Fundamental Aspects of SBRT

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AAPM 2016 SBRT Educational Session
Monday, Aug 1 (1:45 – 2:40 PM)

What Are Fundamental Aspects?

- SBRT and its workflow
- Resources
  - Staff
  - Equipment
  - Training
- Processes
  - Safety
  - Acceptance
  - Commissioning
  - Quality assurance
  - Doc
- The future development – precision SBRT

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Stereotactic Body Radiation Therapy

- SBRT is rapidly adopted into the routine clinical practice at all levels of clinical practices including the community-practice settings
- SBRT definition in AAPM TG101
  - Delivery of large doses in a few fractions (high biological effective dose BED)
  - Conformation of high doses to the target and rapid fall-off doses away from the target to minimize the normal tissue toxicity
  - Requires a high level of confidence in the accuracy of the entire treatment delivery process

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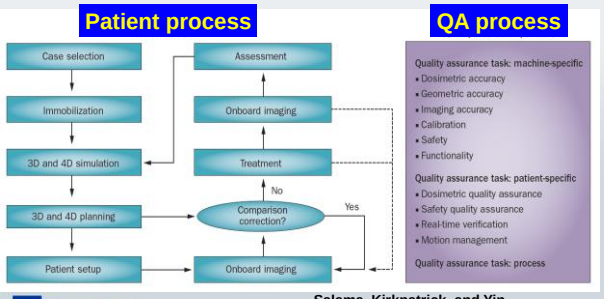
Workflow for SBRT



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Salama, Kirkpatrick, and Yin
Nature Reviews|Clinical Oncology 2012

Minimum Resources

- Staffing and coverage
  - Sufficient physicist and planner
  - Sufficient radiation oncologist
  - Sufficient radiation therapist
- Equipment and devices
  - Dosimetric feasible delivery unit for SBRT
  - Redundant radiation detectors suitable for small fields
  - Appropriate devices for patient setup and immobilization
  - Appropriate devices for proper motion management
  - Reference-grade electrometer suitable for low-charge readings
  - Appropriate end-to-end (E2E) phantoms for use on site
  - QC device for Winston-Lutz type beam alignment verification

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Minimum Resources

- Imaging and planning hardware/software
  - 4D CT capability (for thoracic and abdominal SBRT services)
  - Multi-modality image access and fusion capability (CT, MR & PET)
  - Capability to evaluate composite dose
  - Data management system
- Administrative
  - Commitment to support the delineation of duties, procedural QA, and staff authority required for safe delivery of SBRT services
    *SOP as developed by institutional RT QMP/Medical Director
  - Commitment to facilitate and pay for independent peer review of the SBRT program and on-site proctoring of the first SBRT treatment(s) when it is needed
- An institution should not offer SBRT services unless it can provide appropriate resources

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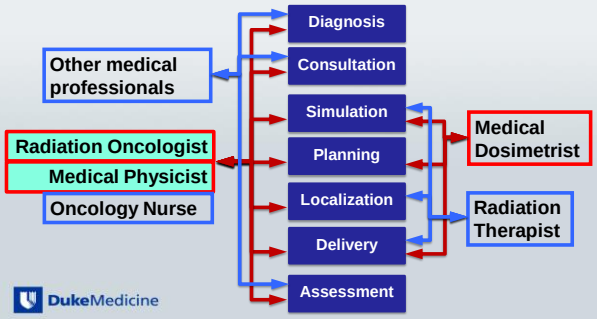
Staff: A Dedicated SBRT Team



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Staff: Qualifications and Responsibilities

- **Qualifications:**
  - Basic credentialing (ABR certifications, etc.)
  - Competency (special training in SBRT procedures)
  - Ongoing training in SBRT for new technologies and techniques
- **Responsibilities**
  - Professional supervision in each step of SBRT process
  - Ensure a consistently safe and accurate treatment delivery
  - ACR-ASTRO Practice Parameter for SBRT: **"The medical physicist is responsible for the technical aspects of radiosurgery and must be available for consultation throughout the entire procedure: imaging, treatment planning, and dose delivery."**

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Staff: Professional Supervision

- **Two responsible professionals for supervision**
  - Radiation Oncologist – supervise clinical procedures
  - Medical Physicist – supervise technical procedures
  - All other team members work under the supervision of these professionals
- **General supervision**
  - The procedure: Overall direction and control but not presence
- **Direct supervision**
  - General supervision + present in the facility/immediately available
- **Personal supervision**
  - General supervision + present during the procedure

