Safety in the MRI-guided Interventional Environment

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MRI-guided interventions

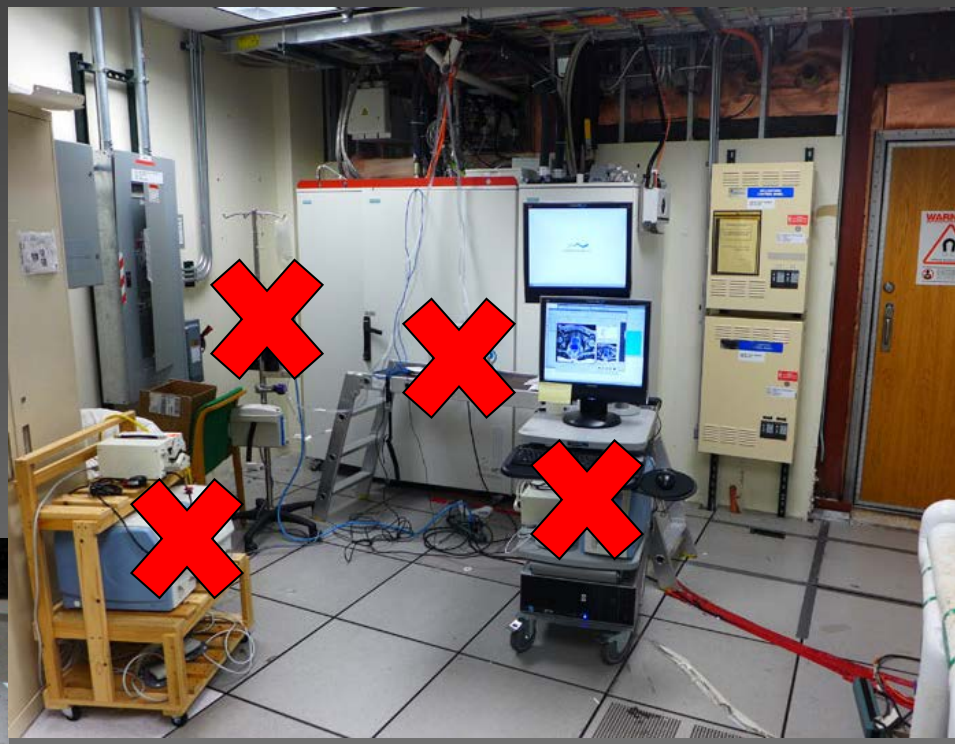
- **MR-guided Focused Ultrasound** (fibroids, painful bone metastases, prostate)
- **MRI-guided Cryoablations** (post-prostatectomy cancer recurrences, vascular maformations)
- **MRI-guided Laser ablations** (refractory eplilepsy, liver metastases)

