MPPG 1 – Evaluation and quality assurance of x-ray based image guided radiotherapy systems

Presented at Spring NCCAAAPM meeting by Andrew Jensen

MPPG background courtesy of Per Halvorsen, Maria Chan, and Joann Prisciandaro

MPPG 1 slides courtesy of Jonas Fontenot, Chair MPPG 1
Learning objectives and disclosures

• Learning objectives
  – Identify the rationale behind medical physics practice guidelines (MPPGs)
  – Compare and contrast task group (TG) reports and MPPGs
  – Identify MPPG 1 test, frequencies, and tolerances

• Disclosures
  – I have no conflicts of interest to disclose
Outline

• Background and rationale for MPPGs
  – Motivations
    • Sources and application of guidance documents
  – Medical Physics Practice Guidelines
    • Vision and scope
    • Process

• MPPG 1
  – Approach
  – Recommendations
Motivations - MIPPA

- **Medicare Improvements for Patients and Providers Act of 2008:**
  - Requires practice accreditation for the “advanced imaging” modalities
    - Includes CT, MR, Nuclear Medicine, and PET
    - Does not include x-ray, fluoroscopy, sonography
    - Does not include anything in radiation oncology
  - Does not apply to hospitals
  - 3 accrediting bodies
    - American College of Radiology (ACR), Joint Commission, and Intersocietal Accreditation Commission
ACR guidelines

- Developed through a consensus-focused process with broad representation by different practice environments
- Aim to define a minimum practice standard
- Significant physician influence
- Devoid of much specificity
Launching a significantly enhanced practice accreditation program and beginning the development of additional accreditation modules specifically addressing new, advanced technologies such as IMRT, SBRT and brachytherapy.
Possible result:

• Multitude of accrediting entities, each defining their own quality control (QC)/safety standards

• State regulations continue to reference Task Group reports, which may not have been written with that use in mind
Proposed solution:

- AAPM develops practice guidelines for medical physics, defining a minimum practice standard for a given scope of clinical service
- Accreditation programs (and state regulators) incorporate the AAPM practice guidelines rather than defining their own
Medical Physics Practice Guidelines

AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE
PROFESSIONAL POLICY:
PROCESS FOR CREATION, APPROVAL, AND REVISION OF
MEDICAL PHYSICS PRACTICE GUIDELINES

INTRODUCTION
The American Association of Physicists in Medicine (AAPM) has long advocated a consistent level of medical physics practice, and has published many guidelines and position statements toward that goal, such as Science Council Task Group reports related to calibration and quality assurance, Education Council and Professional Council Task Group reports related to education, training, and peer review, and Board-approved Position Statements related to the scope of practice, physicist qualifications, and other aspects of medical physics practice. Despite these concerted and enduring efforts, the profession does not have a clear and concise statement of the acceptable practice guidelines for routine clinical medical physics. As accreditation of clinical practices becomes more common, Medical Physics Practice Guidelines (MPPGs) will be crucial to ensuring a consistent benchmark for accreditation programs.

The AAPM will lead the development of MPPGs in collaboration with other professional societies. The MPPGs will be freely available to the general public. Accrediting organizations, regulatory agencies and legislators will be encouraged to reference these
2. Vision

The AAPM will lead the development of MPPGs in collaboration with other professional societies. The MPPGs will be freely available to the general public. Accrediting organizations, regulatory agencies and legislators will be encouraged to reference these MPPGs when defining their respective requirements.

3. Scope

MPPGs are intended to provide the medical community with a clear description of the minimum level of medical physics support that the AAPM would consider prudent in all clinical practice settings. Support includes but is not limited to staffing, equipment, machine access, and training. These MPPGs are not designed to replace extensive Task Group reports or review articles, but rather to describe the recommended minimum level of medical physics support for specific clinical services.
MPPGs

• AAPM Committee Responsibilities
  – Subcommittee on Practice Guidelines (SPG) is responsible for developing a list and priority of appropriate subject areas
  – The Clinical Practice Committee (CPC) is responsible for reviewing the list, the prioritization, and for providing suggested revisions.
  – Professional council (PC) is responsible for final review and approval

• Topics
  – May be submitted by any AAPM member, the AAPM Board of Directors, AAPM Councils, and collaborating societies.
  – The SPG shall review nominations and suggested revisions in a timely manner, but no less frequently than once per year.
Process for MPPG

