MRI safety in Radiation Oncology

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AAPM SAM Session “Development of a Clinical Program for MR-Linac Technology: Tips from Installation to Clinical Implementation” (Speaker #1) July 16, 2020
Learning Objectives

1. Understand the MRI safety challenges in radiation oncology

2. Understand the process of implementing the MRI safety program in an MR-Linac Environment
Essences of MRI Safety

• MRI safety guidelines:
  • 1) AAPM Working Group on MR Safety
  • 2) ACR Manual on MRI safety 4-2020

• MRI facility planning: Safety zones

• MRI safety training and education: Level 1 and level 2 personnel

• MRI policy and procedures: Organization chart

• Emergency plan: Procedures and drills
Challenges of MRI Safety for Radiation Oncology

• New to the RO departments (was a radiology department’s problem)

• New safety concepts (e.g. the magnet is always on)

• Patient scanned in treatment position and PPDs (added MR safety issues)

• Lack of staff training and constant MR safety awareness
Major Hazards of MRI

- Foreign Bodies
- Bio-Effects
- Implants
- Static Field
- Contrast
- Projectiles
- RF
- Cryogens

Invisible initially
Often overlooked

Most Dramatic

Very Rare
The Magnetic is Always On: MRI Field Depends on Distance
Burns can occur if the patient’s skin touches the inside of the MRI scanner during the exam. Padding must be used to prevent this.

If the patient’s arms, legs, or fingers touch each other during the exam, they can form a conductive loop and cause burns. Positioning the patient correctly is critical for safety.
MR System Safety

Magnetic fields – Magnet Quench

Quench emergency switch

Quench

Courtesy of Elekta
MRI Safety Zones

• **Zone I**
  - Areas freely accessible to general public

• **Zone II**
  - Interface between publicly accessible space and strictly controlled MRI Suite
  - Patient screening and preparation (supervised by MR Personnel) should take place here
Safety Zones

• **Zone III**
  • Access and supervision of non-MR personnel controlled by Level 2 personnel
  • Non-MR personnel must accompanied at all times by Level 2 personnel
  • Area physically restricted by keyed locks or passkey systems; free access only for MR personnel with no exceptions
  • Area may extend around and above and below MR unit and also includes cryogen vent location on building exterior (the 5G line)
Safety Zones

• **Zone IV**
  
  • MR scanner room; should be labeled as potentially hazardous
  
  • Level 2 personnel should be able to observe all access points to Zone III and IV at all times via line of sight or video monitors
  
  • Site-access controlled in event of emergent situations
  
  • Sign at entrance (red, illuminated) indicating “The Magnet is always on”, or “The Magnet is on” for resistive systems when appropriate
  
  • Door closed unless needed to be open; caution barrier used otherwise.
  
  • Remain locked after hours
Zones Around an MRI Simulator
2). The MR-Linac
The Unity MR-Linac

 backstage at the venue
Key Elements of MRI Safety for RO

- Access Control
- Planning
- Screening
- Auditing
- Training
- Policies and Procedures
- Scheduling

MRI Safe Facility
Screening is critical!

• Patient Screening: Be alert about patient with implanted devices!

• Visitor/Non-MRI staff screening: Follow protocol

• Immobilization Device Screening: When not sure, contact MRSO for testing
Patient Screening
Patient Screening

• The MRI Patient Screening Questionnaire must be completed *before* an MRI sim exam can be scheduled

• The MRI In-Patient Questionnaire must be documented in EMR

• If you don’t know what a device on the questionnaire is or if your patient has one, be sure to
  • Find out by looking it up from manufacturer’s website
  • Or look it up at “MRIsafety.com”
  • Or contact Jihong Wang

• *Ask more questions if patient had prior surgery!!!
Contra-indications Devices for MRI Scan

• If the patient has any of the followings, they cannot have an MRI scan. **Do not attempt to schedule these patients.**
  
  • Pacemaker
  • Implantable Cardioverter Defibrillator (ICD)
  • Neurostimulators
  • Some are MRI safe and can be scanned but patients go to Diagnostic Imaging for a special clinic.

• Implant malfunctioning after MRI scan!
Screening and Labeling of PPD used in RO

- **MR Safe**: Safe in all MR environments; nonmetallic, nonconductive, nonmagnetic

- **MR Conditional**: May be safely used in MR environment if safe conditions for use are met, i.e. for tested static and spatial gradient field strengths

- **MR Unsafe**: Presents safety risks; ferromagnetic
MRI Safety Organizational Structure in RO

• Establish the MRI Safety Committee
  • Develop MRI safety policy and standard operating procedures

• Identify the key personnel
  • MRMD
  • MRSO
  • MRSE
Personnel Definitions

- **Non-MR Personnel**
  - Patients, visitors, and staff who do not meet criteria of Level 1 or 2 MR Personnel

- **Level 1 MR Personnel**
  - Passed safety educational efforts determined by MR Medical Director (MRMD)
  - Must routinely work in Zone III to maintain status

- **Level 2 MR Personnel**
  - More extensively trained in MR safety issues, including RF safety, dB/dt-related safety for time-varying imaging gradients, cryogen safety, contrast agent safety
Personnel Definitions

- **New administrative roles introduced:**
  - **MR Medical Director (MRMD)**
  - Licensed physician with training in MR safety
  - Has overall and ultimate responsibility for facility operational safety
  - Oversees:
    - Policies and procedures for safe operation
    - Safety and quality assurance program
    - Record keeping
    - Investigation of reported safety events
Personnel Definitions

• **MR Safety Officer (MRSO)**
  • Must be appropriately trained; normally an MR technologist
  • Responsibilities include:
    • Ensure policies and procedures are properly implemented and enforced as they relate to training, education, safety, record keeping, and reporting
    • Report all safety-related issues to MRMD
    • Ensure clear policy for purchasing, testing, and marking equipment that will enter Zones III and IV
Personnel Definitions

• **MR Safety Expert (MRSE)**
  • Acts as resource for MRMD and MRSO for nonmedically related MR safety issues
  • May be external to institution
  • Often an MR Physicist
  • Responsibilities include:
    • Provide advice on engineering, scientific, and administrative aspects of safe MR use; safety framework; policies and procedures; nonroutine MR procedures; MR Safety programs and MR QA programs; root cause analyses
### MRI Safety Training

Proper training level depends on job function

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<th>Personnel Type</th>
<th>Non-MRI Training</th>
<th>Level I Training</th>
<th>Level II Training</th>
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MR-Linac: New Challenges

• Facility planning: New considerations

• New Safety Issues: MRI safety Zone

• Staff Preparation: Training for staffs

• New Workflow and Emergency Policies

• New MRI Safe QC Tools and Procedures
Installation and Site Preparation
MR-Linac Suite

Consideration for both: 1) Radiation Safety  2) MRI Safety
Restricted Access and RF room must remain locked after-hours!!
MRI Safety Preparation for Clinical Operation

• Staff MR Safety Training

• Acquisition of MRI Safe Equipment

• Emergency Procedure Development and Drills (required by our institution safety)
MRI-compatible Devices/Equipment
Special Tools for MR-Linac QA

Must be tested for MR safety!!!
Before MRL Clinical Operation

• MRI Safety Policy (approved and active)

• MRI Safety Committee:
  • Oncologist, Radiation Oncology
  • Physicist, Radiation Physics
  • Champions:
    • Radiation Oncologists, RTTs in each of the clinical areas

• MRI Safety Training (Annual certification)

• Emergency Patient Extraction Procedure Drill
Summary

• Key to MRI safety is education and constant awareness by all staffs

• Patient/visitor screening is key