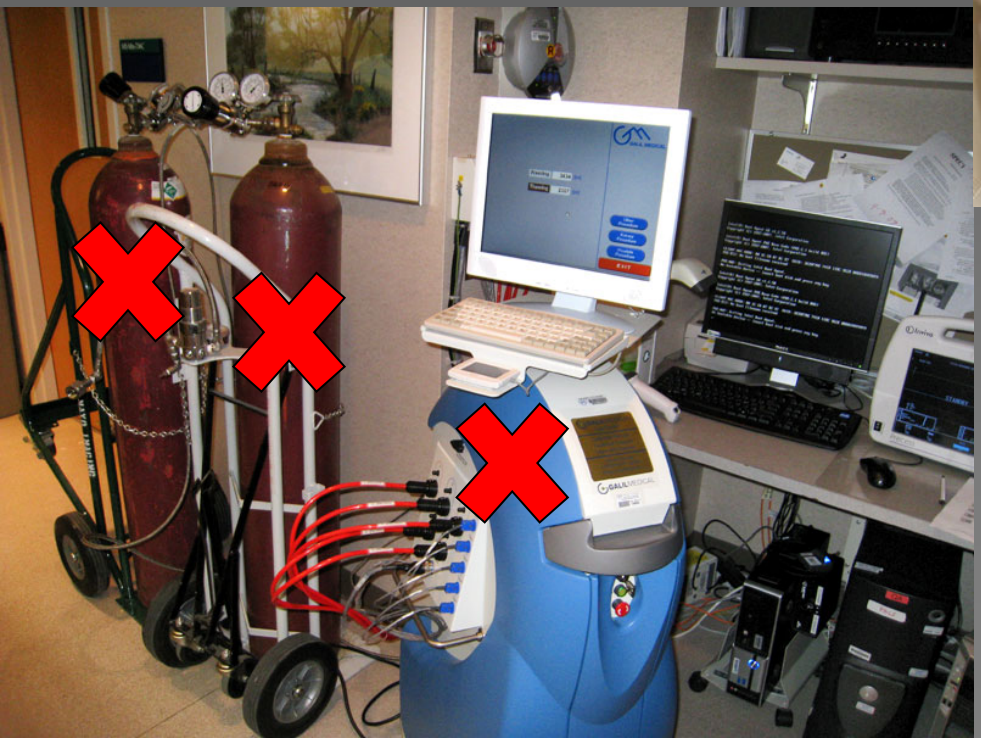
MRI-guided interventions

People

MRI-guided interventions

Equipment





MRI-guided interventions

Why do it?

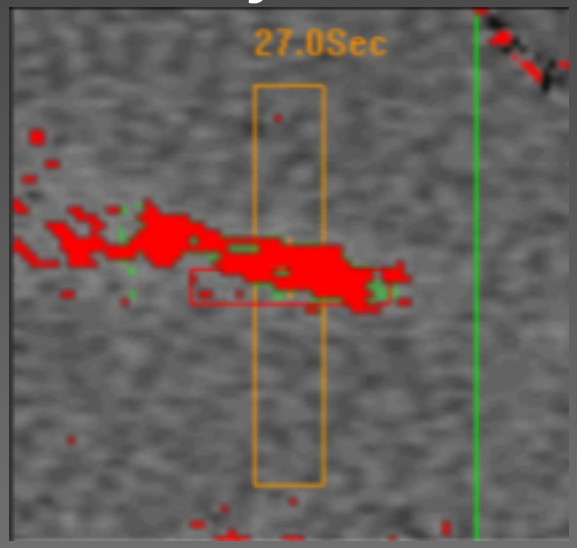
- Advantages
  - Minimal invasiveness
  - Soft-tissue Resolution
  - Increased Lesion Conspicuity
  - Ease of Multiplanar imaging
  - No Radiation
  - Ability to Re-image same slice
  - MR thermometry
- Disadvantages
  - Exam time
  - Lack of Compatible Equipment
  - Lack of Familiarity

