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Distinction in Stereotactic Radiotherapy

Elevating Your Stereotactic Radiotherapy Practice to the Highest Standards

MANUAL

March 2021

ACKNOWLEDGMENTS

The RSS expresses its appreciation for the significant contributions and leadership of Simon Lo, MD, FACR, FASTRO, RSS Distinction in Stereotactic Radiotherapy Medical Director; Jaroslaw Hepel, MD, FACRO, ACRO Accreditation Medical Director; Stanley Benedict, PhD, FAAPM, FACMP, RSS Accreditation Physics Director; Claudio Sibata, PhD, ACRO Accreditation Physics Director; and Joanne Davis, PhD, RSS Executive Director for their efforts to drive this collaborative effort between the RSS and ACRO and to fulfill the vision of the Distinction in Stereotactic Radiotherapy program.

Appreciation is expressed to the RSS Board of Directors and ACRO Board of Directors for their support and commitment to the accreditation program and to the following RSS and ACRO members who have contributed and continue to contribute to the success of the Distinction in Stereotactic Radiotherapy.

Intracranial/CNS Committee: Iris Gibbs, MD (Disease Site Team Leader), Richard Bucholz, MD, Samuel Chao, MD, Jonathan Knisely, MD, Scott Soltys, MD

Spine Committee: Simon Lo, MD (Disease Site Team Leader), Peter Gerszten, MD, Zain Husain, MD, Kristin Redmond, MD, MPH

Lung Committee: Greg Videtic, MD, CM, FRCPC (Disease Site Team Leader), Rachelle Lanciano, MD, Jonathan Lischalk, MD, Arjun Pennathur, MD

Liver Committee: Karyn Goodman, MD (Disease Site Team Leader), Smith "Jim" Apisarnthanarax, MD, Michael Lock, MD, CCFP, FRCPC

Pancreas Committee: Anand Mahadevan, MD (Disease Site Team Leader), Joseph Herman, MD, Cullen Taniguchi, MD, PhD

Prostate Committee: Jonathan Haas, MD (Disease Site Team Leader), Sean Collins, MD, PhD, Constantine Mantz, MD, Najeeb Mohideen, MD, Michael Zelefsky, MD

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1. BACKGROUND

1.1. Stereotactic Radiosurgery/Stereotactic Body Radiotherapy

Stereotactic Radiosurgery (SRS) has historically been used to target intracranial lesions, but its application has been extended to extracranial sites. For the purpose of this program, in addition to standard accreditation, SRS is defined as stereotactic-guided radiotherapy to intracranial lesions in 1-5 fractions with 1 mm targeting accuracy. In the past 30 years, it has been used extensively for the treatment of various benign and malignant intracranial conditions and tumors with promising results.

Stereotactic body radiotherapy (SBRT), also often called stereotactic ablative radiotherapy (SABR), refers to the delivery of a high dose of radiation to an extracranial target within the body in 1-5 fractions. Very advanced treatment planning results in the delivery of high target dose but with a steep dose gradient beyond the target. The ability to deliver high doses of radiation in 1-5 fractions with high targeting accuracy and steep dose gradient beyond the target is a key set of characteristics of SBRT. Robust immobilization, respiratory motion control, meticulous and accurate delineation of target and organs-at-risk (OARs), application of appropriate dose constraints for OARs, advanced treatment planning, appropriate on-board imaging, and accurate treatment delivery quality assurance are all paramount to safe and successful treatment of patients with SBRT.

Given the high dose of radiation delivered and the very high accuracy and precision with SRS/SBRT, high technical skills and expertise and very stringent quality assurance processes are crucial to ensure safe and effective treatment delivery. Apart from the treatment aspects, appropriate selection of patients and post-SRS/SBRT evaluation, including response and toxicity assessment, and imaging are also essential in the delivery of excellent patient care.

1.2. The Radiosurgery Society® and American College of Radiation Oncology®

The Radiosurgery Society® (RSS) is a multi-disciplinary, non-profit professional medical society consisting of radiation oncologists, neurosurgeons, surgeons, medical physicists, dosimetrists, nurses, administrators, and healthcare providers dedicated to advancing the science and clinical practice of SRS and SBRT. The RSS aims to promote education, scholarly exchange of information, clinical research, adoption, and improvement of SRS/SBRT techniques and facilitate the development of SRS/SBRT treatment methods that offer the optimum in safety and efficacy for patients.

The American College of Radiation Oncology® (ACRO), is a professional medical organization whose mission is "to ensure the highest quality for radiation therapy patients and promotes success in the practice of radiation oncology through education, responsible socioeconomic advocacy, and integration of science and technology in the clinical practice." In 1995, ACRO developed its accreditation program, consisting of practice standards for radiation oncology. Practice accreditation is a voluntary process in which professional peers identify standards indicative of quality practice, and an audit is conducted to assure that these standards are followed. Since its establishment, ACRO Accreditation has undergone periodic revisions to reflect clinical and scientific advances within the field, providing for the safe and effective practice of radiation therapy. In 2020, ACRO recognized the rapidly changing landscape of radiation therapy with exceedingly more radiation centers and patients receiving SRS and SBRT, and as a result a need to develop a comprehensive accreditation program specific to SRS/SBRT clinical practice and physics quality assurance. **ACRO and the RSS have similar missions of advancing the field of radiation therapy through education, research and quality assurance programs. In support of the wide clinical adoption of SRS and SBRT, the RSS and ACRO have partnered to create a special accreditation program with a "Distinction in Stereotactic Radiotherapy" within the ACRO Accreditation Program.**

This document is provided to assist applicants seeking ACRO Accreditation and seeking special "Distinction of Stereotactic Radiotherapy" for single fraction SRS and hypo-fractionated (2-5 fractions) stereotactic radiotherapy and may include any or all of the following technologies: Cobalt-60 radiosurgery systems, dedicated or multi-functional linac-based machines, MRI-guided linacs, and robotic radiosurgery systems. The following anatomical sites will be considered for accreditation, including intracranial, spine, lung, liver, pancreas, and prostate.

The intent of this document is to (1) provide institutions with a step wise preparation of the documents needed for review of their program, (2) understand the metrics and ranking for evaluation, and (3) allow the reviewers an opportunity to follow-up on any issues identified for quality assessment of the program. The accreditation process is dynamic, and it is expected that the program itself will also undergo periodic review to ensure that it is providing optimal critical processes to promote quality improvement in SRS/SBRT, which in turn will serve the professional community in radiation oncology with a more informed and better trained staff, and promote safe, effective, and reliable service to patients.

2. DISTINCTION IN STEREOTACTIC RADIOTHERAPY PROGRAM MANAGEMENT

The purpose of the Distinction in Stereotactic Radiotherapy Committee is to assist centers in preparing to meet standards and guidelines as applicable to the specialty of SRS/SBRT. The Medical Director and Physics Director will oversee the Distinction in Stereotactic Radiotherapy Program and will report to the RSS Board of Directors (BOD).

2.1. Medical Director (reports to the RSS BOD)

- 2.1.1. Creates formal recommendations, based on the clinical audits performed by the disease site teams, the medical physics team reports and the onsite administrative reports.
- 2.1.2. Functions as the interface between the RSS BOD, the Disease Site Team Leaders, the Medical Physics Director, the ACRO Accreditation Medical Director and Administrative Director.
- 2.1.3. Forwards a formal report and recommendations of the accreditation status of each practice evaluated to the ACRO Medical Director and then to both the RSS and ACRO boards for review and action.
- 2.1.4. Prepares and forwards a formal report of the Distinction in Stereotactic Radiotherapy Program to the RSS BOD prior to each BOD meeting.
- 2.1.5. Represents the Distinction in Stereotactic Radiotherapy Program at meetings.

2.2. Disease Site Team Leader
(reports to the Medical Director)

- 2.2.1. Chairs the respective disease site team meetings.
- 2.2.2. Defines and updates chart review measures with other members of the disease site team in respective site annually or as needed.
- 2.2.3. Conducts annual review of measures with the Medical Director to assure relevance based on current medical literature.
- 2.2.4. Reviews chart measures with other members of the disease site team to assure appropriate chart measures.
- 2.2.5. Works with ACRO Accreditation staff to assure timely review of charts.
- 2.2.6. Assembles team of chart reviewers to review charts and programs seeking accreditation.
- 2.2.7. Interacts with other Disease Site Team Leaders and Medical Director to determine criteria for full/provisional/denied accreditation.
- 2.2.8. Serves on the Distinction in Stereotactic Radiotherapy Committee.

2.3. Disease Site Team Members
(reports to Disease Site Team Leader)

- 2.3.1. Defines and updates the chart review measures annually or as needed.
- 2.3.2. Reviews charts and programs for the respective disease site.
- 2.3.3. Makes recommendations to the Disease Site Team Leader to determine full/provisional/denied accreditation.

2.4. Medical Physics Director
(reports to RSS BOD and coordinates activities with Medical Director and ACRO Physics Director)

- 2.4.1. Oversees the medical physics aspects of the Distinction in Stereotactic Radiotherapy Program.
- 2.4.2. Chairs the RSS Distinction in Stereotactic Radiotherapy Physics Committee, provides advice and counsel on issues pertaining to medical physics as part of the practice of SRS/SBRT.
- 2.4.3. Defines and updates the medical physics accreditation criteria with other members of the physics team annually or as needed.
- 2.4.4. Creates formal recommendations, based on the standards of care within the field of medical physics.
- 2.4.5. Ensures that the on-site medical physics surveyors follow the guideline criteria, based on clinically accepted standards of care.
- 2.4.6. Forwards a formal report and recommendation of the accreditation status for each reviewed practice to the Medical Director and ACRO Physics Director for review and action.

2.5. Accreditation Physics Committee
(reports to Medical Physics Director)

- 2.5.1. Defines and updates the physics guidelines and criteria review measures annually or as needed.
- 2.5.2. Coordinates with on-site physics reviewers to follow-up on any questions, discrepancies and concerns as determined during the electronic physics review.
- 2.5.3. Makes recommendations to the Medical Director to determine full/provisional/denial accreditation.

2.6. ACRO Accreditation Staff

- 2.6.1. Provides administrative and management support to all aspects of ACRO Accreditation and Distinction in Stereotactic Radiotherapy Program.
- 2.6. 2. Interfaces with the practice coordinator to facilitate the accreditation process.
- 2.6.3. Works with Disease Site Team Leaders and Case Reviewers.
- 2.6.4. Schedules physics and administrative surveyors.
- 2.6.5. Issues final documentation of accreditation status.
- 2.6.6. Handles financial transactions.

3. APPLICANT ELIGIBILITY

For a practice to be considered eligible to apply for the Distinction in Stereotactic Radiotherapy, the applicant center must:

3.1. Be applying for or in process of practice accreditation through ACRO Accreditation and must ultimately achieve a status of "Full Accreditation".

3.2. Have an established SRS/SBRT practice with a minimum of two (2) years of SRS/SBRT experience.

3.3. Treat a minimum of 50 SRS/SBRT cases annually. The SRS/SBRT cases can be delivered using multiple platforms. The minimum number of 50 cases is the sum of all cases treated using different platforms annually.

4. DISTINCTION IN STEREOTACTIC RADIOTHERAPY PRACTICE REVIEW

4.1. Practice Demographics: During the review process, the specifics of the practice, as indicated below, are reviewed.

4.2. Contact person, address, telephone number and email address.

4.3. Type of practice and affiliations.

4.4. Annual number of consultations.

4.5. Annual number of new patients treated.

4.6. Annual number of patients re-treated.

4.7. Annual number of patients treated with curative intent, palliative intent, and for local tumor control.

4.8. Annual number of intracranial SRS/SRT courses for the past two (2) years.

4.9. Annual number of courses of SBRT treatments for the past two (2) years.

4.10. Anatomic sites and stages of diseases treated.

5. MEDICAL CHART REVIEW

5.1. For each Principal Practice, a minimum of five (5) charts will be reviewed with a minimum of two (2) charts per disease site. An attempt to represent the patient mix of the practice will be made by the Accreditation staff when selecting charts to be reviewed. The reviews are scored against established chart review measures. These measures have been approved by the Disease Site Team Leaders and the Distinction in Stereotactic Radiotherapy Committee and are provided in this manual.

5.2. The following processes and documents will be assessed during the online chart review.

- 5.2.1. Consultation and Referring Notes
- 5.2.2 Pathology
- 5.2.3. TNM Staging
- 5.2.4. Appropriate labs and imaging
- 5.2.5. Informed consent
- 5.2.6. Prescription dose
- 5.2.7. Treatment planning
- 5.2.8. Combined modality therapy
- 5.2.9. Simulation documents
- 5.2.10. Physician simulation requests and documentation
- 5.2.11. Simulation procedure and documentation
- 5.2.12. Dose calculation and/or computer planning
- 5.2.13. Treatment aids
- 5.2.14. SRS/SBRT treatment delivery
- 5.2.15 Treatment verification
- 5.2.16. Continuing medical physics consultation
- 5.2.17. SRS/SBRT treatment management
- 5.2.18. Follow-up medical care and imaging evaluation

5.3. Clinical Performance Measures: The following clinical documents must be part of each patient's record and will be reviewed as part of the chart audit.

- 5.3.1. Histopathologic diagnosis
- 5.3.2. Site of disease
- 5.3.3. Stage of disease
- 5.3.4. Pertinent history and physical examination performed by a Radiation Oncologist
- 5.3.5. Appropriate imaging reports
- 5.3.6. Appropriate laboratory reports
- 5.3.7. Treatment plan
- 5.3.8. Documentation of informed consent to treatment
- 5.3.9. Simulation record, when applicable
- 5.3.10. Dosimetry calculations

5.3.11. Graphic treatment plan (e.g., isodose distribution and dose volume histogram (DVH) when applicable

5.3.12. Daily and total radiation therapy dose and treatment volume records

5.3.13. Daily record of Radiation Oncologist's treatment management

5.3.14. Image(s) documenting each treatment field, when applicable

5.3.15. Treatment summary note

5.3.16. Follow-up medical care and imaging evaluation

5.4. Medical Chart Rating Forms: The Distinction in Stereotactic Radiotherapy Committee has chosen to base its assessment of the quality of clinical care on available guidelines and published articles. A list of references for each disease site can be found in Section 12 of this manual. Medical case reviews are carried out online by the team of Disease Site Reviewers reporting to the Disease Site Team Leader. Cases are made available on rotation to disease specific physicians based on their own expertise and clinical interest.

