SBRT QA

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Disclosure

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Outline

SBRT QA

- SBRT prevalence
- Sources of Errors
- Resources
- Commissioning
- Periodic QA
- Treatment Planning
- Patient Specific QA
- Treatment Delivery
- References

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SBRT QA

ACR and ASTRO define SBRT as “an external beam radiation therapy method used to very precisely deliver a high dose of radiation to an extracranial target within the body, using either a single dose or a small number of fractions.”

Oxford Dictionary defines Quality Assurance as “maintenance of a desired level of quality in a service or product, especially by means of attention to every stage of the process ...”

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SBRT QA

ACR accredited institutions performing SBRT

1995	2003	2007	2014
N/A	N/A	39%	90%

Abt Study of Medical Physics Work Values, Report IV, 2015

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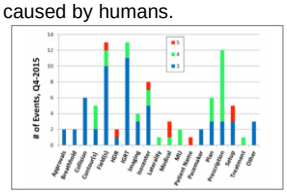
SBRT QA: Errors

The majority of errors in stereotactic procedures and more broadly in radiation therapy are caused by humans.
Solberg et al, PRO 2012, 2(1):2-9.

A 2015 RO•ILS quarterly report concluded that “rushing” is a central theme in high priority incidents.



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SBRT QA: Staffing

Radiation Oncology Practice Accreditation Program Requirements

1 FTE/260 patients (180 academic)

ACR

The Abt Study of Medical Physicist Work Values for Radiation Oncology Physics Services: Round IV

effort/ CPT code

Final Report

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 11, NUMBER 1, WINTER 2010

A grid to facilitate physics staffing justification

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0.008 FTE/SBRT patient

10 hrs/SBRT patient

SBRT QA: Staff Training

AAPM TG 101 states that staff training is of the highest priority and that special SBRT training is needed for all involved staff.

SBRT training should be obtained prior to treating patients.

SBRT training courses – onsite and online – are offered by a number of institutions.

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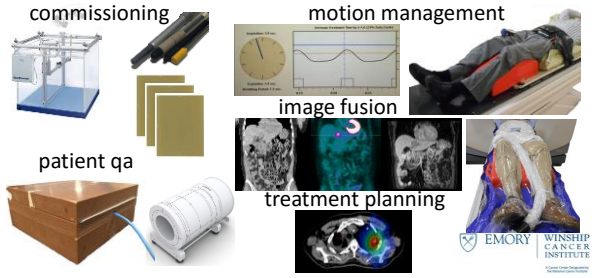
SBRT QA: Resources

SBRT QA: Resources



SBRT QA: Commissioning

Medical physicists are responsible for the technical aspects of SBRT. Responsibilities during acceptance and commissioning include quality assurance of

- Localization/imaging devices used to determine target coordinates
- Treatment planning system
- SBRT treatment machine

Potters et al, IJROBP, 2010, 76: 326-332.

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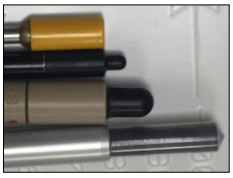
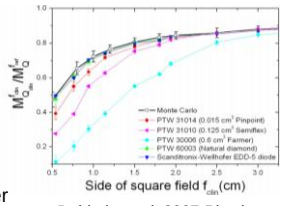
SBRT QA: Commissioning

Appropriate detectors for small field measurements



TG 101 recommends dosimeter with ≤ 1 mm spatial resolution



Doblado et al, 2007 Physica medica 23:58-66

SBRT QA: Commissioning

Commissioning tests of …

- Imaging data integrity
- Dose calculation algorithms
- MLC leaf sequencing
- MU calculations algorithms
- Leaf speed
- Dose rate
- Small MU delivery
- Imaging/localization
- Tracking/gating

… in many cases can be used for QA tests.

Benedict et al, Med Phys, 2010, 37: 4078-4101.

