Safety in the MRI-guided Interventional Environment

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MRI-guided interventions

• **MR-guided Focused Ultrasound** (fibroids, painful bone metastases, prostate)

• **MRI-guided Cryoablations** (post-prostatectomy cancer recurrences, vascular malformations)

• **MRI-guided Laser ablations** (refractory epilepsy, liver metastases)
MRI-guided interventions

People

Anesthesia
MR tech
Radiologist
Urologist
Technical support
Anesthesia
MR tech
Nursing
Radiologist
Urologist
MRI-guided interventions

Equipment
MRI-guided interventions

Why do it?

• **Advantages**
  – Minimal invasiveness
  – Soft-tissue Resolution
  – Increased Lesion Conspicuity
  – Ease of Multiplanar imaging
  – No Radiation
  – Ability to Re-image same slice
  – MR thermometry

• **Disadvantages**
  – Exam time
  – Lack of Compatible Equipment
  – Lack of Familiarity
MRI-guided Focused Ultrasound (MRgFUS)

- ultrasound ablation system integrated with MRI scanner
- treatments of uterine fibroids, bone metastases, prostate cancer
- 278 fibroid patients treated at Mayo Clinic since 2005
- beginning to treat bone metastases (1 treatment so far) and prostate cancer
MRI-guided Focused Ultrasound (MRgFUS)

MR thermometry

27.0 sec

27.0°C
MRI-guided Focused Ultrasound (MRgFUS)

MR thermometry

thermal dose sufficient for tissue ablation
MRI-guided Focused Ultrasound (MRgFUS)

Contrast enhanced T1-weighted images are acquired for treatment assessment.
MRI-guided Focused Ultrasound (MRgFUS)

Treatment-related risks

- Skin Burns (c-section scars, bad acoustic interface at patient skin)
MRI-guided Focused Ultrasound (MRgFUS)

Treatment-related risks

• Skin Burns (c-section scars, bad acoustic interface at patient skin)
• Bowel Perforation (failure to detect fibroid movement, poor monitoring, artifact obscuring bowel)
• Nerve Injury (sonicating too close to nerves or spine)
• Subcutaneous Fat Edema (excessive absorption of US energy in near field)
• Deep Vein Thrombosis (extended time inside MRI scanner >3hrs)
• Increased projectile risk (frequent entry of nursing, tech personnel for administration of sedation, adjustments of patient position, catheter manipulation)
• Prostate cancer tissues are ablated by freezing to lethal temperatures of -40ºC.
• Patients in whom the cancer returned after initial surgery (prostatectomy) and/or radiation therapy.
• MRI is capable of resolving of subtle cancer recurrences in post-prostatectomy prostate bed
MR guided Cryoablation

- Cryoneedles inserted into sites of cancer recurrences
- Argon cools to -186°C (freezing). Helium warms to +33°C (thawing).
- Saline used to increase separation between rectal walls and prostate bed
- Warming catheter inserted into urethra to protect urethral tissues

Joule-Thomson effect (adiabatic expansion of gas)
MR guided Cryoablation

Joule-Thomson effect (adiabatic expansion of gas)

- MRI used to monitor ice ball growth
MR guided Cryoablation

Set-Up

- Equipment Room
  - Sterile surgical area
  - MRI compatible tripod
  - MRI compatible light
  - 1.5T Wide Bore MRI scanner

- MRI Room
  - Junction Box
  - MRI control desk

- Control Room
  - Cryoablation system
  - Argon and Helium Tanks
MR guided Cryoablation

Set-Up

**Cryoablation system**
- Seednet Machine with connector panels
- Argon and Helium gas tanks
MR guided Cryoablation

Set-Up

Cryoablation system
- Seednet Machine with connector panels
- Argon and Helium gas tanks
- MRI-compatible tripod with cryoneedles
MR guided Cryoablation

Set-Up

In-room setup

- Sterile area (arranged on MRI-safe cart)
- MRI-compatible in-room monitor
- MRI-compatible surgical light
MR guided Cryoablation
Set-Up

Cold room setup
- Urethreal Warmer
- Pneumatic pump (DVT prevention)
- Needle guidance system
MR guided Cryoablation
Set-Up

Cold room setup
- Urethreal Warmer
- Pneumatic pump (DVT prevention)
- Needle guidance system
MR guided Cryoablation

Set-Up

- Need to bring non MRI-compatible equipment into scanner room
  - Ultrasound scanner
  - Anesthesia equipment

Procedure
  - Anesthesia equipment
MR guided Cryoablation

Set-Up

**Equipment Room**
- Sterile surgical area
- MRI compatible tripod
- MRI compatible light
- 1.5T Wide Bore MRI scanner

**MRI Room**
- Junction Box
- Junction Box/Gas Panel
- MRI control desk

**Control Room**
- Cryoablation system
- Argon and Helium Tanks

**Procedure**
- Anesthesia equipment
- Specialized MRI coil (requires sterilization)
MR guided Cryoablation

Set-Up

Need to bring non MRI-compatible equipment into scanner room
  • Ultrasound scanner

Mapping of the field around the scanner
Use of tether cords for anchoring
MR guided Cryoablation

Set-Up

Need to bring non MRI-compatible equipment into scanner room
- Ultrasound scanner

MR-compatible US scanner
Treatment-related risks

• Broken cryoneedles can result in patient death (testing the needle integrity prior to insertion essential)
• Bowel injury (poor use of MR-guidance for needle insertion)
• Injury to rectal walls or nerves (poor use of MR-monitoring of ice growth)
• Injury to urethra (failure of urethral warmer system)
• Infection at the cryoneedle insertion site
• Increased projectile risks (large team, frequent entry of personnel for correct needle adjustments, anesthesia process)
• Deep Vein Thrombosis (extended time inside MRI scanner >5hrs)
MR guided Laser Ablation

-- Using stereotactic frame a burr hole is made
-- Laser applicator is guided into the target lesion position
-- Position of the applicator is confirmed with MRI scan
MR guided Laser Ablation

-- MR thermometry used to monitor test and treatment doses in real time
MR guided Laser Ablation

-- Gadolinium enhanced T1-weighted MRI to confirm appropriate extent of ablation
MR guided Laser Ablation

**Treatment-related risks**

- **Substandard treatment**
  - rapid heating may lead to tissue charring at the applicator and prevent penetration of laser energy (need to monitor cooling of the applicator)
  - inadequate MR-monitoring of thermal dose relative to lesion

- **Injury to non-target tissue**
  - inadequate MR-monitoring of thermal dose relative to lesion

- **Infection at the applicator insertion site**

- **Anesthesia-associated risks**

- **Increased projectile risks** (large team, frequent entry of personnel for correct needle adjustments, anesthesia process)
Thank You!