5.4.1. Disease Site Rating Forms: The following Disease Site Criteria are available in the manual. Please refer to these forms prior to submitting online documents.

- Intracranial Chart Review (page 15)
- Spine Chart Review (page 17)
- Lung Chart Review (page 22)
- Liver Chart Review (page 25)
- Pancreas Chart Review (page 29)
- Prostate Chart Review (page 33)

5.4.2. Scoring: Each medical chart review is graded using the Disease Site Criteria, with scores for various aspects of the chart. Each chart is scored on a 100-point basis. To achieve a passing score, each disease site must achieve the following:

5.4.2.1. The technical components including Simulation, Treatment Planning and Treatment Delivery must receive a minimum score of 80% for the technical component.

5.4.2.2. The total chart score must be 80 points or above to be considered as a pass.

If this standard is not met, a recommendation for provisional accreditation may be given for this section. If a provisional recommendation is given, the center will be notified of the concerns and recommendations and given an opportunity to address. If the center is not able to address the recommendations cited in the provisional accreditation or cannot meet the minimum standards, a recommendation of denied accreditation will be given.

6. PHYSICS REVIEW

The following physics processes and documents will be assessed for each Principal Practice and any additional practice during the onsite chart review. A physics upload checklist can be found on page 35. The reviews are scored against established physics review measures. The review criteria and measures have been approved by the Distinction in Stereotactic Radiotherapy Physics Committee and are included below with appropriate references. Please refer to these criteria before submitting your application. The following sections provide a list of items and criteria used to evaluate SRS/SBRT treatment machine commissioning, treatment planning system commissioning, CT simulation and motion management, commissioning and standard operating procedures, patient-specific quality assurance (QA), and plan peer reviews.

6.1. SRS/SBRT Treatment Machines of Three Common Platforms:

6.1.1. Gamma Knife® Radiosurgery System: The Leksell Gamma Knife Perfexion™ and Icon™ are dedicated, comprehensive intracranial SRS systems that include proprietary treatment planning systems (TPS) GammaPlan® (version 10.1 or 11.0). The following sections provide a list of items and criteria used to evaluate the competence of the institution to use Gamma Knife for SRS treatments.

6.1.1.1. Gamma Knife Radiosurgery System staff and training:

- Exceeds Expectations: Active continuous education for participants in neurosurgery, radiation oncology, and medical physics; and IRB-approved Gamma Knife Radiosurgery System clinical trials.
- Meets Expectations: Meets the minimum required by Federal and State requirements, with all neurosurgeons, radiation oncologists and medical physicists trained at a manufacturer-authorized training class. Such training is documented.
- Does Not Meet Expectations: Does not meet the minimum requirements provided in Federal and State requirements.

6.1.1.2. Gamma Knife Radiosurgery System caseload (annual number of treated cases correlates with safety and to maintain expertise/continuity in the SRS program):

- Meets Expectations: > 50 cases/year *
- Does Not Meet Expectations: < 50 cases/year *

*To be determined in consultation with ACRO surveyors.

6.1.1.3 Gamma Knife Radiosurgery System dose calculation and inhomogeneity correction algorithms have been commissioned:

- Exceeds Expectations: Convolution homogeneity correction with Leksell GammaPlan version 10.1, or version 11.0.

- Meet Expectations: GammaPlan 10.1 with no homogeneity correction.
- Does Not Meet Expectations: Other TPS models or GammaPlan versions.

6.1.1.4. Gamma Knife Radiosurgery System output calibration validation:

- Exceeds Expectations: All the items below, plus end-to-end (E2E) dosimetry measurements with an uncertainty analysis.
- Meets Expectations. Documents a third-party output validation, such as Imaging and Radiation Oncology Core (IROC) or Radiation Dosimetry Services (RDS), OSLD/TLD service obtained before initial clinical use and annual spot checks.
- Does Not Meet Expectations: Documents are not available or validation not performed before initial clinical use or annual spot checks.

6.1.1.5. Gamma Knife Radiosurgery System records of quality assurance QA documents:

- Exceeds Expectations: Exceeds federal and state requirements.
- Meets Expectations: Meets federal and state requirements for daily, monthly, and annual checks.
- Does Not Meet Expectations: Documents are not available or do not meet federal and state requirements.

6.1.1.6. Gamma Knife Radiosurgery System written directive:

- Exceeds Expectations: The written directive meets federal and state requirements and is documented in the patient's electronic medical record.
- Meets Expectations: The written directive meets federal and state requirements.
- Does Not Meet Expectations: Documents are not available or do not meet federal and state requirements.

6.1.1.7. Gamma Knife Radiosurgery System treatment checklists:

- Exceeds Expectations: A checklist is available which exceeds all the items below.
- Meets Expectations: A workflow checklist is used, which includes documentation for completing a timeout protocol. (Halvorsen et al., 2017).
- Does Not Meet Expectations: A checklist is unavailable or does not meet the recommendations, or a timeout protocol is not in place.

6.1.1.8. Gamma Knife Radiosurgery System shot coordinate check:

- Exceeds Expectations: The documented coordinate check procedure exceeds all items below.
- Meets Expectations: For trunnions, three separate individuals will confirm the set coordinates for each isocenter before exposure. For the Automatic Positioning System (Model 4C), Perfexion, or Icon, the downloaded isocenter coordinates will be checked by two individuals before start of treatment. The coordinate check will be documented.
- Does Not Meet Expectations: Documents are not available or do not meet the above expectation.

6.1.1.9. Gamma Knife Radiosurgery System physical presence requirement:

- Exceeds Expectations: Patient-specific database showing compliance with the items below.
- Meets Expectations: Written policy on the physical presence requirement of the authorized user and authorized medical physicist.
- Does Not Meet Expectations: Documents not available or do not meet the above expectation.

6.1.1.10. Requested Gamma Knife Radiosurgery System treatment planning documents:

- Type of TPS (manufacturer, model, and version) for Gamma Knife Radiosurgery System.
- Plans for all patients evaluated by radiation oncologist, with their plan criteria evaluations (planning target volume (PTV) coverage and OAR sparing).
- Acceptance testing and commissioning reports.
- Written procedures for daily, monthly, and annual quality assurance testing.
- Reports of most recent daily, monthly, and annual quality assurance tests.
- Written procedure for patient treatment process.
- Most recent calibration certificates for detector and electrometer used in annual quality assurance tests.
- Results of external audits (e.g., Imaging and Radiation Oncology Core (IROC) or Remote Dosimetry Services (RDS)).

6.1.1.11. Gamma Knife Radiosurgery System References:

- Manuals (4C, Perfexion and Leksell Gamma Knife Icon Licensing Guidance)
- Leksell Gamma Knife Perfexion and Leksell Gamma Knife Icon Licensing Guidance, Revision 0, May 25, 2016
- Halvorsen, P H, Cirino, E, Das, I J, Garrett, J, Yang, J, Yin F, Fairobent, L. (2017) AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS-SBRT. Journal of Applied Clinical Medical Physics. 18(5): 10-21.

6.1.2. CyberKnife® Robotic Radiosurgery System: The CyberKnife is a dedicated, comprehensive whole body robotic stereotactic radiotherapy systems that includes proprietary TPS MultiPlan® and Precision™ planning systems. Under the guidance of stereotactic x-ray imaging, the system applies motion management utilizing robotics to track and correct the motion of the patient and target. The following sections provide a list of items and criteria used to evaluate the competence of the institution to use CyberKnife for stereotactic radiosurgery treatments.

6.1.2.1. CyberKnife staff and training:

- Exceeds Expectations: Documentation of initial and ongoing training for radiation oncologist, physicists, therapists and dosimetrists.
- Meets Expectations: Documentation of initial training or on-job training for radiation oncologist, physicists, therapists and dosimetrists.
- Does Not Meet Expectations: No training or insufficient training performed or any documentation of training.

6.1.2.2. CyberKnife caseload (annual number of treated cases correlates with safety and to maintain expertise/continuity in the SRT program):

- Meets Expectations: > 50 cases/year *
- Does Not Meet Expectations: cases/year < 50 cases/year *

* To be determined in consultation with ACRO surveyors.

6.1.2.3 CyberKnife acceptance testing:

- Exceeds Expectations: Documentation of CyberKnife specific acceptance testing results for the functional tests, E2E tests under various tracking modalities, laser & radiation alignment above and beyond that provided in guidance documents (Benedict et al., 2010; Solberg et al., 2012).
- Meets Expectations: Documentation of acceptance testing according to American Association of Physicists in Medicine (AAPM) and American Society for Radiation Oncology (ASTRO) guidance documents (Benedict et al., 2010; Solberg et al., 2012).
- Does Not Meet Expectations: Does not meet minimum recommendations provided in the AAPM and ASTRO guidance documents.

6.1.2.4. CyberKnife commissioning:

- Exceeds Expectations: Small field measurements with appropriate detectors and scanning method including output factors and beam profiles; Documentation of SRS/SBRT specific commissioning procedures; E2E tests for both localization and dosimetric accuracy; Passing an independent E2E SRS/SBRT phantom test such as IROC.
- Meets Expectations: Small field measurements with appropriate detectors and scanning method including output factors and beam profiles; Documentation of SRS/SBRT specific commissioning procedures; E2E tests for both localization and dosimetric accuracy.
- Does Not Meet Expectations: Does not meet minimum recommendations provided in the AAPM and ASTRO guidance documents.

6.1.2.5. CyberKnife safety and QA:

- Exceeds Expectations: Documentation of ongoing practice quality improvement for SRS/SBRT techniques in accordance with guidance documents (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010). Presence of a departmental QA committee; Participation in national incident reporting system such at Radiation Oncology® Incident Learning System (ROILS).
- Meets Expectations: Documentation of ongoing Practice Quality Improvement for SRS/SBRT techniques in accordance with guidance documents (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010; Halvorsen et al., 2017). Presence of a departmental QA committee.
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010).

6.1.2.6. CyberKnife policies and procedures:

- Exceeds Expectations: Comprehensive policies and procedures for SRS/SBRT treatment of all disease sites encompassing simulation, contouring and treatment planning, image-guided treatment and routine QA safety (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010). Individual checklists for all related items, including treatment. Physicist direct supervision of simulation and all treatment fractions.
- Meets Expectations: Comprehensive policies and procedures for SRS/SBRT treatment of all disease sites encompassing simulation, contouring and treatment planning, and routine QA safety (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010). Physicist direct supervision of simulation and the first treatment fraction.
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010). No direct physicist supervision.

6.1.2.7 CyberKnife routine QA and patient-specific QA:

- Exceeds Expectations: Routine daily, monthly and annual QA performed per TG 135 (Dieterich et al., 2011) including imaging QA. E2E tests of all modalities performed monthly. Patient specific QA performed (cone, Iris™ variable aperture collimator, multi-leaf collimator (MLC)).
- Meets Expectations: Meeting minimum equipment QA and tolerances for CyberKnife, defined in AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS-SBRT (Halvorsen et al., 2017). Patient Specific QA performed (MLC only).

- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents. (Benedict et al., 2010; Solberg et al., 2012; Dieterich et al., 2011; Potters et al., 2010; Halvorsen et al., 2017). Patient specific QA not performed using MLC.

6.1.2.8 CyberKnife dosimetry:

- Exceeds Expectations: Monte Carlo (MC) algorithm with ≤ 1% uncertainty applied to all clinical cases with heavy tissue heterogeneity. No obvious planning technical error. Dose summation for re-treatment performed with appropriate software and evaluated clinically.
- Meets Expectations: MC algorithm available to evaluate clinical cases with heavy tissue heterogeneity. Minimum obvious planning technical error. Dose summation for re-treatment performed with appropriate software and evaluated clinically.
- Does Not Meet Expectations: MC algorithm not available to evaluate clinical cases with heavy tissue heterogeneity. Obvious planning error. Dose summation for multi-courses treatment performed with appropriate software and evaluated clinically.

6.1.2.9. CyberKnife references:

- Benedict SH, Yenice KM, Followill D, Galvin JM, Hinson W, Kavanagh B, Keall P, Lovelock M, Meeks S, Papiez L, Purdie T, Sadagopan R, Schell MC, Salter B, Schlesinger DJ, Shiu AS, Solberg T, Song DY, Stieber V, Timmerman R, Tome WA, Verellen D, Wang L, Yin FF. (2010) Stereotactic body radiation therapy: The report of aapm task group 101. Medical Physics 37:4078-4101.
- Solberg TD, Balter JM, Benedict SH, Fraass BA, Kavanagh B, Miyamoto C, Pawlicki T, Potters L, Yamada Y. (2012) Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy: Executive summary. Practical Radiation Oncology 2:2-9.
- Dieterich S, Cavedon C, Chuang CF, Cohen AB, Garrett JA, Lee CL, Lowenstein JR, d'Souza MF, Taylor DD Jr, Wu X, Yu C. (2011) Report of AAPM TG 135: quality assurance for robotic radiosurgery. Medical Physics 38(6):2914-36.
- Klein EE, Hanley J, Bayouth J, Yin FF, Simon W, Dresser S, Serago C, Aguirre F, Ma L, Arjomandy B, Liu C, Sandin C, Holmes T, Task Group AAoPiM. (2009) Task group 142 report: Quality assurance of medical accelerators. Medical Physics 36:4197-4212.
- Potters L, Kavanagh B, Galvin JM, Hevezi JM, Janjan NA, Larson DA, Mehta MP, Ryu S, Steinberg M, Timmerman R, Welsh JS, Rosenthal SA. (2010) American Society for Therapeutic R, Oncology, American College of R. American society for therapeutic radiology and oncology (ASTRO) and american college of radiology (ACR) practice guideline for the performance of stereotactic body radiation therapy. International Journal of Radiation Oncology, Biology, Physics 76:326-332.
- Halvorsen, P H, Cirino, E, Das, I J, Garrett, J, Yang, J, Yin F, Fairobent, L. (2017) AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS-SBRT. Journal of Applied Clinical Medical Physics. 18(5): 10-21.

6.1.3. L-shaped Linac Systems: With the recent technical advance of Volume Modulated Arc Therapy (VMAT) and image guidance, L-shaped Linac machines have gained popularity to deliver SRS/SBRT treatments, compared to other specialized machines such as Gamma Knife and CyberKnife. The goal of this section is to provide a list of items and ranking criteria to evaluate the competence of the institution to use L-shaped Linac machines for SRS/SBRT treatments. This section does not discuss motion management and patient specific QA, which are detailed in separate sections.