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Acceptance Testing

- The QMP must be involved with the process of facility design, equipment selection and specifications, and provide direct supervision during the acceptance testing process
- Customer acceptance test procedures (ATP):
  - To ensure that the equipment satisfies the performance requirements stated in the purchase agreement, including that the equipment is safe to operate
- Some ATP measurements also serve as components in establishing the routine quality assurance program
- The vendor must demonstrate acceptable system performance

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Commissioning

- **Understand scope of procedures/services to be offered**
- **Scope of commissioning = Scope of clinical services**
- **Commissioning contents**
  - Equipment commissioning
    - Validating the planning and delivery system for the services to be offered
  - Process commissioning
    - Implementation: Developing appropriate QC and technical procedures to support services to be offered
  - Commissioning verification/validation
    - Performing End-to-End (E2E) tests
- **Documentation**

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AAPM-RSS: SRS-SBRT Practice Guideline draft 2016

Equipment Commissioning

- Performed by a qualified physics team
- Develop a comprehensive baseline characterization
- Validate the planning and delivery system with E2E
- Identify any limitations relative to clinical use
- Develop procedures for clinical operaiton
- Develop comprehensive QA programs for
  - Treatment delivery machine
  - Immobilization devices
  - Ancillary systems for imaging and motion management
  - Treatment planning systems

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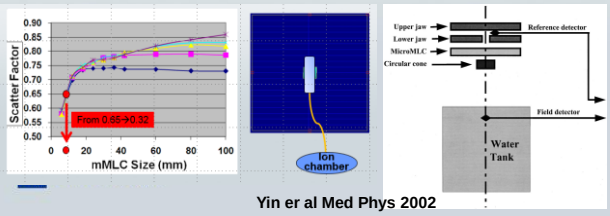
Commissioning - *Special Considerations*

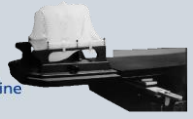
- **Small field dosimetry**
  - Detector
    - Major factors: source size, detector size and response
    - Small field micro-detectors: diode, plastic scintillators, etc.
  - Measurement method



Yin er al Med Phys 2002

Commissioning - *Special Considerations*

- **Immobilization equipment**
  - Targeting accuracy and precision (E2E testing)
  - Beam attenuation and surface dose characteristics
- **Treatment planning system**
  - Dose model: accuracy, attenuation, heterogeneity
  - Multi-modality image fusion accuracy
- **Motion management**
  - Dynamic phantom E2E study: accuracy of position/dose



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Process Commissioning: Clinical Implementation

Guidance from AAPM TG 101 report

The high dose delivery and precision targeting requirements of SBRT demands stringent procedures and tools in order to guarantee that the accuracy of the system is achieved for each treatment and each fraction. The critical steps for initiating a clinical SBRT program involve:

- **Establish the scope of the SBRT program including a selection of treatment sites and the clinical goals for each site.**
- **Determine a treatment modality, dose-fractionation scheme, and treatment planning goals target definition, target coverage, conformity index, etc. that support the clinical goals for each treatment site.**
- **For each treatment modality and treatment scheme, determine the equipment requirements for patient positioning, treatment delivery, and verification.**
- **Determine personnel needs for SBRT implementation and maintenance.**
- **Establish and perform acceptance and commissioning test procedures for the SBRT equipment.**
- **Establishing SBRT simulation, treatment planning, delivery and verification guidelines, reporting methodology and routine QA procedures, and action levels.**
- **Conducting personnel training.**

Process Commissioning: Clinical Implementation

- **The clinical team needs to develop Standard Operating Procedures (SOPs) for each anatomical site to be treated should be developed to address processes in patient review, simulation, planning, treatment and follow-up etc.**
- **Patient safety should be the primary consideration when developing any SOP**
- **References available including AAPM task group reports, ACR-ASTRO Practice Parameters and recent AAPM Medical Physics Practice Guidelines**

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Standard Operating Procedures

- **Safety** (mechanical tolerance, time allowance, right of stop, …)
- **Patient selection** (criteria, tumor board, …)
- **Simulation** (setup, immobilization, imaging/parameters, motion, …)
- **Treatment planning** (algorithm, image fusion, organs, motion, beam design, grid, prescription, 2nd MU, combination dosimetry, …)
- **Treatment delivery** (professional supervision, check list, pre-treatment QA check, dry-run, image-guidance, motion management, pre, during, and post treatment monitoring, …)
- **Patient follow-up** (schedule, clinical tests, …)
- **Checklists** (safety checklists, treatment-specific checklists, …)
- **Training** (initial, ongoing training, documentation, competency requirements, vendor training, non-vendor training, …)