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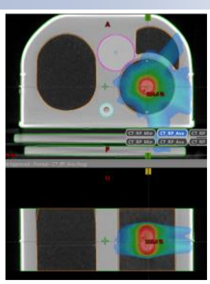
SBRT QA: End to end testing



MD Anderson Cancer Center

Making Cancer History

Report of Lung Phantom Irradiation

Date of Report:	December 28, 2015
Institution:	Emory University Hospital Midtown
Physicist:	Justin Roper, Ph.D.
Radiation Machine:	Varian, TrueBeam (2383) – 6 MV FFF
Collimator:	MLC
Technique:	IMRT - Rapid Arc
Treatment Planning System:	Varian, Eclipse (IMRT) – AAA
Date of Irradiation:	October 16, 2015
Method to account for Target Motion	Gating

Description of procedure:

An anthropomorphic lung phantom incorporating a cylindrical dosimetry insert that simulated the left lung was placed in the supine position in a CT scanner and imaged. The insert contained a spherical centered target. TLD capsules located near the center of the target provided point dose information and three sheets of GAFChromic™ Dosimetry Media provided dose distributions in the axial, coronal and sagittal planes. The phantom included heart and spinal cord structures, each one containing one TLD capsule. The right lung was also included. The phantom with the insert was irradiated to approximately 6 Gy using a IMRT technique. The analyses of the results were based on dose calculation applying correction for tissue heterogeneity. A reciprocating table connected to a motor controller was used to simulate respiratory motion. Based on the method to account for respiratory induced target motion adopted by the institution, a previously programmed breathing cycle was used during treatment and CT procedures. The dosimetric precision of the TLD is 3%, and the spatial precision of the film and densitometer system is 1 mm.

Summary of TLD and film results:

Location	IROC-H vs. Inst	Criteria	Acceptable
PTV_TLD_sup	0.96	0.92 – 1.05	Yes
PTV_TLD_inf	0.96	0.92 – 1.05	Yes

Film Plane	Gamma Index*	Criteria	Acceptable
Axial	99%	≥ 80%	Yes
Coronal	97%	≥ 80%	Yes
Sagittal	97%	≥ 80%	Yes
Average over 3 planes	93%	≥ 85%	Yes

*Percentage of points meeting gamma-index criteria of 7% and 5 mm

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SBRT QA: Commissioning

Before commissioning becomes a distant memory:

- Clearly document all work
- Develop policies and procedures, including checklists
- Establish a comprehensive QA program

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SBRT QA: Periodic machine QA

TG 142 is the current standard for periodic machine QA

SRS/SBRT machines have the tightest tolerances

TABLE I. Daily.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Dosimetry			
X-ray output constancy (all energies) Electron output constancy (weekly, except for machines with unique e-monitoring requiring daily)		3%	
Mechanical			
Laser localization	2 mm	1.5 mm	1 mm
Distance indicator (ODI) @ iso	2 mm	2 mm	2 mm
Collimator size indicator	2 mm	2 mm	1 mm
Safety			
Door interlock (beam-off)		Functional	
Door closing safety		Functional	
Audiovisual monitor(s)		Functional	
Stereotactic interlocks (lockout)	NA	NA	Functional
Radiation area monitor (if used)		Functional	
Beam on indicator		Functional	

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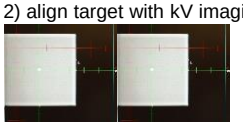
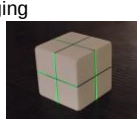
SBRT QA: Periodic Machine QA

ASTRO and ACR recommend evaluating the accuracy of imaging and treatment delivery systems together.

1) offset target 2) align target with kV imaging





3) validate with treatment beam, e.g., portal imaging, Winston Lutz

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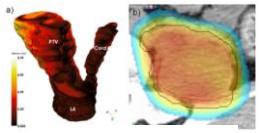
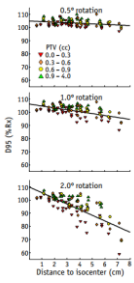
SBRT QA: Robotic couch QA

- Central BB insensitive to rotations
- Rotational errors can be important
- Robotic couches allow for 6 DoF corrections
- Quality assurance needed for robotic couches

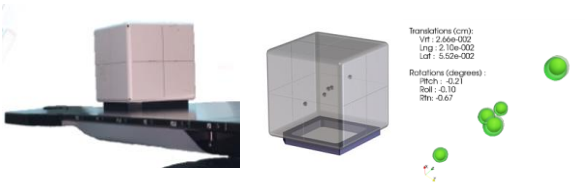


Schreibmann et al, 2011, JACMP 12(3):540-46



Roper et al, 2015, IJROBP 93(3):540-46

SBRT QA: Robotic couch QA



Cook, Roper, Elder, Schreibmann, Unified imaging and robotic couch QA, Accepted in Medical Physics