6.1.3.1. L-Shaped Linac staff and training:

- Exceeds Expectations: Documentation of initial and ongoing training for radiation oncologist, physicists, therapists, and dosimetrists.
- Meets Expectations: Documentation of initial training for physicists, therapists, and dosimetrists.
- Does Not Meet Expectations: No training performed or any documentation of training.

6.1.3.2. L-Shaped linac caseload (annual number of treated cases correlates with safety and to maintain expertise/continuity in the stereotactic radiotherapy program):

- Meets Expectations: > 50 cases/year *
- Does Not Meet Expectations: cases/year < 50 cases/year *

* To be determined in consultation with ACRO surveyors.

6.1.3.3. L-Shaped Linac acceptance testing:

- Exceeds Expectations: Documentation of SRS/SBRT specific acceptance testing results for the beam model (TPS), Linac and related MLC and imaging systems, above and beyond that provided in guidance documents (Benedict et al., 2010; Solberg et al., 2012)
- Meets Expectations: Documentation of acceptance testing according to AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012)
- Does Not Meet Expectations: Does not meet minimum recommendations provided in the AAPM and ASTRO guidance documents.

6.1.3.4. L-Shaped Linac commissioning:

- Exceeds Expectations: Small field measurements with appropriate detectors including output factors and beam profiles; documentation of SRS/SBRT specific commissioning procedures; E2E testings for both localization and dosimetric accuracy; passing an independent E2E SRS/SBRT phantom test such as IROC.

- Meets Expectations: Small field measurements with appropriate detectors including output factors and beam profiles; documentation of SRS/SBRT specific commissioning procedures; E2E testings for both localization and dosimetric accuracy. Tests performed based on recommendations provided in guidance documents (Benedict et al., 2010; Ezzell et al., 2009; Klein et al., 2009).
- Does Not Meet Expectations: Does not meet minimum recommendations provided in the AAPM and ASTRO guidance documents.

6.1.3.5. L-Shaped Linac safety and QA program:

- Exceeds Expectations: Documentation of ongoing practice quality improvement for SRS/SBRT techniques in accordance with guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010). Presence of a departmental QA committee; participation in national incident reporting system such at ROILS.
- Meets Expectations: Documentation of ongoing practice quality improvement for SRS/SBRT techniques in accordance with guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010). Presence of a departmental QA committee.
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010).

6.1.3.6. L-Shaped Linac policies and procedures:

- Exceeds Expectations: Comprehensive policies and procedures for SRS/SBRT treatment of all disease sites encompassing simulation, contouring and treatment planning, image-guided treatment and routine QA safety (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010). Individual checklists for all related items, including treatment. Physician direct supervision of simulation and all treatment fractions.
- Meets Expectations: Comprehensive policies and procedures for SRS/SBRT treatment of all disease sites encompassing simulation, contouring and treatment planning, and routine QA safety (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010). Physicist direct supervision of simulation and the first treatment fraction.
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010). No direct physicist supervision.

6.1.3.7. L-Shaped Linac Routine QA: Daily QA:

- Exceeds Expectations: Perform Winston-Lutz test prior to every treatment fraction; daily laser localization is within 1 mm; daily collimator size indicator is within 1 mm.
- Meets Expectations: Only perform Winston-Lutz test prior to the first treatment fraction. Daily laser localization is within 1 mm; daily collimator size indicator is within 1 mm.
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010).

6.1.3.8. L-Shaped Linac Routine QA - MLC:

- Exceeds Expectations: Testing of MLC leaf position accuracy and travel speed within 1 mm prior to every treatment fraction.
- Meets Expectations: Testing leaf position accuracy and travel speed within 1 mm monthly.
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010).

6.1.3.9. L-Shaped Linac Routine QA - Imaging:

- Exceeds Expectations: Daily testing of positioning/repositioning accuracy within 1 mm; daily testing of imaging and treatment coordinate coincidence within 1 mm (Klein et al., 2009).
- Meets Expectations: Daily testing of positioning/repositioning accuracy within 1mm; Daily testing of imaging and treatment coordinate coincidence within 1 mm (Klein et al., 2009).
- Does Not Meet Expectations: Does not meet minimum recommendations provided for safety in the AAPM and ASTRO guidance documents (Benedict et al., 2010; Solberg et al., 2012; Potters et al., 2010).

6.1.3.10 L-Shaped Linac Equipment Tertiary Collimators:

- Exceeds Expectations: Smallest conical collimator is less than 4 mm or smallest leaf MLC width is less than 3 mm (Benedict et al., 2010).
- Meets Expectations: Smallest conical collimator is less than 6 mm or smallest leaf MLC width is less than 5 mm (Benedict et al., 2010).
- Does Not Meet Expectations: Smallest conical collimator is more than 6 mm or smallest leaf MLC width is more than 5 mm.

6.1.3.11. Equipment Delivery:

- Exceeds Expectations: Beams are delivery by non-coplanar arcs.
- Meets Expectations: Beams are delivery by coplanar arcs or more than 9 static gantry angles (Benedict et al., 2010).
- Does Not Meet Expectations: Beams are delivered by static gantry only with less than 9 angles.

6.1.3.12. L-Shaped Linac references:

- Benedict SH, Yenice KM, Followill D, et al. (2010) Stereotactic body radiation therapy: The report of AAPM task group 101. Medical Physics 37:4078-4101.
- Ezzell GA, Burmeister JW, Dogan N, et al. (2009)

Imrt commissioning: Multiple institution planning and dosimetry comparisons, a report from aapm task group 119. Medical Physics 36:5359-5373.

- Klein EE, Hanley J, Bayouth J, et al. (2009) Task group 142 report: Quality assurance of medical accelerators. Medical Physics 36:4197-4212.
- Potters L, Kavanagh B, Galvin JM, et al. (2010) American Society for Therapeutic Radiology and Oncology (ASTRO) and American College Of Radiology (ACR) practice guideline for the performance of stereotactic body radiation therapy. International Journal of Radiation Oncology, Biology, Physics 76:326-332.
- Solberg TD, Balter JM, Benedict SH, et al. (2012) Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy: Executive summary. Practical Radiation Oncology 2:2-9.

6.2. SRS/SBRT Treatment Planning System Evaluation: Treatment Planning System (TPS) is a computerized system that allows clinicians to plan and view the radiation dose distributions that are prescribed to the patient. Clinicians rely on the dose distributions calculated by the TPS to determine or modify the treatment parameters, optimizing the target dose and normal tissue sparing.

Stereotactic radiotherapy utilizes a larger fractional dose in fewer fractions than traditional radiation therapy, aiming to increase the biological damage to the tumor. It is of great concern to minimize the toxicity of nearby OAR and therefore, SRS/SBRT is often limited to smaller targets and requires a highly focused dose to the tumor with a sharper dose fall-off to achieve acceptable doses to OAR. The goal of this section is to provide a list of items for the evaluation of TPS and their ranking criteria in the Distinction in Stereotactic Radiotherapy to ensure the accuracy of the TPS dose calculation, especially for small fields, and to maintain the level of safety in the overall treatment planning process required for SRS/SBRT.

6.2.1. Staff and Training:

- Exceeds Expectations: Exceeds the minimum requirements provide in the AAPM guideline (TG 101).
- Meets Expectations: Meets the minimum requirements provided in the AAPM guideline. Training provided by manufacturer for TPS for at least one of the SRS/SBRT team.
- Does Not Meet Expectations: Does not meet the minimum requirements provided in the AAPM guideline.

6.2.2. Caseload (Minimum number of cases is needed to maintain expertise/continuity in the stereotactic radiotherapy program):

- Meets Expectations: > 50 cases/year *
- Does Not Meet Expectations: cases/year < 50 cases/year *

* To be determined in consultation with ACRO surveyors.

6.2.3. Dose calculation and inhomogeneity correction algorithms:

- Exceeds Expectations: Radiation transport-based algorithms, e.g., Monte Carlo and Acuros® XB (Boltzmann transport equations), are used for stereotactic radiotherapy.
- Meets Expectations: Model-based algorithms accounting for electron scattering in heterogeneous tissues are considered, e.g., Analytical Anisotropic Algorithm (AAA) and Collapsed Cone Convolution (CCC), are used for stereotactic radiotherapy.
- Does Not Meet Expectations: Correction factor-based algorithms or model-based algorithms not accounting for electron scattering in heterogeneous tissues, are used for stereotactic radiotherapy e.g., pencil beam convolution (PBC) are used for lung SBRT.

6.2.4. Small field data acquisition and scanning resolution:

- Exceeds Expectations: Documents describing the methods for small field data acquisition including validation of the model for smaller field size such as 2x2 or 1x1 cm2. TPS scanning resolutions are available and exceed established AAPM guidelines.
- Meets Expectations: Documents describing the methods for small field data acquisition including validation of the model for the smallest field size used clinically meet the requirements of AAPM guidelines.
- Does Not Meet Expectations: Documents are not available or do not meet AAPM guidelines.

6.2.5. TPS validation:

- Exceeds Expectations: Third party phantom-specific validation under small field conditions including tissue heterogeneity (if appropriate) such as IROC is available.
- Meets Expectations: In-house validation is available, meeting the minimum requirements in AAPM TG-53 and AAPM TG-142.
- Does Not Meet Expectations: Documents are not available or do not meet the requirements specified in AAPM TG-53 or TG 142.

6.2.6. Imaging utilized for target delineation (co-registration):

- Exceeds Expectations: Rigid and deformable image registration (IR) tools and validation of them (as specified in AAPM TG 132) are available for multiple imaging modalities including MR and PET.

- Meets Expectations: Documents describing the IR tools meeting and validation of them as specified in the AAPM TG 132 are available.
- Does Not Meet Expectations: Documents are not available or do not meet AAPM validation requirements for use of IR in the clinic.

6.2.7. Records of QA documentation for the TPS:

- Exceeds Expectations: Exceeds the requirements in AAPM TG 53 and periodic QA documents include small field dosimetry checks.
- Meets Expectations: Meets the requirements in AAPM TG-53
- Does Not Meet Expectations: Documents are not available or do not meet AAPM guidelines.

6.2.8. E2E testing (imaging-specific tests and dosimetric tests):

- Exceeds Expectations: Documents for E2E tests including phantoms incorporating motion and/or heterogeneity (if appropriate) are available and validated by the third party such as IROC.
- Meets Expectations: Documents for E2E testing are available and measurements are in agreement with AAPM guidelines.
- Does Not Meet Expectations: Documents are not available or do not meet AAPM guidelines.

6.2.9. Established plan evaluation metrics and criteria for SRT plans:

- Exceeds Expectations: Plan evaluation metrics and criteria are well-defined per site and in agreement with guidelines such as QUANTEC and TG 101 and the automatic evaluation tool is available.
- Meets Expectations: Plan evaluation metrics and criteria are well-defined.
- Does Not Meet Expectations: No clear plan evaluation metrics and criteria are available or do not meet AAPM guidelines.

6.2.10. Treatment planning checklists (Beam Geometry, heterogeneity correction, etc.):

- Exceeds Expectations: A checklist exceeding the AAPM guideline requirements is automatically generated from the TPS.
- Meets Expectations: A checklist is available and meets the requirements of the AAPM guidelines.
- Does Not Meet Expectations: A checklist is unavailable or does not meet the requirements of AAPM guidelines.

6.2.11. Images from TPS:

- Exceeds Expectations: Digitally reconstructed radiographs (DRRs) for setup verification and/or CT are automatically exported to oncology information system and are used as an independent check of patient setup daily, and during physics initial and weekly chart review.
- Meets Expectations: DRRs for setup verification and/or CT are manually exported to oncology information system and are used as an independent check of patient setup.
- Does Not Meet Expectations: DRRs for setup verification and/or CT are not exported to oncology information system and are not used as an independent check of patient setup.

6.2.12. Requested TPS documents:

- Type of TPS (manufacturer, model, and version) for SRS/SBRT
- Plans for all patients evaluated by physician(s) and their plan criteria evaluations (PTV coverage and OAR sparing)
- Test plans used for commissioning
- Clinical protocol participation (if applicable)
- Stereotactic radiotherapy scorecards (checklists for planning)

6.2.13. TPS references:

- Manual for ACRO Accreditation, 2017
- AAPM MPPG 5.a. (2015) Commissioning and QA of Treatment Planning Dose Calculations – Megavoltage Photon and Electron Beams
- Fraass B, Doppke K, Hunt M, Kutcher G, Starkschall G, Stern R, Van. Dyk J. (1988) American Association of Physicists in Medicine Radiation. Therapy Committee Task Group 53: Quality assurance for clinical radiotherapy treatment planning. Medical Physics 25: 1773-1829.
- AAPM TG 101. (2010) Stereotactic body radiation therapy.
- Solberg, T.D., Balter, J.M., Benedict, S.H., Fraass, B.A., Kavanagh, B.D., Miyamoto, C., Pawlicki, T., Potters, L., Yamada, Y. (2012) Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy: Executive summary (Supplemental Material On-Line: Full Text), Practical Radiation Oncology 2: 2–9.
- AAPM TG 53. (1998) Quality assurance of clinical radiotherapy treatment planning.
- AAPM TG 132. (2017) Use of image registration and fusion algorithms and techniques in radiotherapy.

6.3. CT Simulation and Motion Management - Respiratory motion can have a significant effect on dosimetry. Up to 5cm of tumor motion has been measured which exceeds the size of typical margins (Keall et al., 2006; Langen et al., 2001). Motion as high as 4 cm has been observed for abdominal organs (Keall et al., 2006; Langen et al., 2001). With the use of on-board imaging and stereotactic techniques, smaller margins may be desired exacerbating this problem. Therefore, several techniques can be employed to measure this motion and to limit its effects on dosimetry (Keall et al., 2006; Brandner et al., 2006). These techniques start with identifying and measuring the motion. Next, a means for accounting for the motion must be chosen (treat the full range of motion, gate the treatment, or restrict the motion). The treatment planning must account for the measured motion in accordance with the means chosen to account for it. Plan QA must assure that the plan is done, and the treatment is prepared to account for the motion. The treatment must be delivered using the proper motion control (Keall et al., 2006; Slotman et al., 2006). In addition, the physicist is responsible for checking the tools and techniques to assure that they perform as intended (Keall et al., 2006). The following will help the reviewer understand:

- The role of the various individuals involved in motion management planning
- How motion is evaluated
- What motion management techniques are used
- The criteria used to determine what motion management techniques to apply
- How the motion management techniques are incorporated into treatment planning and delivery
- Treatment plan QA pertaining to motion management
- Treatment delivery QA pertaining to motion management
- QA of motion management equipment and techniques

6.3.1. Treatment volumes for respiratory motion:

- Exceeds Expectations: Target(s) and critical organs in thorax and abdomen are identified and evaluated.
- Meets Expectations: Target(s) and critical organs in abdomen and mid and lower lobes of lungs identified and evaluated.
- Does Not Meet Expectations: Target(s) and critical organs in thorax only are identified and evaluated.