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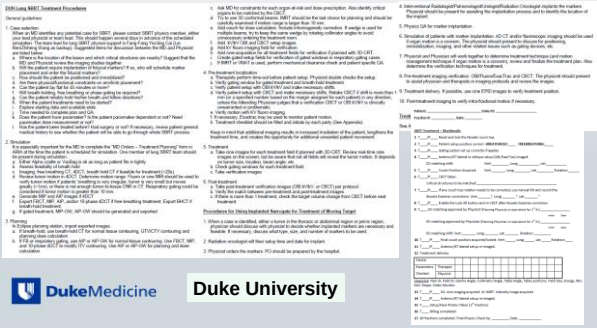
Example for LUNG SBRT Procedures



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Process Commissioning: End-to-End (E2E) Testing

- To assess the clinical team's readiness and to validate the SOP, the team should conduct dry runs of the entire process: End-to-End (E2E) testing
- The pre-implementation E2E tests and findings should be described in the commissioning report
- Each step in the E2E testing should be performed by the staff member who will perform the step when the program is clinically implemented
- E2E process dry runs should be performed for
  - Each category of SBRT service
  - When a key aspect of the process is changed

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Commissioning - Documentation

- Independent review
  - E2E phantom tests - IROC
  - An independent physicist's on-site review
- Commissioning report
  - The scope of commissioning work and key results should be summarized in a written commissioning report

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Quality Assurance

- Critical to ensure the correct dose is delivered to the target, given the very small target volumes and rapid dose fall-off associated with SBRT.
- SBRT related QAs
  - Equipment specific QA
  - Patient specific QA
  - Procedure specific QA

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Minimum Equipment Specific QA

Recommendations for QA related to SBRT

- TG-142 describes the linear accelerator QA for both conventional radiation therapy procedures and for SBRT procedures
- TG-135 provides specific guidance for QA of robotic radiosurgery systems
- MPPG 5.a provides minimum QA recommendations for treatment planning system dose algorithms
- MPPG is developing minimum QA recommendations for machines
- The baseline performance values for routine equipment QA should be established during machine commissioning and initial calibration
- The SOPs for SBRT relevant QA tests, frequencies, tolerances, and actions should be defined

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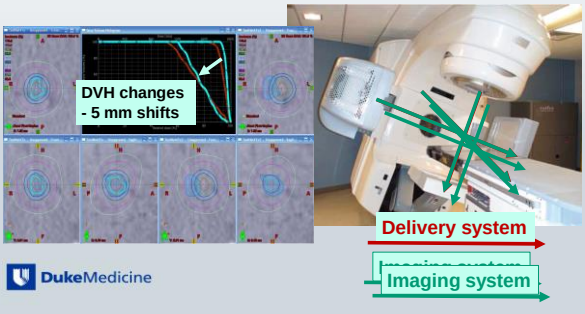
Example for Device Specific QA: Consistency of Imaging and Delivery



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Patient Specific QA (PSQA)

- QMP with special training determines the PSQA protocols and instrumentation used for PSQA
- Special needs
  - Smaller volume, high dose heterogeneity, fast dose falls off
  - Require high spatial resolution and a broad dose range QA devices
  - Small field dose measurement instrumentation should be available
  - Clinical service should not be initiated if PSQA could not be done
- Main components
  - A dry-run of the approved treatment plan should be performed to check for potential collision
  - When the MLC collimator is applied to modulate the dose, absolute dose and dose distributions should be validated prior to treatment

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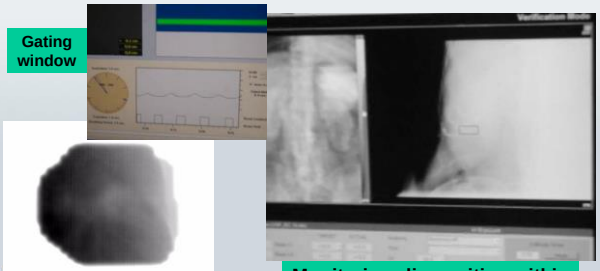
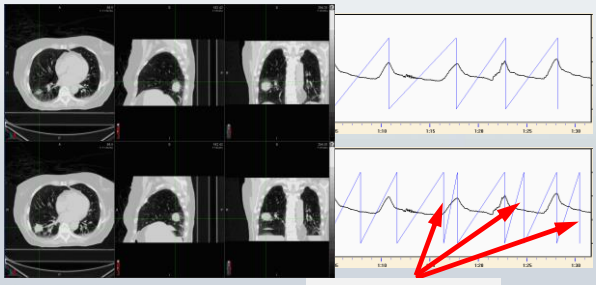
Patient Specific QA: Real-time Verification