- **Timeline**
  - *1 year* from commencement to approval to finish

- **Requirements**
  - Well defined-scope
  - Motivated MPPG members
  - Motivated SC and PC members

1. Nominations of topics
2. Formation of MPPG TG
3. Commencement of MPPG
4. Initial meeting and preliminary recommendations
5. Draft MPPG
6. Comment period (AAPM members, committees, others)
7. Approval
8. Publication on AAPM website and in JACMP.
TG reports vs MPPGs

TGs are

- Intended to be technical reference for medical physicists – compendia of the known science on a topic
- Written by a core group of subject-matter experts
- Reviewed by subject-matter committee and approved by one Council
TG reports vs MPPGs

MPPGs are

– Developed following a structured process to become consensus practice guidance documents
– Developed with cross-Council participation
– Open for review/comment by ALL members
– Intended to be adopted by regulatory agencies and accrediting entities
– Updated regularly – sunset dates / revision #
– Freely available to ALL – not just AAPM
Current MPPG Task Groups

• Evaluation and QA of x-ray based image guided radiotherapy systems (Fontenot)
• CT protocol management and review (Cody)
• Development, implementation, use and maintenance of safety checklists for radiation oncology (del los Santos)
• Treatment planning system commissioning and QA (Smilowit)
• Definition of Supervision (Siebert)
MPPG #1

Evaluation and Quality Assurance of X-ray Based Image Guided Radiotherapy Systems

Committee Members:
Jonas Fontenot (chair) – Mary Bird Perkins Cancer Center
Andrew Jensen – MN Oncology
Jack Yang – Monmouth Medical Center
Hassaan Alkhatib – Richland Memorial Hospital
Jeff Garrett – Mississippi Baptist Medical Center
Steve McCullough – Methodist Richardson Cancer Center
Brent Parker – University of Texas Medical Branch at Galveston
Art Olch (TPC rep) – Children’s Hospital of LA
Rationale

• IGRT systems come in many flavors
  – Megavoltage imaging systems
    • Two-dimensional
    • Three-dimensional
  – Kilovoltage imaging systems
    • Two-dimensional
      – Gantry-mounted
      – Room-mounted
    • Three-dimensional
      – Gantry-mounted
      – Room-mounted
Rationale

• Many guidance documents are available
  – TG-58 – TG-135
  – TG-75 – TG-142
  – TG-101 – TG-148
  – TG-104 – TG-179

• Obstacles to successful implementation of an IGRT program
  – Unfamiliarity with technology
  – Variety/complexity of guidance documents
  – Few process descriptions
  – What is required?
Goals

• Succinctly state the minimum acceptable standards for using IGRT, similar to ACR-ASTRO technical standards
• “Clinical recipe” for the solo physicist
• Inform the reader of the needs of this particular technology (time, effort, resources)
• Compile necessary references for further investigation
Intended Users and Uses

• Medical physicists
  – What is required for safe and effective use?
    • Tools
    • Time/effort
    • Procedures

• Administrators
  – How much will it cost (hard/soft)?

• Accrediting bodies
• Regulatory agencies
Approach

• Survey existing TG recommendations
• Survey IGRT practices/observations at MPPG members’ institutions
  – University clinics
  – Community clinics
• Rank, prioritization of minimally acceptable practice
• Expansion of process descriptions, categorized by IGRT approach
• Address applicable areas of need identified by SPG
Approach

• Timeline of activities
  – 2/13/12: MPPG TG formed
  – 3/19/12: Scope and Timeline submitted to SPG
  – 3/27/12: IGRT program questionnaire submitted to MPPG member institutions (who, what, when, where, how)
  – 5/15/12: IGRT program data collected from MPPG member institutions
  – 7/01/12: Working draft of report submitted to SPG
  – 7/29/12: Face-to-face meeting at AAPM
    • 8/21/12: Teleconference
    • 8/28/12: Teleconference
    • 9/11/12: Teleconference
    • 9/18/12: Teleconference
    • 10/2/12: Teleconference
  – 10/7/12: Report submitted for internal review
    • SPG, PC, TPC, QASC, EXCM, Chairs of TG 75, 104, 111, 135, 179
  – 11/13/12: Internal review comments received (95)
    • 12/3/12: Teleconference
    • 12/7/12: Teleconference
  – 12/15/12: Report submitted for public comment
  – 1/28/13: Public review comments received (34)
    • 2/05/13: Teleconference
  – 3/11/13: Report approved by MPPG members for formal process approval
Staff Responsibilities