6.3.2. Techniques used for assessing motion measurement:

- Exceeds Expectations: 4DCT or 4DMR
- Meets Expectations: Fluoroscopy or ultrasound
- Does Not Meet Expectations: No techniques used or described.

6.3.3. Physician involvement:

- Exceeds Expectations: Observes respiratory cycle, observes set up including respiration surrogates, reviews motion (i.e., cine), chooses treatment phases based on motion.
- Meets Expectations: Observes respiratory cycle, observes set up including respiration surrogates reviews motion (i.e., cine), chooses treatment phases based on motion.
- Does Not Meet Expectations: Only reviews a summary of the motion without reviewing the motion imaging personally.

6.3.4. Physicist involvement:

- Exceeds Expectations: Assist with 4D imaging; assist with motion measurement; assist with planning; assist with gated treatment; QA of plan, imaging, gated treatment.
- Meets Expectations: Assist with motion measurement; QA of plan, imaging, gated treatment.
- Does Not Meet Expectations: If not involved in motion analysis.

6.3.5 Displacement value to determine if gating or motion limiting devices will be used:

- Exceeds Expectations: 0.5 cm
- Meets Expectations: 1.0 cm
- Does Not Meet Expectations: Displacement > 1.0 cm without justification.

6.3.6. Process used to verify adequate coverage during planning:

- Exceeds Expectations: Review extremes of treatment phases, review maximum-intensity-projections (MIP) of thorax.
- Meets Expectations: Fluoroscopy or ultrasound, review MIP or average-IP of abdomen.
- Does Not Meet Expectations: No imaging is reviewed.

6.3.7. Process used to verify adequate coverage at the time of treatment:

- Exceeds Expectations: Fluoroscopy, repeat 4DCT or 4D MR
- Meets Expectations: Ultrasound or CBCT
- Does Not Meet Expectations: No imaging is reviewed.

6.3.8. How often adequate coverage is verified:

- Exceeds Expectations: Daily
- Meets Expectations: Once during treatment
- Does Not Meet Expectations: No imaging is reviewed.

6.3.9. Is coaching used?

- Meets Expectations: Yes
- Does Not Meet Expectations: No

6.3.10. What limits use of gating?

- Exceeds Expectations: Short breathing period (for instance, < 3 seconds), inability to follow coach, poor reconstruction of 4DCT or other imaging.
- Meets Expectations: Poor reconstruction of 4DCT or other imaging.

6.3.11. Respiratory phases used for treatment (if gating used):

- Exceeds Expectations: Around end expiration or breath hold. End expiration is more reproducible, coaching is highly recommended for end inspiration and breath hold if gating is used.
- Meets Expectations: Around end inspiration, all phases are used with margins based on measured motion.
- Does Not Meet Expectations: All phases but motion measurements are not used to define margins.

6.3.12. Techniques to track treatment phases (if gating used):

- Exceeds Expectations: External surrogate (RPM, VisionRT), frequent X-ray (CyberKnife), spirometry, internal surrogate (Calypso®).
- Meets Expectations: Other than described above.
- Does Not Meet Expectations: No tracking used.

6.3.13. Verify end to end process (if gating used):

- Exceeds Expectations: Annual or other.
- Does Not Meet Expectations: No QA performed.

6.3.14. Verify accuracy of time measurements (imaging and treatment), if gating used:

- Exceeds Expectations: Monthly.
- Meets Expectations: Annually.
- Does Not Meet Expectation: No QA performed.

6.3.15. Verify accuracy of amplitude measurements (imaging and treatment), if gating used:

- Exceeds Expectations: Monthly.
- Meets Expectations: Annually.
- Does Not Meet Expectation: No QA performed.

6.3.16. Verify gating, if gating used:

- Exceeds Expectations: Monthly.
- Meets Expectations: Annually.
- Does Not Meet Expectation: No QA performed.

6.3.17. Motion limiting devices if used:

- Meets Expectations: Abdominal compression, respiration restrictor.
- Does Not Meet Expectation: No description of devices.

6.3.18. Motion management references:

- Keall PJ, Mageras GS, Balter JM, et al. (2006) The management of respiratory motion in radiation oncology report of AAPM Task Group 76. Medical Physics 33:3874–3900.
- Langen KM, Jones DTL (2001) Organ motion and its management. Int J Radiat Oncol Biol Phys. 50:265–278.
- Brandner ED, Heron D, Wu A, Huq MS, Yue NJ, Chen H. (2006) Localizing moving targets and organs using motion-managed CTs. Med Dosimetry 31:134–140.
- Slotman BJ, Lagerwaard FJ, Senan S. (2006) 4D imaging for target definition in stereotactic radiotherapy for lung cancer. Acta Oncol. 45:966–972.

6.4. Patient Specific Quality Assurance (QA) Procedures: Patient specific intensity-modulated radiotherapy (IMRT) QA measurements are important components of processes designed to identify discrepancies between calculated and delivered radiation doses. IMRT QA verification is an important process employed to check the accuracy of IMRT plan dose calculations and to detect clinically relevant errors in the radiation delivery, thereby ensuring the safety of patients and fidelity of treatment. Measurement-based patient specific IMRT QA methods are widely used and are the core element of most IMRT QA programs.

6.4.1. Documentation of process:

- Exceeds Expectations: Electronic documentation of the patient specific QA process that can be found on a platform that indicates dates of revisions and modifications, content of revisions and individuals.
- Meets Expectations: Electronic or paper documentation that is accessible by staff.
- Does Not Meet Expectations: No documentation.

6.4.2. Phantom:

- Meets Expectations: Phantom is composed of either uniform material (plastic/solid water) or known substances (eg, 2-D array) that can be modelled in or a CT scan used in the treatment planning system.
- Does Not Meet Expectations: The phantom is not modelled in the treatment planning system. Phantom is composed of unknown material and not CT scanned into the treatment planning system.

6.4.3. Electronic Portal Imaging Device (EPID):

- Exceeds Expectations: Corrections to the QA measurements are made to correct for operational characteristics (detector response, arm sag, etc).
- Meets Expectations: Limits in using EPID for patient specific QA are clearly outlines in procedures (eg, maximum dose, dose rate, energies that the EPID can still be used). Documentation of the calibrations

are kept and a clear department policy on calibration frequency exists. Commissioning documentation exists following the recommendations of TG 58.

6.4.4. Measuring device:

- Meets Expectations: Documentation of periodic calibration (or calibration check) of devices used.
- Does Not Meet Expectations: Lack of documentation of calibration of measuring device (eg, EPID, 2D array, chambers, etc).

6.4.5. Dose calculation:

- Meets Expectations: for Phantom/CT based QA, uses advanced dose calculation algorithms (eg, in Eclipse™, Analytical Anisotropic Algorithm (AAA) or Acuros®XB). For EPID based portal dosimetry, calculation algorithm is most recent. Calculations are with dose heterogeneity corrections. Material overrides are indicated, and reasons given (in documentation or procedures). Documentation exists for the commissioning of the TPS and Portal dosimetry programs.
- Does Not Meet Expectations: No using latest version of dose calculation in TPS.

6.4.6. Algorithms:

- Meets Expectations: uses advanced dose calculation algorithms (e.g., in Eclipse, AAA or Acuros XB) or most recently updated EPID portal dosimetry
- Does Not Meet Expectations: No using latest version of dose calculation in TPS or Portal dosimetry. Pencil beam algorithms are not acceptable.

6.4.7. Heterogeneity corrections:

- Meets Expectations: Algorithms that account for 3D scatter integration must be used, such as Monte Carlo based calculation algorithms, or at the very least AAA or Acuros. Heterogeneity corrections should be used, or the departmental procedure should outline when it is not.
- Does Not Meet Expectations: Not using heterogeneity corrections.

6.4.8. Calculation resolution:

- Meets Expectations: Same as calculation resolution grid used for planning. For small targets, this should be the highest resolution the TPS allows, at minimum 2mm grid size (3 mm is discouraged).
- Does Not Meet Expectations: Using a low-resolution calculation grid (3mm or greater) that causes a loss of information due to interpolation.

6.4.9. Analysis:

- Meets Expectations: Results are analyzed using standard dose difference, DTA, analysis, and verification metrics. Tolerances and action limits are well defined following (or tighter than) those in AAPM Task Group 218 (2018) Tolerance Limits and methodologies for IMRT measurement-based verification QA..
- Does Not Meet Expectations: No analysis or only partial analysis of the results. Lower tolerance values than in AAPM Task Group 218 (2018) Tolerance Limits and methodologies for IMRT measurement-based verification QA.

6.4.10. Documentation of QA results:

- Meets Expectations: Documentation containing patient identification information is stored in the patient EMR. Shows that the plan run for QA is the plan to be checked. Shows equipment used for QA test. Shows the data and analysis of the QA test. Indicates pass/fail criteria. If tests fail, indicate the next steps.
- Does Not Meet Expectations: documentation is not attached to the patient record. Documentation lacks analysis.

6.4.11. Policies regarding IMRT QA failures:

- Meets Expectations: Clear guidelines and policies exist in the department regarding QA failures following best practice outlines in AAPM Task Group 218 (2018) Tolerance Limits and methodologies for IMRT measurement-based verification QA..
- Does Not Meet Expectations: No policies exist.

6.4.12. References for patient-specific QA:

- Tolerance limits and methodologies for IMRT measurement-based verification QA: Recommendations of AAPM Task Group No. 218.
- Clinical use of electronic portal imaging: Report of AAPM Radiation Therapy Committee Task Group 58.
- Stereotactic body radiation therapy: The report of AAPM Task Group 101.

6.5. Training: Center to provide documentation or certificate of training that was completed.

6.6. Adopting New and Emerging Technology for Stereotactic Radiotherapy: Center to provide description of preparations for new resources, staff, training, QA, planning, etc.

6.7. Clinical Trials (Optional)– Center to provide list of clinical trials they are participating in.

6.8. Physics Review Rating Forms: Physics reviews are carried out by the onsite ACRO physics surveyor. Cases are made available on rotation to medical physicists based on their own expertise. Each review is graded using a standard form.

6.9. Follow-up Physics Review: If discrepancies, deviations, or questions regarding physics documents, processes, or policies, additional follow-up may be performed during an on-site physics review.

7. RADIATION THERAPY PERSONNEL FOR SRS/SBRT TREATMENT DELIVERY

The processes and documentation for the radiation therapy personnel during SRS/SBRT treatment will be assessed for each Principal Practice and any additional practice during the physics review. A Radiation Therapy Checklist should be made available for review. Refer to these references for personnel requirements and proper documentation.

Potters, L., Kavanagh, B., Glavin, J., Hevezi, J., Janjan, N., Larson, D., Mehta, M., Ryu, S., Steinberg, M., Timmerman, R., Welsh, J., and Rosenthal, S. (2010) American Society for Therapeutic Radiology and Oncology and American College of Radiology Practice Guidelines for the Performance of Stereotactic Body Radiation Therapy. Int. J. Radiation Oncology Biol. Phys. 76 (2): 326-332.

Solberg, T., Balter, J.M., Benedict, S. H., Fraass, B. A., Kavanagh, B., Miyamoto, C., Pawlicki, T., Potters, L., Yamada, Y. (2011) Quality and Safety Considerations in Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy. Practical Radiation Oncology. Practical Radiation Oncology, 14 Sep 2(1):2-9.

8. ADMINISTRATIVE ONSITE REVIEW

To be performed by ACRO reviewers during radiation oncology accreditation process. Refer to ACRO Accreditation Manual.

9. MEDICAL CHART DOCUMENT UPLOAD CHECKLIST

1. Consult Note
2. TNM Staging
3. Pathology
4. Imaging Reports and Surgical Notes
5. Referring Notes
6. Consent Form
7. Clinical Treatment Plan Note
8. Simulation Documents - Directive, Note, Documents, and Images
9. Physician Orders and Planning Directives
10. Documentation of Image Fusion - including type of scan and sequence used
11. Treatment Prescription
12. Treatment Plan - including isodose plan and dose volume histograms (DVH), reduced fields & composite plans (include all slices and PTV and isodose lines as well as coronal and sagittal views)
13. Digital Reconstructed Radiographs (DRRs)
14. Other Treatment Plan or Procedure Documents and Notes
15. Quality Assurance (QA) and Weekly Physics Checks
16. Daily Dose Log and Documentation of On-Board Imaging
17. On Treatment Review Notes
18. Peer Review Documentation
19. End of Treatment Note
20. Follow up Notes
21. Other/Additional Documentation

DISEASE SITE REVIEW CRITERIA

10.1. Intracranial

	Review Criteria	Intracranial SRS	Points /100
H & P	Relevant history stated	Neurologic status Prior radiation Neuro deficit at presentation Prior surgery Chemotherapy/Immunotherapy/Targeted Therapy/Systemic Therapy Extent of disease	x/5
	Relevant physical findings	Detailed neurological exam Karnofsky Performance Score (KPS)	x/2
	Appropriate staging & imaging	MRI brain required unless contraindicated CT, PET, angiogram as indicated Audiogram, visual fields as indicated Advanced imaging (mass spectroscopy, perfusion, etc.) as indicated	x/5
	Pathology report/Surgical reports	Primary malignant and metastatic tumors: Appropriate documentation of pathology required. Benign tumors: Pathology only if indicated or available. Genetic markers as indicated	x/3
	Appropriate patient selection for treatment/Discussion of options	Patient/indications appropriate for treatment. Treatment options discussed.	x/5
Simulation	Appropriate consent form	Signed informed consent prior to start of treatment	x/2
	Appropriate immobilization for patient set-up	Either frame-based or frameless with intrafraction image guidance	x/3
	Appropriate imaging performed to allow for target localization and treatment planning • Areas scanned • Slice thickness • Imaging studies	High resolution MRI scan of slice thickness of (American College of Radiology Imaging Network (ACRIN) guidelines) CT only in conjunction with MRI unless contraindicated Trigeminal Neuralgia – should include high resolution imaging Arteriovenous malformation (AVM) – neuroangiogram required Contrast use for benign and malignant tumors	x/10
	Appropriate treatment plan note	Rationale for intended dose/fractionation, technique and concurrent use of chemotherapy.	x/3
	Appropriate simulation note	Performed and documented.	x/2
Treatment Planning	Appropriate target and normal tissue delineation • Imaging fusions • Target identification • Normal tissues	Appropriate co-registration of images. Identification of final target(s). Identification of organs at risk.	x/10
	Appropriate treatment prescription	• Total Dose • Fractionation: – Dose per fraction – Number of fractions • Isodose line • Target volume	x/10
	Quality of plan	– Conformity Index – Coverage – Heterogeneity Index	x/10
	Appropriate dose constraints (as appropriate depending on location)	– Brainstem – Optic Nerve – Cerebellum – Parotid – Cochlea – Retina – Lens – Spinal Cord – Optic Chiasm	x/10

