been determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Answer: 2**

- The majority of reported incidents were detected by the radiation therapists at the treatment unit and were found during a treatment appointment. Detection by the QC process was the next most common method of detection. Although QC checklists and checks by dosimetry and physicists are important, they are no substitute for vigilance at the machine, particularly on the first day of treatment.

- **Reference:**
  

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### Serious SRS Events Reported

- A calibration error on a radiosurgery linac that affected 77 patients in Florida in 2004-2005
- Similar errors in measurement of output factors affecting 145 patients in Toulouse, France in 2006-2007, and 152 patients in Springfield, MO from 2004 to 2009
- An error in a cranial localization accessory that affected 7 centers in the U.S. and Europe
- Errors in failure to properly set backup jaws for treatments using small circular collimators affecting a single arteriovenous malformation patient at an institution in France, 3 patients at an institution in Evanston, IL.
Planning Aspects for New SBRT Program

Personnel Qualifications for an SRT 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>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish site or program goals, specific disease site, identify program specialist, develop guidelines for treatment, follow-up, and outcomes</td>
<td>Initially</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Develop resource requirements, personnel, physical plant, training</td>
<td>Initially</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Perform technology assessment to ensure the required proportion of qualified personnel in CyberKnife, Elintron, and TomoTherapy personnel</td>
<td>Initially</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Perform technology assessment to ensure the required proportion of qualified personnel in CyberKnife, Elintron, and TomoTherapy personnel</td>
<td>Initially</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Ensure personnel meets dose volume considerations</td>
<td>Initially</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Develop team to ensure the use of technical competencies and patient communication</td>
<td>Ongoing</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>&quot;Quality and Safety Considerations in SRS and SBRT&quot;, Solberg et al, Practical Rad Onc, 2011</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Personnel qualifications for a stereotactic program

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Duration or Frequency</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>All personnel must determine their level of education and fulfillment of their responsibilities through educational programs, have the appropriate educational programs, and their qualifications</td>
<td>Initially</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>All personnel must receive training in the step-by-step process required to implement the SBRT program</td>
<td>Ongoing</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>&quot;Quality and Safety Considerations in SRS and SBRT&quot;, Solberg et al, Practical Rad Onc, 2011</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Commissioning of a SRS Program

Table 3. Essential commissioning elements of a stereotactic program.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Duration</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate resources, specialized equipment, personnel, time, must be included and available prior to initiation of acceptance commissioning process and procedures.</td>
<td>6-10 weeks</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Independent assessment of technical equipment should be performed prior to initiating a clinical stereotactic program.</td>
<td>4-6 months</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>Comprehensive commissioning of stereotactic systems should include the range of stereotactic delivery parameters and techniques, and specifically addressing use of low-intrusively-reflecting stereotactic systems, and the use of technical equipment, should be performed prior to initiating a clinical stereotactic program.</td>
<td>2 years</td>
<td>Solberg et al, 2011</td>
</tr>
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<td>Independent verification of system commissioning, utilizing appropriate specialized resources such as those from the Radiation Physics Center, should be performed prior to initiating a clinical stereotactic program.</td>
<td>2-4 weeks</td>
<td>Solberg et al, 2011</td>
</tr>
<tr>
<td>&quot;Quality and Safety Considerations in SRS and SBRT&quot;, Solberg et al, Practical Rad Onc, 2011</td>
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Recommendations to guard against catastrophic failures:
- Principals
- Primary Reviews
- 2nd Reviews
Develop checklists for your program.

Appendix: Example checklists from 3 Institutions for SBRT

- Frame-based SRS Checklist
- Frameless SRS Checklist
- SBRT Spine Worklist
- SBRT Lung Worklist
- SRS Checklist
- Trigeminal neuralgia SRS checklist
- SBRT Checklist
- SBRT – Elekta SBRT Frame
- Beam Configuration
- Planning

“Quality and Safety Considerations in SRS and SBRT”, Solberg et al, Practical Rad Onc, 2011

Many tasks are repeated a number of times over the course of an SBRT treatment and the use of procedural checklists for all aspects of the process can be particularly effective at ensuring compliance and minimizing error.

Which of the following best describes the use of checklists for treatments?

1. Checklists are helpful for the initial stages of an SBRT program, but they may be removed from service once the staff have adequate experience.
2. The adoption of site specific checklists from other institutions with well established programs will usually suffice for another program initiating the same service.
3. Checklists are exclusively for the therapists to review and ensure that the patient has been set-up correctly and in accordance with the treatment plan.
4. Check-lists to be used prior to daily treatment must be customized to the particular treatment planning and delivery systems available at the institution.
5. Site specific and machine specific checklists should not be used since they will add much confusion to the therapists activities.
Answer: 4

- 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:
  - 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, “Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy” Practical Radiation Oncology (2011)

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Is all image guidance helpful.....
Be Efficient – Be Safe

Thank You!