Patient-specific QA: 4DCT Imaging Artifact



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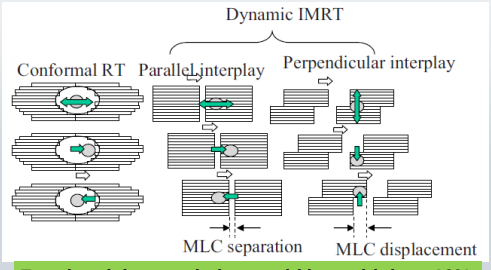
Patient Specific QA: MLC Interplay Effects for Moving Target



Fractional dose variation could be as high as 10%

Court et al Med Phys 2008

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Procedure Specific QA

Address issues related to operational tasks, such as:

- **The workflows to perform SBRT as defined in the SOP documents are consistently followed**
- **Staffing level is appropriate**
- **Staff training and ongoing training are available and appropriate**
  - **Training and competency assessments**
  - **Supervision of an experienced expert**
  - **Ongoing competency assessment**
- **Proper follow-up actions are taken for any actual and/or potential ("near miss") treatment incidents**
- **Annually review: SOP documents defining the workflow of each SBRT service if no major changes**

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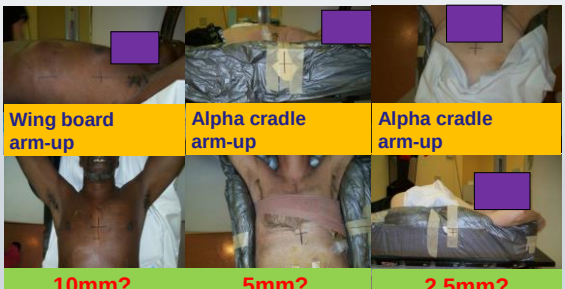
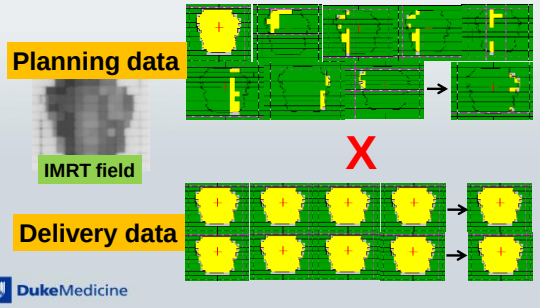
Procedure-specific QA: Margin Factors



How to margin (SM) with these different immobilizations?

Procedure-specific QA: Data Consistency



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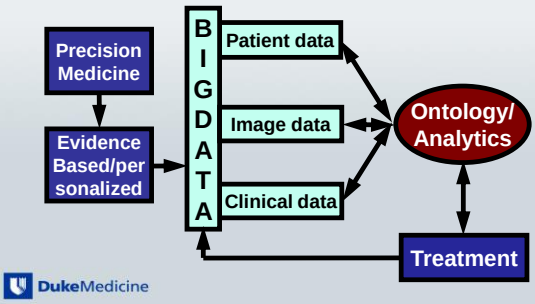
The Future Development in SBRT



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Summary

- A team of appropriate trained for SBRT is the key for the program success.
- Radiation Oncologist and Medical Physicist are the two responsible professionals for the delivery of SBRT services
- The provision of SBRT services should follow a structured SOP with clearly defined roles, responsibilities, procedures and action levels
- The sufficient resources and programmatic components are imperative to safe implementation of SBRT services

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Acknowledgements

The members of Medical Physics Practice Guideline 9: SRS-SBRT Practice Guideline, AAPM Professional Council

- Per Halvorsen, MS, FAAPM, FACR, Chair
- Eileen Cirino, MS, FACMP
- Indra J. Das, PhD, FAAPM, FACMP
- Jeffrey A. Garrett, MS
- Jun Yang, PhD
- Fang-Fang Yin, PhD, FAAPM
- Lynne A. Fairobent, AAPM Staff

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Thank you for your attention

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