10.1. Intracranial (continued)

	Review Criteria	Intracranial SRS	Points /100
Treatment Delivery	Appropriate treatment verification	For Gamma Knife: Coordinate verification for frame-based or CBCT (ICON) for mask-based. For CyberKnife: Stereoscopic X-rays on 6D skull system. For LINAC-based systems: Meeting standards as per specifications of the immobilization system and treatment device used.	x/5
	On-treatment documentation	On treatment visit note documenting the general condition and side effects of the treatment or procedure note including such information.	x/3
	Daily dose log/physics chart	Performed and documented.	x/2
After SBRT Care	Treatment summary	Documentation of treatment dates, area treated, diagnosis or disease treated, delivered dose and fractionation, technique, planning prescription, treatment tolerance, follow up plan.	x/2
	Follow-up plan	Documentation of plan for radiation oncology and neurosurgery follow-up. Additional imaging and clinical tests as indicated (for example MRI, CT, audiogram, visual fields, endocrine labs).	x/3
	Overall appropriateness of care	Documented.	x/5

DISEASE SITE REVIEW CRITERIA

10.2. Spine

	Review Criteria	Intact Spine	Post-Op Spine	Re-irradiation	Points /100
H & P	Relevant history stated, including pathology and date of diagnosis. Description of other sites of disease (widespread versus limited metastases).	Site and degree (use Brief Pain Inventory (BPI) of pain. Any symptoms of spinal instability. Neurologic deficits.	Site and degree (use BPI) of pain (preop and postop). Any symptoms of spinal instability (preop and postop). Neurologic deficits (preop and postop).	See Intact Spine or Post-Op Spine	x/2
	Relevant physical findings, performance status, neurologic findings including spinal instability neoplastic score (SINS).	Site of spinal tenderness, nature of pain (non-mechanical vs. mechanical), and neurologic deficits. Spinal instability neoplastic score (SINS).	Site of pain, nature of pain (non-mechanical vs. mechanical), and neurologic deficits (preop and postop). Spinal instability neoplastic score (SINS) (preop).	See Intact Spine or Post-Op Spine	x/2
	Appropriate cancer staging	CT chest, abdomen and pelvis or PET/ CT +/- bone scan	CT chest, abdomen and pelvis or PET/ CT +/- bone scan	CT chest, abdomen and pelvis or PET/ CT +/- bone scan	x/2
	Pathology report/Surgical reports	Pathology report: Original pathology or biopsy of spinal metastasis	Pathology report: Pathology of surgical specimen Surgical report: Type of surgery, extent of resection of epidural disease, placement of cage/ screws	See Intact Spine or Post-Op Spine	x/2
	Relevant radiographic evaluation including documentation of MRI imaging findings including Bilsky grade metastatic epidural spinal cord compression.	Axial T1 with and without gad to evaluate extent of disease and axial T2 to evaluate Bilsky grade (if used for target delineation, a thin slice volumetric MRI is needed).	Postop CT myelogram (preferred) or alternatively MRI using artifact reduction technique to evaluate extent of resection of epidural disease and residual Bilsky grade (if used for target delineation, a thin slice volumetric MRI is needed) and compare with preop MRI.	See Intact Spine or Post-Op Spine	x/3
	Description, dosing and timing of previous radiation courses, especially in regards to whether the lesion(s) under consideration have received irradiation.	Not Applicable	Not Applicable	Spinal levels encompassed by previous radiotherapy field, prior spinal cord dose at the levels being considered for SBRT, and time lapse since prior radiotherapy.	x/3
	If the patient is currently on systemic therapy, the regimen and frequency should be discussed.	Schedule and time of last dose of systemic chemotherapy, targeted therapy, or immunotherapy.	Schedule and time of last dose of systemic chemotherapy, targeted therapy, or immunotherapy.	Schedule and time of last dose of systemic chemotherapy, targeted therapy, or immunotherapy.	x/3
	Appropriate patient selection for treatment including NOMS framework/ Multidisciplinary discussion including discussion of treatment options	Indications include radioresistant primary, 1-3 levels of adjacent diseases, prior overlapping radiation therapy. Contraindications include involvement of > 3 contiguous vertebral bodies, ASIA Grade A status, Bilsky Grade 3 disease.	Indications include radioresistant primary, 1-3 levels of adjacent diseases, prior overlapping radiation therapy. Contraindications include involvement of > 3 contiguous vertebral bodies, ASIA Grade A status, postoperative Bilsky Grade 3 residual.	See Intact Spine or Postop Spine	x/3

10.2. Spine (continued)

	Review Criteria	Intact Spine	Post-Op Spine	Re-irradiation	Points /100
Simulation	Appropriate consent form listing acute and late complications spinal cord injury/ neurologic injury, vertebral compression fracture, pain flare and esophagitis (for cervical/ thoracic lesions).	Acute- Fatigue, skin irritation, pain, nerve pain, and irritation of throat/ esophagus/ bowel/ stomach Late- Spinal cord injury/ neurologic injury, vertebral compression fracture, and esophageal injury.	Acute- Fatigue, skin irritation, pain, nerve pain, and irritation of throat/ esophagus/ bowel/ stomach Late- Spinal cord injury/ neurologic injury, vertebral compression fracture, and esophageal injury.	See Intact Spine or Postop Spine	x/2
	Appropriate pre-simulation tumor localization and preparation for image-guidance Review of diagnostic imaging	A thin slice volumetric T1 with and without gad to evaluate extent of disease and T2 with axial reference to evaluate Bilsky grade.	A postop CT myelogram (for delineation of the spinal cord and evaluation of residual epidural disease in cases with significant metallic artifact) and a preop T1 or T2 variant MRI for comparison A post-op thin slice volumetric T1 or T2 variant MRI with artifact reduction technique is an acceptable alternative if the spinal cord can be visualized clearly.	See Intact Spine or Postop Spine	x/3
	Appropriate immobilization and arm positioning for patient set-up.	Immobilization device: C1-T3/4: Thermoplastic S-frame (SF) mask T4/5 or below: Long body vacuum bag/ cradle, preferably with dual vacuum system if LINAC-based	Immobilization device: C1-T3/4: Thermoplastic S-frame (SF) mask T4/5 or below: Long body vacuum bag/ cradle, preferably with dual vacuum system if LINAC-based	Immobilization device: C1-T3/4: Thermoplastic S-frame (SF) mask T4/5 or below: Long body vacuum bag/ cradle, preferably with dual vacuum system if LINAC-based	x/5
	Appropriate imaging performed to allow for tumor localization and treatment planning.	Treatment planning CT scan	Treatment planning CT scan	Treatment planning CT scan	x/5
	Appropriate treatment plan note documenting image fusion.	Rationale for choice of imaging modality for fusion and intended dose/fractionation, technique	Rationale for choice of imaging modality for fusion and intended dose/fractionation, technique	Rationale for choice of imaging modality for fusion and intended dose/fractionation, technique	x/2
	Appropriate simulation note, include description of method of immobilization.	CT-based, supine with appropriate immobilization device, slice thickness of 1.0-1.5 mm, images from base of skull to at least mid-thoracic spine for cervical spine lesion, from at least mid-cervical to mid- lumbar spine for thoracic spine lesion, and from at least mid-thoracic to whole sacral spine for levels L1 or below (this allow accurate verification of spinal levels). Set up documentation.	CT-based, supine with appropriate immobilization device, slice thickness of 1.0-1.5 mm, images from base of skull to at least mid-thoracic spine for cervical spine lesion, from at least mid-cervical to mid- lumbar spine for thoracic spine lesion, and from at least mid-thoracic to whole sacral spine for levels L1 or below (this allow accurate verification of spinal levels). Set up documentation.	CT-based, supine with appropriate immobilization device, slice thickness of 1.0-1.5 mm, images from base of skull to at least mid-thoracic spine for cervical spine lesion, from at least mid-cervical to mid- lumbar spine for thoracic spine lesion, and from at least mid-thoracic to whole sacral spine for levels L1 or below (this allow accurate verification of spinal levels). Set up documentation.	x/3

10.2. Spine (continued)

	Review Criteria	Intact Spine	Post-Op Spine	Re-irradiation	Points /100
Treatment Planning	Appropriate image fusion	Simulation CT should be fused with a thin slice volumetric T1 or T2 variant MRI which allows accurate identification and delineation of the extent of bony, paraspinal and epidural disease. In addition, a thin slice volumetric T2 variant MRI should be fused to allow precise identification of the spinal cord (CT myelogram is an acceptable alternative). The images should be rigidly co-registered at the region of the target volume. In cases where the spine flexion varies between image datasets, multiple MRI series should be co-registered to allow precise registration throughout the entire target volume.	Simulation CT should be rigidly fused with a postop CT myelogram (for delineation of the spinal cord and evaluation of residual epidural disease in cases with significant metallic artifact) and a preop T1 or T2 variant MRI for comparison to help target delineation. The images should be rigidly co-registered at the region of the target volume. In cases where the spine flexion varies between image datasets, multiple MRI series should be co-registered to allow precise registration throughout the entire target volume. A postop thin slice volumetric T1 or T2 variant MRI with artifact reduction technique is an acceptable alternative if the spinal cord can be visualized clearly.	See Intact Spine or Postop Spine	x/5
	Appropriate target delineation • Target delineation	GTV should be region of gross tumor involvement based on simulation CT and co-registered MRI. For CTV, follow guidelines for spinal metastases per Cox et al., 2012. • GTV involves any portion of vertebral body – CTV includes entire vertebral body • GTV lateralized within the vertebral body – CTV includes vertebral body and ipsilateral pedicle/transverse process • GTV diffusely involves vertebral body – CTV includes entire vertebral body and bilateral pedicles/transverse processes • GTV involves vertebral body and unilateral pedicle – CTV includes entire vertebral body, pedicle, ipsilateral transverse process, and ipsilateral lamina • GTV involves vertebral body and bilateral pedicles/transverse processes – CTV includes entire vertebral	GTV should be region of gross tumor involvement based on simulation CT and co-registered MRI. GTV to include postoperative residual based on MRI. For CTV, follow guidelines per Redmond et al., 2016. • CTV includes entire extent of preoperative tumor, anatomic compartment involved, & any postoperative residual. • Surgical instrumentation & incision not included unless involved. • Consider an additional expansion of up to 5 mm cranio-caudally beyond known epidural disease extent based on pre- & postoperative imaging. PTV – 0-2 mm radial expansion of the CTV. Larger expansions of up to 5 mm may be utilized in areas of extensive paraspinal extension	See Intact Spine or Postop Spine.	x/5
	Appropriate normal tissue delineation (as relevant based on location)	Normal tissues including the heart, lungs, brachial plexus, lumbrosacral plexus, esophagus, bowel, spinal cord, and/or thecal sac present within 2 vertebral bodies above and below the target volume should be contoured. Spinal cord planning organ at risk volume (PRV) should include the true spinal cord on T2 variant MRI with a 0-2 mm radial margin or the thecal sac without an expansion. The spinal cord PRV should be subtracted out from the PTV. Representative samples of contours should be show in axial, sagittal and coronal views on the treatment plan document.	Normal tissues including the heart, lungs, brachial plexus, lumbrosacral plexus, esophagus, bowel, spinal cord, and/or thecal sac present within 2 vertebral bodies above and below the target volume should be contoured. Spinal cord PRV should include the true spinal cord on CT myelogram (preferred) or T2 variant MRI (with artifact reduction technique) with a 0-2 mm radial margin or the thecal sac without an expansion. The spinal cord PRV should be subtracted out from the PTV. Representative samples of contours should be show in axial, sagittal and coronal views on the treatment plan document.	See Intact Spine or Postop Spine	x/5

10.2. Spine (continued)

	Review Criteria	Intact Spine	Post-Op Spine	Re-irradiation	Points /100
Treatment Planning	Appropriate treatment prescription • Total Dose • Fractionation	>90% GTV and >85% PTV receive 16-24 Gy in 1 fraction, 24 Gy in 2 fractions, 24-30 Gy in 3 fractions, 30-40 Gy in 5 fractions	>90% GTV and >85% PTV receive 16-24 Gy in 1 fraction, 24 Gy in 2 fractions, 24-30 Gy in 3 fractions, 30-40 Gy in 5 fractions	>85% GTV and >80% PTV receive 24-30 Gy in 3-4 fractions, 25-40 Gy in 5 fractions	x/3
	Appropriate dose constraints for organs-at-risk	Spinal cord: For single fraction follow RTOG 0631 if a PRV expansion is not used. If a cord PRV expansion is performed or if the thecal sac is used a cord surrogate, follow the 5% risk of spinal cord myelopathy constraints from Sahgal et al. For other structures follow AAPM TG-101 (Benedict et al.) For single fraction SBRT, it is also acceptable to use the constraints from Cox B, et al. For brachial plexus, it is acceptable to use the following references: Forquer JA, et al. and Lindberg K, et al.	Spinal cord: For single fraction follow RTOG 0631 if a PRV expansion is not used. If a cord PRV expansion is performed or if the thecal sac is used a cord surrogate, follow the 5% risk of spinal cord myelopathy constraints from Sahgal et al. For other structures follow AAPM TG-101 (Benedict et al.) For single fraction SBRT, it is also acceptable to use the constraints from Cox B, et al. For brachial plexus, it is acceptable to use the following references: Forquer JA, et al. and Lindberg K, et al.	For the spinal cord PRV allow no more than a cumulative BED3 of < 75 Gy accounting for 25% repair if >6 months out from the prior RT treatment and 50% repair if >12 months out from the prior RT treatment. Alternatively follow spinal cord objectives as outlined in Sahgal et al. As there are no robust dose guidelines for other organs-at risk in the setting of re-irradiation, it is acceptable to follow dose constraints described in the following references: Aorta: See reference Evans, et al. OARs in the chest: Binkley M, et al. and Schroder C, et al.	x/5
	Appropriate treatment technique	Step and shoot IMRT, VMAT, TomoTherapy or CyberKnife	Step and shoot IMRT, VMAT, TomoTherapy or CyberKnife	Step and shoot IMRT, VMAT, TomoTherapy or CyberKnife	x/5
	Appropriate treatment planning algorithm	Use the RTOG approved treatment planning algorithms	Use the RTOG approved treatment planning algorithms	See Intact Spine or Postop Spine.	x/3
	Appropriate computer plan and DVHs	>90% GTV and >85% PTV receive prescribed dose (PRV cord/ thecal sac/ cord dose permitting)	>90% GTV and >85% PTV receive prescribed dose (PRV cord/ thecal sac/ cord dose permitting)	>85% GTV and >80% PTV receive prescribed dose (PRV cord/ thecal sac/ cord dose permitting)	x/5
	QA/ Physics Check	Documentation	Documentation	Documentation	x/2
	Peer Review	Documentation	Documentation	Documentation	x/2