- IGRT implementation requires a team approach
  - Radiation Oncologist
  - Medical Physicist
  - Medical Dosimetrist
  - Radiation Therapist
  - Information Technologist
Staff Responsibilities

• Medical physicist
  – Must be competent to practice independently in the subfield of therapeutic radiological physics. The individual must be certified (ABR, ABMP, CCPM).
  – Responsibilities of the qualified medical physicist in an IGRT program include:
    • Performs acceptance testing and commissioning
    • Implements and manages of a quality assurance program
    • Develops and implements standard operating procedures (including imaging protocols and repositioning thresholds)
Staff Responsibilities

• Radiation Oncologist
  – Manages patient positioning procedures
  – Specifies imaging modalities and frequencies
  – Identifies registration targets and repositioning thresholds
  – Performs timely review of clinical IGRT images
  – Conducts regular reviews of the IGRT program

• Medical Dosimetrist
  – Creates and transfers to the OIS all patient-specific data necessary for IGRT implementation
Staff Responsibilities

• Radiation Therapist
  – Understands the use of positioning devices in IGRT
  – Prepares the IGRT system for acquisition of patient-specific positioning verification images
  – Implements the IGRT treatment protocol under the supervision of the radiation oncologist and medical physicist
  – Acquires positioning verification images for review by the radiation oncologist
  – Assists in periodic review of the stability of the IGRT system (e.g. daily QA)
Staff Responsibilities

• Information technologist
  – Provides and maintains resources necessary for storing, archiving and retrieving images generated during IGRT.
  – May be accomplished by a dedicated Information Specialist or duties assigned to another team member.
Implementation Guidelines

• Required resources - Time
  • Two dimensional MV imaging systems
    – Acceptance/Commissioning/Documentation: 18-36 hours
    – Ongoing support: 25-50 hours annually
  • Two dimensional kV imaging systems
    – Acceptance/Commissioning/Documentation: 18-36 hours
    – Ongoing support: 25-50 hours annually
  • Three dimensional MV imaging systems
    – Acceptance/Commissioning/Documentation: 18-36 hours
    – Ongoing support: 100-125 hours annually
  • Three dimensional kV imaging systems
    – Acceptance/Commissioning/Documentation: 18-36 hours
    – Ongoing support: 100-125 hours annually
Implementation Guidelines

• Required resources - Equipment
  – Quality tools **must** provide reliable values of the measured parameters.
    • Image quality
    • Spatial accuracy (scaling)
    • Congruence of imaging and treatment isocenters
    • Accuracy of registration/couch movements
    • Imaging dose
  – Phantoms specifically designed for IGRT are available and, when coupled with automated image analysis tools, can improve efficiency.
Implementation Guidelines

• Required resources
  – Training
    • Training for the operation of the IGRT system must be provided
    • Prior to initial use of IGRT, the treatment team should meet to discuss staff responsibilities, clinical goals and process workflows.
    • Physicist should also review the image acquisition procedures with the therapists and radiation oncologists.
# Recommendations

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Tolerance</th>
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<tbody>
<tr>
<td><strong>Acceptance/Commissioning</strong></td>
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<tr>
<td>Customer acceptance procedures</td>
<td></td>
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<tr>
<td>TPS integration</td>
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<td>OIS integration</td>
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<tr>
<td>Establish routine QA baselines</td>
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<tr>
<td>Documentation</td>
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<tr>
<td><strong>Daily</strong></td>
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<tr>
<td>Safety/interlocks</td>
<td>Functional</td>
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<tr>
<td>Imaging-treatment isocenter coincidence (SRS only)</td>
<td>1 mm</td>
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<tr>
<td>Positioning/repositioning (SRS only)</td>
<td>1 mm</td>
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<tr>
<td>Imaging-treatment isocenter coincidence (SBRT only)</td>
<td>2 mm</td>
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<tr>
<td>Positioning/repositioning (SBRT only)</td>
<td>2 mm</td>
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<tr>
<td><strong>Weekly</strong></td>
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<tr>
<td>Imaging-treatment isocenter coincidence (non-SRS/SBRT)</td>
<td>2 mm</td>
</tr>
<tr>
<td>Positioning/repositioning (non-SRS/SBRT)</td>
<td>2 mm</td>
</tr>
</tbody>
</table>
# Recommendations