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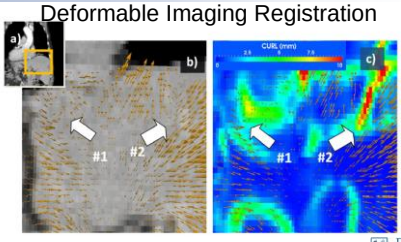
SBRT QA: Simulation and Planning

Deformable Imaging Registration



Schreibmann et al, 2012 JACMP 13:126-139

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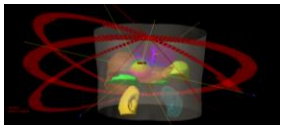
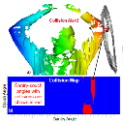
SBRT QA: Simulation and Planning



Conventional Collision Check

Virtual Collision Check



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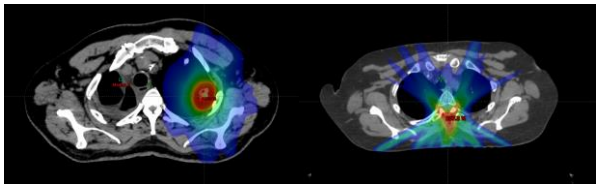
SBRT QA: Simulation and Planning

Site specific expertise



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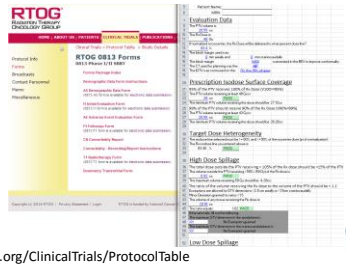
SBRT QA: Simulation and Planning



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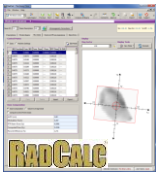
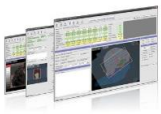
https://www.rtog.org/ClinicalTrials/ProtocolTable

SBRT QA: Patient Specific QA

Monitor Unit Verification



Monte Carlo



IMSure QA Software

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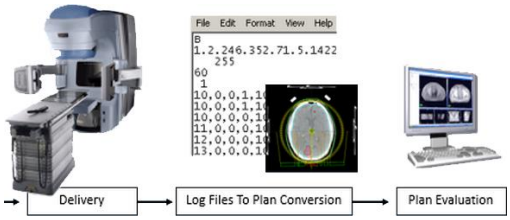
SBRT QA: Patient Specific QA

SBRT QA: Patient Specific QA



SBRT QA: Treatment Delivery

AAPM TG 101 recommends that a QMP be present for the entire 1st SBRT fraction then be available for any subsequent fractions.

SBRT QA: Treatment Delivery

Spatial accuracy is paramount

Initial positioning
- Coarse: body frames/marks
- Final: imaging

During treatment
- Aggressive immobilization or
- Image based tracking

Benedict et al, Med Phys, 2010, 37: 4078-4101.

SBRT QA: Treatment Delivery

Does the time of day matter?

A failure mode and effect analysis study concluded that treating patients during lunchtime or at the end of the day could result in a greater rate of errors.

Solution: Schedule SBRT patients at times when there are fewer distractions.

Perks et al, IJROBP, 2012, 83: 1324-1329.

SBRT QA: Beyond Periodic QA

TG 100: Application of risk analysis methods to radiation therapy quality management

Huq et al, Med Phys, 2016, 43: 4209-62.

SBRT QA: References

Task Group 142 report: Quality assurance of medical accelerators, Klein et al, Medical Physics, 36, 4197-4212 (2009).

Task Group 101 report: Stereotactic body radiation therapy, Benedict et al, Medical Physics, 37, 4078-4101 (2010).

Task Group 100 report: Application of risk analysis methods to radiation therapy quality management, Huq et al, Medical Physics, 43, 4209-4262 (2016).

American Society for Therapeutic Radiology and Oncology (ASTRO) and American College of Radiology (ACR) practice guideline for the performance of stereotactic body radiation therapy, Potters et al, IJROBP, 76(2): 326-32 (2010).

https://www.astro.org/RO-ILS.aspx

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