10.2. Spine (continued)

	Review Criteria	Intact Spine	Post-Op Spine	Re-irradiation	Points /100
Treatment Delivery	Appropriate treatment verification	Stereoscopic X-ray or CBCT or MRI (MR LINAC): Pre-treatment, after shift and midway (except CyberKnife where there is continuous tracking).	Stereoscopic X-ray or CBCT or MRI (MR LINAC): Pre-treatment, after shift and midway (except CyberKnife where there is continuous tracking).	Stereoscopic X-ray or CBCT or MRI (MR LINAC): Pre-treatment, after shift and midway (except CyberKnife where there is continuous tracking).	x/5
	Weekly on-treatment documentation/Pain score	Document KPS or ECOG Performance Score, skin reaction, BPI (pain score), and neurologic symptoms.	Document KPS or ECOG Performance Score, skin reaction, BPI (pain score), and neurologic symptoms.	Document KPS or ECOG Performance Score, skin reaction, BPI (pain score), and neurologic symptoms.	x/3
	Daily dose log/physics chart	Performed and documented	Performed and documented	Performed and documented	x/2
After SBRT Care	Treatment summary	Documentation of treatment dates, area treated, diagnosis or disease treated, delivered dose and fractionation, technique, beam energy, planning prescription, treatment tolerance, response if any, follow up plan.	Documentation of treatment dates, area treated, diagnosis or disease treated, delivered dose and fractionation, technique, beam energy, planning prescription, treatment tolerance, response if any, follow up plan.	Documentation of treatment dates, area treated, diagnosis or disease treated, delivered dose and fractionation, technique, beam energy, planning prescription, treatment tolerance, response if any, follow up plan.	x/2
	Follow-up plan including monitoring of acute, subacute and late effects	Clinical follow up in 4 weeks and subsequent follow up every 2-3 months. MRI spine Q3 months (Thibault et al.) Response assessment after stereotactic body radiotherapy for spinal metastasis: a report from the SPIne response assessment in Neuro-Oncology (SPINO) group. Lancet Oncology 2015)	Clinical follow up in 4 weeks and subsequent follow up every 2-3 months. MRI spine with artifact reduction technique or (Thibault et al. Response assessment after stereotactic body radiotherapy for spinal metastasis: a report from the SPIne response assessment in Neuro-Oncology (SPINO) group. Lancet Oncology 2015)	See Intact Spine or Postop Spine	x/3
	Overall appropriateness of care	Spine SBRT selection process, treatment approach and rationale, risk/benefits/ side effects	Spine SBRT selection process, treatment approach and rationale, risk/benefits/ side effects	Spine SBRT selection process, treatment approach and rationale, risk/benefits/ side effects	x/5

DISEASE SITE REVIEW CRITERIA

10.3. Lung

	Review Criteria	Lung SBRT	Points /100
H & P	Relevant history stated	History of CT screening (if applicable). Current/Presenting Thoracic Symptoms, if any, since early-stage disease most commonly asymptomatic (otherwise cough, dyspnea, change in COPD experience, history of pneumonia; rarely: hemoptysis, pleural effusion, chest pain). Systemic symptoms very rare (may include weight loss, anorexia, fatigue, even rarer hypertrophic osteoarthropy or other paraneoplastic syndromes). Tobacco History History of previous malignancy and status-e.g., oligometastatic disease. History of prior radiation and chemotherapy. History of underlying lung diseases: eg. COPD, interstitial lung disease, pulmonary fibrosis. History of connective tissue disorders. Use of oxygen.	x/5
	Relevant physical findings	VSS with saO2 on room air or on OS Performance status Thoracic Exam	x/2
	Appropriate work-up and staging	CT chest, PFTs, PET Scan (rationale if not used), MRI if clinically indicated (e.g., neurological symptoms, central tumor, tumor size), EBUS or mediastinoscopy staging of the mediastinum as appropriate/available. Cardiac evaluation as appropriate for risk assessment and determine operative risk in selected patients.	x/5
	Pathology report/Surgical reports	Appropriate documentation of primary sampling and/or tissue if possible. If biopsy, not possible documentation of such and rationale then for treatment (e.g., sequential CT scans showing growth, PET SUV, previous treatment)	x/3
	Appropriate patient selection for treatment/Discussion of options	Documentation of assessment for medical operability by an experienced thoracic cancer clinician (e.g., a thoracic surgeon, medical oncologist, radiation oncologist, or pulmonologist). In addition, documentation of a multidisciplinary team discussion with (e.g., a thoracic surgeon, medical oncologist, radiation oncologist, or pulmonologist) can be very beneficial. As indicated, Surgery evaluation if appropriate based on stage (early stage) and co-morbidities. This determination on surgical candidacy is ideally performed by a thoracic surgeon and is particularly important for the early stage cancer patients. Comments on medically inoperable versus high risk operable as indicated.	x/5

10.3. Lung (continued)

	Review Criteria	Lung SBRT	Points /100
Simulation	Appropriate consent form listing side effects	A standard consent form with site-specific information regarding potential toxicities related to lung SBRT is signed by the patient. As indicated, institution-specific requirements regarding delineation of potential toxicities related to lung SBRT and treatment site (e.g., Most Common: no side effects; Common and Self-Limited: fatigue; Not Rare: dermatitis/desquamation, chest wall toxicity with neuropathy and rib fracture; Rare: esophagitis, esophageal stricture, clinical pneumonitis, damage to great vessels, cardiac damage (e.g. pericarditis, myocarditis, increased risk of coronary artery disease (CAD), and valvular damage), vocal cord damage, lung fibrosis, damage to the proximal bronchial tree (leading to possible atelectasis, pneumonia, fistula), hemaptysis, brachial plexopathy; Very Rare: myelitis)	x/2
	Appropriate pre-simulation tumor localization and preparation for image-guidance • Review of diagnostic imaging • Fiducial placement	Review of the pertinent CT and PET imaging should be performed prior to simulation to ensure appropriate simulation CT parameters such as the need for fiducials, IV contrast timing, need for oral contrast, etc.	x/5
	Appropriate immobilization for patient set-up	Documented of rigid system used- A variety of immobilization systems may be used	x/2
	Appropriate Motion Management	As appropriate, free breathing, 4DCT, Breath hold technique, motion restriction, fiducial tracking, gating Appropriate definition of ITV by technique	x/2
	Appropriate imaging performed to allow for tumor localization and treatment planning • Areas scanned • Slice thickness • Contrast use • Imaging studies for motion management treatment delivery	• CT scan of chest from at least thoracic inlet to bottom of lung. • Axial acquisitions with gantry 0 degrees will be required with spacing ≤3.0 mm between scans. • IV contrast as indicated by tumor location, proximity to relevant critical structures and as medically appropriate • Considerations to account for the effect of internal organ motion (e.g., breathing) on target positioning and reproducibility: Acceptable maneuvers include reliable abdominal compression, accelerator beam gating with the respiratory cycle, tumor tracking, and active breath-holding techniques. • 4-dimensional CT image-guided GTV delineation to take tumor motion into consideration as dictated by tumor localization and motion managing technique	x/5
	Appropriate treatment plan note	Rationale for intended dose/fractionation, technique.	x/2
	Appropriate simulation note	• CT-based, supine with form immobilization cast/molded cradle, slice thickness of ≤3mm, images from at least thoracic inlet to bottom of lung. • Motion management technique • IV/oral Contrast use as indicated • Set up documentation.	x/2

10.3. Lung (continued)

	Review Criteria	Lung SBRT	Points /100
Treatment Planning	Appropriate target and normal tissue delineation • Imaging fusions • Target identification • Normal tissues	• Target lesion to be outlined/verified by specialist physician and designated the gross tumor volume (GTV). • GTV will generally be drawn using CT pulmonary windows; however, soft tissue windows with contrast may be used to avoid inclusion of adjacent vessels, atelectasis, or mediastinal or chest wall structures within the GTV. • As indicated, fusion of CT treatment planning images with diagnostic CT imaging (+/- contrast), diagnostic or planning PET CT imaging as indicated and available, for target imaging	x/10
	Appropriate treatment prescription • Total Dose • Fractionation	• As appropriate, publication derived techniques (trials e.g., RTOG 0236, 0813, 0915; institutional series, etc.) • Location dependent e.g., peripheral vs. central. Central vs. ultra-central • SBRT-appropriate total doses and appropriate dose per fraction (>8) in Gy. • GTV=CTV • An internal target volume (ITV) around the GTV, accounting for tumor motion may be defined from the 4D CT dataset as acquired by the chosen method of motion management. May be adjusted based on location to critical OARs. • PTV expansion of ITV typically ~5mm, may vary in cranio-caudal axis.	x/10
	Appropriate dose constraints	• As appropriate, publication-derived techniques (trials e.g., RTOG 0236, 0813, 0915; institutional series, etc.) • Location dependent and fractionation dependent total dose: e.g., peripheral vs. central. • Three-dimensional coplanar or non-coplanar beam arrangements will be custom designed for each case to deliver highly conformal prescription dose distributions. • Planning to provide DVH/isodose distribution/dose constraints for assessment of target and normal tissue constraints. • Contouring of Normal Tissue Structures should be carried out for every patient irrespective of the location of the PTV and at a minimum should include right and left lungs, whole lung, whole heart, esophagus, spinal cord, trachea, tracheo-bronchial tree. As indicated by tumor parameters, liver, stomach, kidneys, brachial plexus, skin, great vessels may be contoured. Regarding the ribs/chest wall as organs of interest, the goal of any plan will be to optimize target treatment parameters and be mindful of rib dosing (as low as reasonably achievable [ALARA]), but in no way compromise target coverage or restrict potential delivery parameters for the sake of rib dosing.	x/10
	Appropriate treatment technique	As appropriate, platform (e.g., robotic linac radiosurgery) and/or publication-derived techniques (trials e.g., RTOG 0236, 0813, 0915; institutional series, etc.)	x/10
Treatment Delivery	Appropriate treatment technique	Cone Beam CT or appropriate imaging/verification modalities, as indicated by treatment platform –as performed, physician and/or physicist verification on site must be documented.	x/5
	Weekly on-treatment documentation	Documented Diagnosis, dose delivered of total planned dose, subjective, objective, assessment and plan (SOAP) assessment of patient toxicity assessment, interventions as indicated, medications as indicated, assessment and plan.	x/3
	Daily dose log/physics chart	Performed and documented.	x/2
After SBRT Care	Treatment summary	Documentation of treatment dates, area treated, diagnosis or disease treated, delivered dose and fractionation, technique, beam energy, planning prescription, treatment tolerance, response if any, follow up plan	x/2
	Follow-up plan	Appropriate clinical and radiographic follow up documented, including management of subacute and late complications	x/3
	Overall appropriateness of care	Lung SBRT selection process, treatment approach and rationale, risk/benefits/side effects	x/5

DISEASE SITE REVIEW CRITERIA

10.4. Liver

	Review Criteria	Liver SBRT	Points /100
H & P	Relevant history stated	History of chronic liver disease: hepatitis B/C, heavy alcohol abuse, non-alcoholic fatty liver disease. Liver decompensation/failure symptoms: jaundice, acholic stools, dark urine, ascites, hepatic encephalopathy, esophageal varices/upper GI bleeding.	x/5
	Relevant physical findings	Signs of liver failure. Abdominal exam.	x/2
	Appropriate staging	Labs: CBC, CMP, INR, tumor markers if appropriate (AFP, CA19-9, CEA). Lab values for input into Child Pugh Score should be available. Imaging: CT or MRI abdomen, CXR or CT chest, bone or PET scan if appropriate.	x/5
	Pathology report/ Surgical reports	**Hepatocellular carcinoma (HCC):** not commonly required if radiologic criteria are met (LIRADS-5) in the setting of AFP elevation and chronic liver disease. Pathologic confirmation needed for intrahepatic cholangiocarcinoma and liver metastases and considered for LIRADS-4 HCC lesions.	x/3
	Appropriate patient selection for treatment/Discussion of options	**Evaluation and management in a multi-disciplinary setting is strongly recommended.** Indications: Ineligible or inappropriate for other definitive/ablative liver directed therapies (e.g. surgery, RFA): • Recurrence after other liver directed therapies (e.g. chemoembolization) • Planned consolidation after surgery, chemoembolization, RFA • Bridge to liver transplantation Appropriate candidates: • Well to moderately compensated liver function (CP-A to B7). Unclear safety in CP-B8+ patients • Unifocal lesion. Limited multifocal lesions reasonable to consider if liver dose constraints met • Tumor(s) not abutting/in close proximity (> 1 cm) to GI visceral organs	x/5