**Semi-Annually**
- **Image scaling**: 2 mm

**Annually**
- **Imaging dose**
  - 2D MV
  - 2D kV (static imaging mode)
  - 2D kV (fluoroscopy mode)
  - All 3D imaging modes

- **Imaging dose**
  - ±1 cGy of acceptance value
  - ±3.0 mGy of acceptance value
  - ±1 cGy/min of acceptance value
  - ±1 cGy of acceptance value

- **Image quality**
  - 2D (spatial resolution, contrast)
  - 3D (uniformity, spatial resolution, contrast)

**Upgrade/Repair/Service**
- Verify / Re-establish QA baselines (as appropriate)

Abbreviations: SRS = stereotactic radiosurgery, SBRT = stereotactic body radiation therapy
Recommendations

• “Acceptance value”
  – Refers to the IGRT system manufacturer’s minimum performance standard stated in the customer acceptance procedure documentation.
  – If unavailable or not specified, then “acceptance value” can be taken as the value measured at the time of commissioning.

  • Most IGRT system manufacturers have stated performance specifications for image quality and, in such cases; those may serve as the tolerance values for routine QA measurements of image quality.
  • Some IGRT system manufacturers do not have stated performance specifications for imaging dose and, in such cases, the imaging dose measured at the time of commissioning may serve as the baseline value to which future measurements are compared.
Recommendations

- In general, the frequency of routine QA tests is proportional to the importance of their performance for the purpose of patient alignment
  - Imaging-treatment isocenter coincidence, positioning/repositioning are considered critical
  - Daily checks of these parameters are preferred, but weekly checks are considered acceptable for IGRT save SRS/SBRT

- Imaging dose
  - Measured for at least one (conservative) acquisition technique of each mode of clinical operation.

- Augmented with procedures required by state regulation

- IGRT systems with known recurring problems should be subjected to more frequent QA at the discretion of the QMP.
Process Descriptions

- Sample process description for each required QA task

**xxi. Imaging dose (2D kV systems)**

Imaging dose from 2D kV systems is most typically characterized using entrance surface air kerma (skin exposure). Measurement equipment used to measure the entrance air kerma includes a calibrated ionization chamber and a phantom. The ionization chamber is placed between the source and the phantom in such a way as to minimize scatter radiation to the ionization chamber. The field size is set to cover the detector. A clinically relevant beam is delivered, and the air kerma rate is calculated for static and fluoroscopic imaging modes, respectively.

Measured imaging dose **should** be documented and its management **should** be approached with the goal of keeping it as low as necessary to achieve clinically useful images. (Time: 15-60 minutes, depending on the number of techniques measured)
Conclusions

- IGRT implementation and QA is challenging
- There are QA elements common to all x-ray based IGRT systems
  - Safety
  - Image quality
  - Geometric fidelity
    - Scaling
    - Treatment-imaging isocenter coincidence
    - Registration/table shifts
  - Dose
- A successful MPPG1 will improve the quality of clinical support for various IGRT strategies
References

- AAPM TG-179: Quality assurance for image-guided therapy utilizing CT-based technologies
- AAPM TG-75: The management of imaging dose during image-guided radiotherapy
- AAPM TG-104: The role of in-room kV X-ray imaging for patient setup and target localization
- AAPM TG-148: QA for helical tomotherapy
- AAPM TG-58: Clinical use of electronic portal imaging
- AAPM TG-135: Quality assurance for robotic radiosurgery
- AAPM TG-142: Quality assurance of medical accelerators
- AAPM TG-111: Comprehensive methodology for the evaluation of radiation dose in x-ray computed tomography
- ACR-ASTRO Practice guideline for image-guided radiation therapy
- AAMD Scope of Practice for a Medical Dosimetrist link: http://www.medicaldosimetry.org/generalinformation/scope.cfm
- ASRT Radiation Therapy Practice Standards; Link: http://www.asrt.org/docs/practice-standards/GR11_RT_PS.pdf
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