10.4. Liver (continued)

	Review Criteria	Liver SBRT	Points /100
Simulation	Appropriate documentation listing side effects	A standard consent form or appropriate documentation with site-specific information regarding potential acute and late toxicities related to liver SBRT is signed by the patient. Side effects can include but are not limited to: • Fatigue • Nausea/vomiting/anorexia • Weight loss • Dermatitis • Increased frequency of bowel movements or change in stool consistency • Bowel injury (ulceration, bleeding, perforation, fistula, obstruction) • Abdominal discomfort • Biliary obstruction due to inflammation • Tumor abscess • Liver dysfunction including elevated liver transaminases, in severe cases, radiation-induced liver disease (RILD) can occur, RILD is a clinical syndrome of fatigue, elevated liver enzymes (particularly alkaline phosphatase over liver transaminases), tender anicteric hepatomegaly and ascites. Although most patients recover, RILD can lead to liver failure and death. • Additional potential late toxicities after liver SBRT may include: biliary sclerosis, hepatic subcapsular injury, rib fracture, myositis, and depending on whether or not normal tissues such as esophagus, stomach, duodenum or large bowel are within the high-dose regions of the radiation treatment: esophagitis, gastrointestinal bleeding, small bowel obstruction, gastric outlet obstruction, and fistula formation.	x/2
	Appropriate pre-simulation tumor localization and preparation for image-guidance • Review of diagnostic imaging • Fiducial placement	• Various imaging modalities are used for staging and planning liver SBRT patients. Review of the pertinent CT, MRI, ultrasound, and other imaging should be performed prior to simulation to ensure appropriate simulation CT parameters such as the need for fiducials, IV contrast timing, need for oral contrast, etc. Review of diagnostic imaging to determine the best phase for delineating the tumor should be performed prior to simulation and scan timing with respect to the contrast administration should be based on diagnostic radiology algorithms or on discussion with the diagnostic radiologists. • In order to allow for appropriate image guidance at the time of treatment delivery, implantation of fiducial markers adjacent to the liver tumor(s) can be considered prior to simulation, typically by ultrasound or CT-guidance by an interventional radiologist. Preferably, markers should be radiographically visible by kilo-voltage X-rays. • If using MR-guided SBRT on an MR Linac, fiducial markers are not required.	x/3
	Appropriate immobilization for patient set-up	The treatment position should be reproducible using an immobilization device with patient in supine position. To allow for lateral beam angles or arcs, the arms should be up. Options for immobilization may include: an alpha cradle or vacloc bag, or commercially available SBRT immobilization systems.	x/2
	Appropriate Motion Management	Documentation of a motion management strategy to reduce respiratory motion and improve the accuracy of treatment planning/delivery. Motion management techniques can be categorized as motion compensating or motion restricting and can be any of the following: • Respiratory gating • Tumor tracking (i.e. Synchrony system on CyberKnife) • Voluntary or assisted breath hold with end-exhale preferred • Abdominal compression	x/3
	Appropriate imaging performed to allow for tumor localization and treatment planning • Areas scanned • Slice thickness • Contrast use • Imaging studies for motion management treatment delivery	CT images should be obtained from at least two centimeters above the dome of the diaphragm to the bottom of the kidneys. A multi-phase liver protocol CT scan (1-2 mm cuts) should performed for high resolution delineation of the tumor and surrounding structures. Intravenous contrast is administered in a rapid bolus such that either the arterial phase and/or portal venous phase should be obtained. For most hepatic metastases, lesions are best seen in the portal venous phase. They appear as hypointense in relation to the liver parenchyma. Hypervascular tumors, such as hepatocellular carcinoma (HCC) and metastatic breast, renal cell, thyroid, and neuroendocrine cancers may be better imaged in the arterial phase. Oral contrast can be given approximately one half hour before simulation to allow for visualization of the small bowel and stomach. For patients being treated with respiratory gating or breath hold, the simulation scan CT scan should be performed during breath holding. A 4DCT scan should be performed for most patients, particularly those treated with respiratory gating, abdominal compression, tumor tracking, or when motion management is not being employed, and used to create a tumor-specific internal target volume (ITV). If 4DCT demonstrates > 5 mm of tumor motion, motion mitigation strategies are strongly recommended (ICRU TG-76).	x/10
	Appropriate treatment plan note	Rationale for intended dose/fractionation, technique.	x/2
	Appropriate simulation note	Documentation of CT-based simulation including set up (i.e. supine with a mobiliz ation cast/molded cradle), use of IV and/or oral contrast, type of motion management to be used, 4DCT, etc.	x/2

10.4. Liver (continued)

<table>
<tr><th></th><th>Review Criteria</th><th>Liver SBRT</th><th>Points /100</th></tr>
<tr><td rowspan="4">Treament Planning</td><td>Appropriate target and normal tissue delineation
• Imaging fusions
• Target identification
• Normal tissues</td><td>For liver tumors in particular, CT scans alone may not clearly delineate disease. Incorporation of additional diagnostic imaging including fluorodeoxyglucose positron-emission tomography (FDG-PET) scans and magnetic resonance imaging (MRI) during planning can be helpful in better identifying the target. These additional images can be fused to the simulation CT in the radiation oncology planning software. However, caution is advised when fusing diagnostic scans with the simulation CT scan, especially when matching on bony anatomy or the liver edge, due to the complex motion and deformation of the liver. If the diagnostic scan was not performed in the same respiratory phase, the fusion may not be accurate.

The gross tumor volume (GTV) should determined based on the portal-venous phase (liver metastases and intrahepatic cholangiocarcinomas) or washout area on the arterial phase (HCC) CT scans. If respiratory gating is to be used, the GTV should be defined in an expiratory phase CT image with the aid of any diagnostic imaging such as a PET-CT or MRI. The prescribed planning target volume (PTV) is defined as the GTV plus a margin of typically 5-10 mm.

Alternatively, when motion restriction techniques are used or free-breathing cases, an ITV should be generated based on either CT average from 4DCT or a minimum-intensity-projection (MINIP) image can be generated from the 4DCT. The MINIP is reconstructed from low attenuation projections of the 4DCT scan at each table position and can be useful for liver SBRT because it aids in the identification of lesions which are hypodense compared to the surrounding normal liver.

Critical structures to be identified include the kidneys, liver, esophagus, stomach, duodenum, and spinal cord. A free-breathing PET-CT may also be registered with the exhalation arterial phase CT scan to confirm the tumor position and aid in the delineation of normal liver and adjacent tissues.

If not producing an ITV, the margin expansion to account for respiratory motion can be incorporated into the PTV margin.</td><td>x/10</td></tr>
<tr><td>Appropriate treatment prescription
• Total Dose
• Fractionation</td><td>The prescription dose and fractionation for liver SBRT should be rational and justifiable based on relevant literature, clinical trial protocols, and national guidelines. The total dose and fractionation are dependent on several factors including:
• The underlying liver function of the patient
• Number of lesions treated
• Size of the lesion(s)
• Proximity to critical structures
Patients with liver metastases and normal underlying liver function are most commonly treated with 3-5 fractions to a total dose of 45-60 Gy.
Importantly, patients with HCC with poor underlying liver function (Child-Pugh Score ≥ B8) may not be good candidates for liver SBRT, while those with Child-Pugh Score A-B7 can be treated with a regimen of 27.5 – 50 Gy in 5 fractions (based on the RTOG 1112 protocol).</td><td>x/10</td></tr>
<tr><td>Appropriate dose constraints</td><td>
<table>
<tr><th>OAR</th><th>3 fractions</th><th>5 fractions</th><th>References</th></tr>
<tr><td colspan="4">Liver-GTV</td></tr>
<tr><td>Non-cirrhotic</td><td>MLD <1200-1500 cGy rV19 ≥700 cc</td><td>MLD <1500-1800 cGy
rV21 ≥700 cc</td><td>TG-101
QUANTEC
HyTEC</td></tr>
<tr><td>CP-A cirrhosis</td><td>MLD <1200-1500 cGy</td><td>MLD <1300-1700 cGy
rV15 ≥700 cc</td><td>RTOG 1112
QUANTEC
HyTEC</td></tr>
<tr><td>CP-B7 cirrhosis</td><td>N/R</td><td>MLD <600-1000 cGy
rV10 ≥500 cc</td><td>QUANTEC
HyTEC</td></tr>
<tr><td>Esophagus</td><td>D0.03cc <2520 cGy
V17.7 <5 cc</td><td>D0.03cc <3500 cGy
D0.5cc <3200 cGy
V19.5 <5 cc</td><td>TG-101
RTOG 1112</td></tr>
<tr><td>Stomach</td><td>D0.03cc <2200 cGy
V16.5 <10 cc</td><td>D0.03cc <3200 cGy
D0.5cc <3000 cGy
V18 <10 cc</td><td>TG-101
RTOG 1112</td></tr>
<tr><td>Duodenum</td><td>D0.03cc <2200 cGy
V16.5 <5 cc</td><td>D0.03cc <3200 cGy
D0.5cc <3000 cGy
V18 <5 cc</td><td>TG-101
RTOG 1112</td></tr>
</table>
<table>
<tr><th>OAR</th><th>3 fractions</th><th>5 fractions</th><th>References</th></tr>
<tr><td>Small bowel</td><td>D0.03cc <2500 cGy
V18 <5 cc</td><td>D0.03cc <3200 cGy
D0.5cc <3000 cGy
V19.5 <5 cc</td><td>TG-101
RTOG 1112</td></tr>
<tr><td>Large bowel</td><td>D0.03cc <2800 cGy
V24 <20 cc</td><td>D0.03cc <3400 cGy
D0.5cc <3200 cGy
V25 <20 cc</td><td>TG-101
RTOG 1112</td></tr>
<tr><td>Heart</td><td>D0.03cc <3000 cGy|
V24 <15 cc</td><td>D0.03cc <3800 cGy
V32 <15 cc</td><td>TG-101</td></tr>
<tr><td>Chest wall</td><td>D0.5cc < 3700 cGy
V30 < 30 cc</td><td>D0.5cc <3900 cGy
V32 <30 cc</td><td>UK Consensus</td></tr>
<tr><td>Kidneys</td><td>rV16 >200 cc</td><td>Mean <1000 cGy</td><td>TG-101
RTOG 1112</td></tr>
<tr><td>One kidney</td><td>V10 <10%</td><td>V10 <10%</td><td>RTOG 1112</td></tr>
<tr><td>Cord</td><td>D0.03cc <2190 cGy
V18 <0.35 cc
V12.3 <1.2 cc</td><td>D0.03cc <3000 cGy
V23 <0.35 cc
V14.5 <1.2 cc</td><td>TG-101</td></tr>
</table>
MLD = mean liver dose rVdose = liver-GTV volume receiving less than a certain dose (liver spared) N/R = not recommended
</td><td>x/10</td></tr>
<tr><td>Appropriate treatment technique</td><td>3DCRT, IMRT, CyberKnife Robotic Radiosurgery or arc rotational therapy can be appropriate for planning SBRT.</td><td>x/4</td></tr>
</table>

10.4. Liver (continued)

	Review Criteria	Liver SBRT	Points /100
Treatment Delivery	Appropriate treatment verification	Chart rounds and image review (quality assurance process in place)	x/5
	Weekly on-treatment documentation/	Evidence of MCVT/CBCT localization at each treatment. IGRT images in treatment position for every fraction to be archived for possible future assessment. 2D planar MV alone are not appropriate. Motion management utilization documentation: Breath hold, abdominal compression, or surrogate marker consistent with planning. Shift documentation Treatment interruptions indicated Labwork to identify issues such as obstruction and RILD at start and end of treatment.	x/5
	Daily dose log/ physics chart	Performed and documented.	x/2
After SBRT Care	Treatment summary	Documentation of treated sites, technique, beam energy, treatment dates, concurrent treatments, interruptions in treatment, toxicities and follow-up plan.	x/2
	Follow-up plan	Evidence of standard imaging and blood work follow up plans (random or variable follow up is not appropriate). In particular, blood work that could identify thrombocytopenia, kidney injury, progression of Child-Pugh status and gastroduodenal toxicity Appropriate clinical and radiographic follow up documented, including management of subacute and late complications	x/3
	Overall appropriateness of care	Clear indication of appropriate management as demonstrated by treatment approach and rationale, documentation of workup, diagnosis, simulation, planning, treatment. Follow up indicates toxicity rates consistent with literature.	x/5

DISEASE SITE REVIEW CRITERIA

10.5. Pancreas

	Review Criteria	Pancreas SBRT	Points /100
H & P	Relevant history stated	Pain, jaundice, painless jaundice, nausea/vomiting (obstruction), hematemesis /melena, dyspepsia, weight loss, light stools, depression, family history of pancreas cancer	x/5
	Relevant physical findings	Jaundice, weight loss, Left supraclavicular (Virchow's) node Abdominal exam: Hepatomegaly, palpable gall bladder, ascites, signs of portal hypertension, lower extremity edema (DVT)	x/2
	Appropriate staging	Labs: CBC, CMP, CA19-9, LFTs, CEA, HgA1c Imaging: CT Abdomen and Pelvis and/or MRI abdomen – Pancreas protocol (thin slice), CT chest, bone or PET scan if appropriate is metastasis suspected. Alliance/NCCN Classification: Resectable/Borderline/Locally Advanced/Metastatic	x/5
	Pathology report/Surgical reports	EUS: Cytology/Histology of primary and suspected metastasis. Fiducial placement If stent placed, confirm metal.	x/3
	Appropriate patient selection for treatment/ Discussion of options	Multidisciplinary review of imaging (Alliance/NCCN criteria: Resectable/Borderline/Locally Advanced) and patient (Age, ECOG Performance status, LFT/Renal function and comorbidities). **Resectable:** Surgery and Pathology guided adjuvant therapy – Primarily systemic combination chemotherapy. SBRT indicated for R2 resection, aborted surgery, or local recurrence. **Borderline resectable:** Consider Clinical trial. Neoadjuvant combination systemic therapy and radiation (SBRT, hypofractionated RT (15 fx), conventional with concurrent chemotherapy) and reevaluate for resectability – followed by pathology guided adjuvant therapy. **Locally Advanced:** Consider Clinical trial. Definitive combination systemic therapy and radiation (intercurrent SBRT, hypofractionated RT, or conventional with concurrent chemotherapy). reevaluate for resectability.	x/5
	Appropriate consent form listing side effects	A standard consent form with site-specific information regarding potential toxicities related to pancreas SBRT is signed by the patient. Side effects can include but are not limited to: **Acute:** • Fatigue • Nausea/vomiting/anorexia • Weight loss • Increased frequency of bowel movements or change in stool consistency • Abdominal discomfort **Late:** • Biliary obstruction due to inflammation • Bowel injury (ulceration, bleeding, perforation, fistula, obstruction) • Liver dysfunction including elevated liver transaminases, in severe cases, radiation-induced liver disease (RILD) can occur, RILD is a clinical syndrome of fatigue, elevated liver enzymes (particularly alkaline phosphatase over liver transaminases), tender anicteric hepatomegaly and ascites. • Additional potential late toxicities after Pancreas SBRT may include: biliary stenosis, renal injury, portal hypertension, pancreatic insufficiency.	x/2
	Appropriate pre-simulation tumor localization and preparation for image-guidance • Review of diagnostic imaging • Fiducial placement	Review of various imaging modalities are used for staging and planning Pancreas SBRT patients including multi-phasic pancreas protocol CT, MRI, Endoscopic ultrasound and endoscopic retrograde cholangiopancreatograpy (ERCP) should be performed prior to simulation. PET/CT can be helpful when evaluating local recurrence after surgery and to evaluate questionable metastatic disease. Fiducial placement to be attempted in all patients for image guidance during treatment. 3-5 fiducial gold seeds are advised to be placed in or adjacent to the tumor, preferably by endoscopic ultrasound (EUS) guidance. Because these seeds can migrate several mm in the first few days after implantation, the simulation should be performed up to a week after the implantation procedure. Review of diagnostic imaging to determine the best phase for delineating the tumor should be performed prior to simulation and scan timing with respect to the contrast administration (ideally venous phase) should be based on diagnostic radiology algorithms or on discussion with the diagnostic radiologists. When MR guided RT is available, fiducials may not be necessary. Review renal function as IV contrast administration is strongly advised. Nothing by mouth (NPO) 3 hours prior to simulation is recommended.	x/5
	Appropriate immobilization for patient set-up	The treatment position should be reproducible using an immobilization device with patient in supine position. To allow for lateral beam angles or arcs, the arms should be up. Arms could by the patient side for certain techniques e.g.,CyberKnife. Options for immobilization may include: an alpha cradle or vacloc bag, or commercially available SBRT immobilization systems. Compression can substantially decrease motion but can also push the stomach and/or duodenum closer to the tumor.	x/2

10.5. Pancreas (continued)

	Review Criteria	Pancreas SBRT	Points /100
Simulation	Appropriate Motion Management	Documentation of a motion management strategies to reduce respiratory motion and improve the accuracy of treatment planning/delivery. Motion management techniques can be categorized as motion restricting (e.g., Breath Hold, abdominal compression), motion compensating (Gating, Active Breath Control (ABC) or Tumor tracking (i.e. Synchrony system on CyberKnife, fiducials, spacers)	x/2
	Appropriate imaging performed to allow for tumor localization and treatment planning • Areas scanned • Slice thickness • Contrast use • Imaging studies for motion management treatment delivery	CT images should be obtained from at least two centimeters above the dome of the diaphragm to the bottom of the kidneys. A Pancreas protocol CT scan (1-3 mm cuts) should performed for high resolution delineation of the tumor and surrounding structures. Intravenous contrast is administered in a rapid bolus such that either the arterial phase or portal venous phase should be obtained. Additional image set in portal venous phase is recommended. Both the arterial phase and the portal venous phase images are required for delineation of the TVI (tumor vessel interphase) Oral contrast can be given approximately one-half hour before simulation to allow for visualization of the small bowel, particularly duodenum and stomach. Alternatively, patients can be NPO for 3 hours prior to simulation and treatment for more reproducible set-up. For patients being treated with respiratory gating or ABC, the simulation scan CT scan should be performed when the patient is being coached to hold his/her breath while in expiration. A 4DCT scan should be performed for most patients, particularly those treated with respiratory gating, abdominal compression, tumor tracking, or when another motion management is not being employed, a 4DCT can be used to create a tumor-specific internal target volume (ITV) and ibowel or istomach if indicated.	x/5
	Appropriate treatment plan notes	Rationale for intended dose/fractionation, technique.	x/2
	Appropriate simulation notes	Documentation of CT-based simulation including set up (i.e. supine with a mobilization cast/molded cradle), use of IV and/or oral contrast, type of motion management to be used, 4DCT, etc.	x/2

10.5. Pancreas (continued)

<table>
<tr><th></th><th>Review Criteria</th><th>Pancreas SBRT</th><th>Points /100</th></tr>
<tr><td rowspan="4">Treament Planning</td><td>Appropriate target and normal tissue delineation
• Imaging fusions
• Target identification
• Normal tissues</td><td>CT scans alone may not clearly delineate disease. Incorporation of additional diagnostic imaging including fluorodeoxyglucose positron-emission tomography (FDG-PET) scans and magnetic resonance imaging (MRI) during planning can be helpful in better identifying the target. These additional images can be fused to the simulation CT in the radiation oncology planning software. If the diagnostic scan was not performed in the same respiratory phase, the fusion may not be accurate.
The gross tumor volume (GTV) is determined on free breathing scan or at breath hold if that motion management is used. iGTV accounts for GTV in all phases of breathing with the aid of any diagnostic imaging such as a PET-CT or MRI.
The tumor vessel interface (TVI) is recommended to be contoured for all significant vessels (PV, SMA, SMV and CHA). For SBRT, the prescribed planning target volume (PTV) is defined as the GTV plus a margin of typically 3 - 10 mm. Alternatively, if motion restriction techniques are used, a minimum-intensity-projection (MiniP) image can be generated from the 4DCT to help define the internal target volume, which encompasses the full range of target motion.
Critical structures to be identified include the kidneys, liver, stomach, duodenum, small bowel and spinal cord. A free-breathing PET-CT may also be registered with the exhalation arterial phase CT scan to confirm the tumor position and aid in the delineation of normal liver and adjacent tissues.</td><td>x/10</td></tr>
<tr><td>Appropriate treatment prescription
• Total Dose
• Fractionation</td><td>The prescription dose and fractionation for pancreas SBRT should be rational and justifiable based on relevant literature, clinical trial protocols, and national guidelines.
Most commonly 3-5 fractions are used to a total dose of 30-50Gy.</td><td>x/10</td></tr>
<tr><td>Appropriate dose constraints</td><td>
<table>
<tr><th>Description</th><th>Planning System Name</th><th>Constraints</th></tr>
<tr><td>Modified PTV</td><td>mPTV</td><td>V25 >95% (range25-40 Gy)</td></tr>
<tr><td>PTV</td><td>PTV</td><td>V20 >95%</td></tr>
<tr><td>OAR</td><td></td><td>Constraints</td></tr>
<tr><td>Duodenum</td><td>Duodenum</td><td>V15 <9cc</td></tr>
<tr><td></td><td></td><td>V20 <3cc</td></tr>
<tr><td></td><td></td><td>V33 <1cc</td></tr>
<tr><td>Small Bowel</td><td>Bowel</td><td>V15 <9cc</td></tr>
<tr><td></td><td></td><td>V20 <3cc</td></tr>
<tr><td></td><td></td><td>V33 <1cc</td></tr>
<tr><td>Stomach</td><td>Stomach</td><td>V15 <9cc</td></tr>
<tr><td></td><td></td><td>V20 <3cc</td></tr>
<tr><td></td><td></td><td>V33 <1cc</td></tr>
<tr><td>Liver</td><td>Liver</td><td>V12 <50%</td></tr>
<tr><td>Combined Kidneys</td><td>Kidneys</td><td>V12 <75%</td></tr>
<tr><td>Spinal Cord</td><td>Spinal Cord</td><td>V20 <1cc</td></tr>
<tr><td>Spleen</td><td>Spleen</td><td>No constraint</td></tr>
</table>
</td><td>x/10</td></tr>
<tr><td>Appropriate treatment technique</td><td>Static IMRT, or arc rotational therapy (VMAT) or non isocentric (CyberKnife) can be appropriate for planning SBRT.</td><td>x/10</td></tr>
</table>

10.5. Pancreas (continued)

	Review Criteria	Pancreas SBRT	Points /100
Treatment Delivery	Appropriate treatment verification	Chart rounds and image review (quality assurance process in place) as per institutional standards meeting accreditation requirements.	x/5
	Weekly on-treatment documentation/	Evidence of MCVT/CBCT localization at each treatment. IGRT images in treatment position for every fraction to be archived for possible future assessment. 2D planar MV alone are not appropriate. Motion management utilized is documented: Breath hold, ABC, Synchrony tracking, Phase/Amplitude based gating with or without triggered imaging with surrogate marker consistent with planning. Shift documentation. Treatment interruptions indicated. Lab work to identify issues such as biliary or intestinal obstruction and RILD at start and end of treatment.	x/3
	Daily dose log/ physics chart	Performed and documented.	x/2
After SBRT Care	Treatment summary	Documentation of treated sites, technique, beam energy, treatment dates, concurrent treatments, interruptions in treatment, and toxicity	x/2
	Follow-up plan	Evidence of planned standard imaging and blood work follow up plans (random or variable follow up is not appropriate). In particular, blood work that could identify tumor marker (CA 19-9) response, kidney/liver injury. Appropriate clinical and radiographic follow up documented, including management of subacute and late complications. Documentation of Multidisciplinary review post treatment to reassess resectability.	x/3
	Overall appropriateness of care	Clear indication of appropriate patient selection in a multidisciplinary setting: Preferably in protocol. e.g. Borderline/Locally advanced pancreas cancer or neoadjuvant SBRT for resectable disease on protocol. Workup, diagnosis, simulation, planning, treatment and documentation as above. Follow up monitoring including documentation of acute and late toxicities and rates consistent with literature.	x/5

DISEASE SITE REVIEW CRITERIA

10.6. Prostate

	Review Criteria	Prostate SBRT	Points /100
H & P	Relevant history stated	Comorbidities, including cardiac history (stent placement), osteoporosis, obesity, prior bowel surgery, indicate if history of Crohn's disease or ulcerative colitis. Chemotherapy history, current use of immunosuppressive agents and anticoagulant use. Use of hormones. Prior TURP and/or prior colonoscopy (within 90 days of treatment). Estimated life expectancy. Prostate cancer quality of life questionnaire (EPIC, AUA), potency/sexual history (SHIM). Documentation of implanted hardware adjacent to prostate.	x/5
	Relevant physical findings	ECOG/Karnofsky Performance Score Digital rectal exam	x/2
	Appropriate staging	Gleason score, PSA (within 90 days of treatment), PSA doubling time, PSA density, T stage, CT, MRI (when appropriate), ultra sound-based estimate or prostate size. Bone scan when appropriate.	x/5
	Pathology	Recommend biopsy within one year prior to treatment, Gleason score. Number of cores positive/number of cores taken/% core positive.	x/3
	Appropriate patient selection for treatment/Discussion of options	Multidisciplinary discussion, patient/indications appropriate for treatment. Treatment options discussed.	x/5
Simulation	Appropriate consent form listing possible acute and late side effects	Side effects including, but not limited to: • Increased urinary frequency • Urinary urgency • Increased bowel frequency • Increased bowel urgency • Hematuria • Urinary retention • Dysuria • Rectal bleeding • Rectal ulcer • Impotence • Development of secondary malignancy • Erectile dysfunction • Late urinary symptom flare	x/5
	Appropriate treatment plan note	Treatment planning note documented.	x/5
	Appropriate simulation note/process	Appropriate bowel or bladder preparation. CT simulation including immobilization device, positioning of arms, areas scanned, slice thickness, use of contrast, respiratory phase/4DCT and respiratory motion control (if relevant). Fiducial marker placement, number of fiducials placed and procedure (transrectal or transperineal). Description of any rectal spacers or protectants. Set up documentation.	x/10

10.6. Prostate (continued)

	Review Criteria	Prostate SBRT	Points /100
Treament Planning	Appropriate treatment plan prescription	Description of clinical target volume (CTV) and planning target volume (PTV), including margins. Dose range and fractionation, method of image guidance (KV, CBCT, other method).	x/10
	Treatment plan	Time interval between fiducial placement and imaging. Treatment planning MRI (recommended), or CT urethrogram. Fusion of appropriate imaging to planning CT.	x/5
	Treatment technique	Appropriate target delineation including GTV, CTV and PTV as appropriate. • Rectum- Defined as a solid structure, including the lumen and rectal wall, extending from the level of the ischial tuberosity to the sigmoid flexure. • Bladder – Defined as a solid structure including the bladder wall and lumen. • Femoral heads – Including the femoral head and neck. • Sigmoid colon or other bowel – Bowel lying within 2 cm of the PTV. For non-isocentric plans, distal hot spots need to be avoided. • Prostatic urethra (for inhomogeneous plans) – Lumen-mucosal interface, extending from bladder neck to the membranous urethra. • Penile bulb – Bulbous spongiosum that lies inferior to the urogenital diaphragm. • Testis – As low as possible, no beams transversing the testis.	x/10
	Appropriate dosimetry	• PTV: Dose of 35-40 Gy delivered in 5 fractions. Volume of PTV receiving 36.25 Gy shall be at least 95%, and prescribed dose shall be > 75-85% Dmax. • Bladder: < 40% bladder volume receiving 50% of prescribed dose and < 10% receiving 100% dose. • Rectum: volume of rectum receiving 36.25 Gy shall be < 1 cc, <40% of rectum shall receive 50% of prescribed dose, < 20% receiving 80% of dose, < 10% receiving 90% of dose, < 5% receiving 100% of dose. • Sigmoid colon or other bowel: volume receiving 30Gy shall be < 1 cc. • Hips: < 5% receiving 40% of prescribed dose. • Testis: Care should be made to minimize dose to the testis.	x/10
Treatment Delivery	Appropriate treatment verification	Appropriate imaging should take place prior to each treatment field/arc or at least every 1-2 minutes for robotic SBRT.	x/2
	Peer review/ chart rounds	Peer review should be performed prospectively.	x/2
	Treatment documentation/daily dose log/ physics chart reviews	Appropriate Radiation Oncologist and Medical Physics supervision. Performed and documented.	x/3
	Appropriate treatment management	On treatment visits documented, management of side effects, after each treatment.	x/3
After SBRT Care	Treatment summary	Complete and signed	x/2
	Follow-up plan	Appropriate clinical and radiographic follow-up including management of subacute and late side effects. PSA results post-treatment (every 3-6 months for the first 5 years and then yearly after). Quality of life assessments.	x/5
	Overall appropriateness of care	Prostate SBRT selection process, treatment approach and rationale, risk/benefits/side effects documented.	x/3

11. PHYSICS DOCUMENT CHECKLIST

SRT/SBRT Physics Category	Requested Documentation	Expected Findings	RANKING (1 High-5 Low)
1. Treatment Machine Commissioning			
2. Planning System Commissioning			
3. CT Simulation & Motion Management			
4. IGRT Commissioning and SOP			
5. Patient Specific QA Procedures			
6. Plan Peer Reviews: Physician/Physics/RTT			
7. Treatment Delivery – Checklist for Treatment			
8. Clinical Trials: Established Guidelines			
9. Adoption of New and Emerging Technology			
10. Manufacturer Provided Training			
11. Other Documented SRT Training/CME etc.			

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12.1. CNS

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12.2. Spine

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Version: February 28, 2021