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



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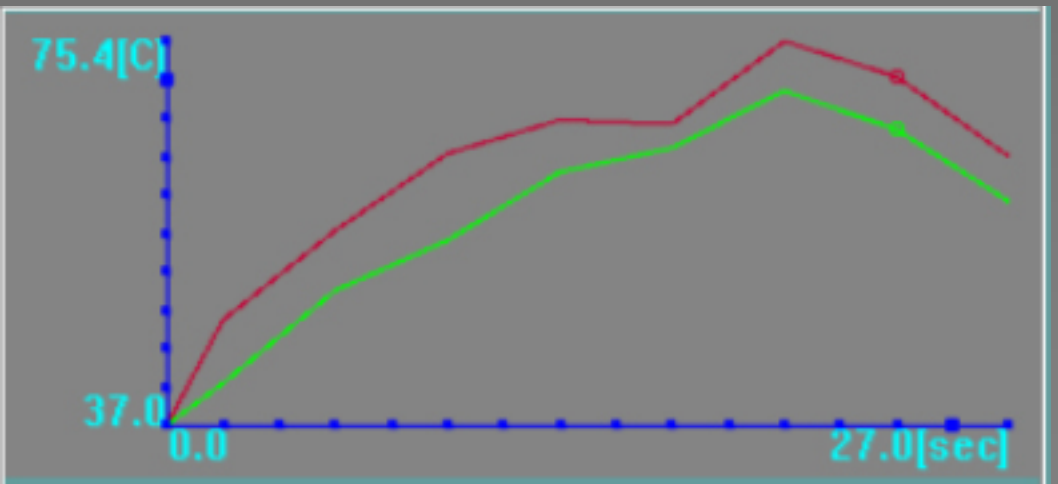
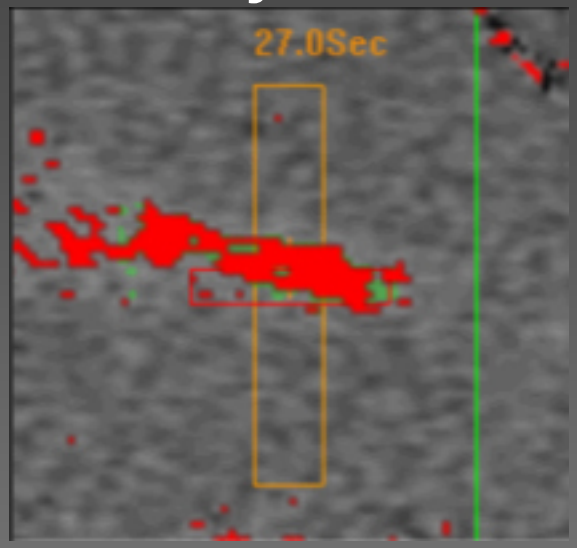
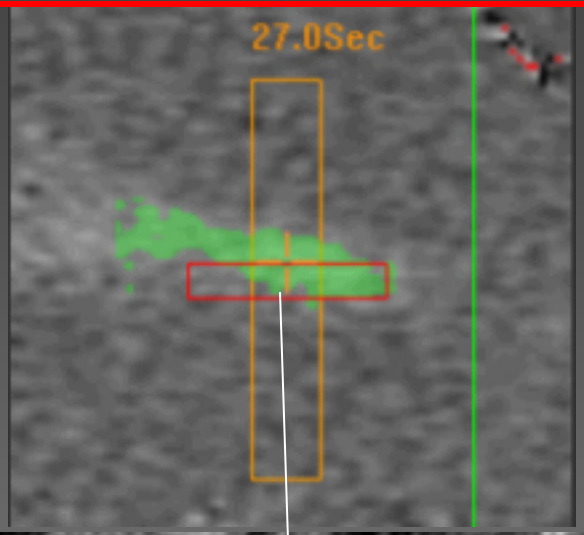


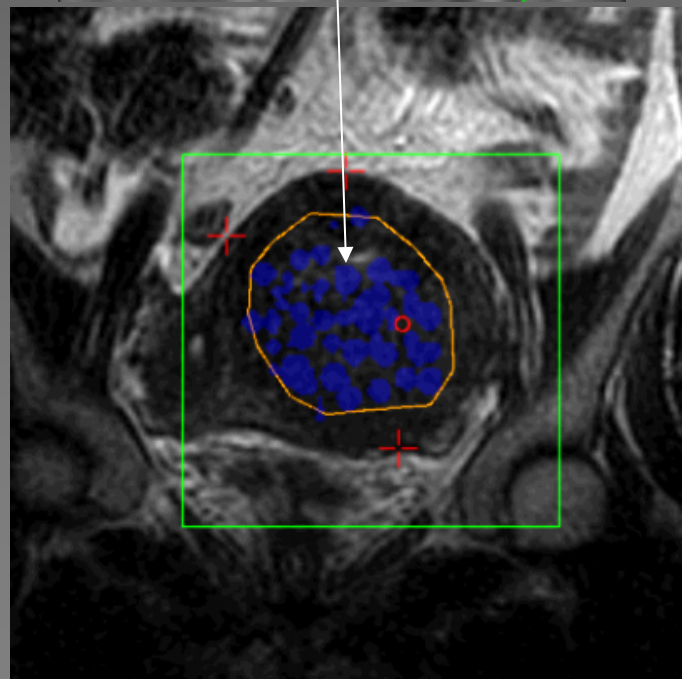
MRI-guided Focused Ultrasound (MRgFUS)

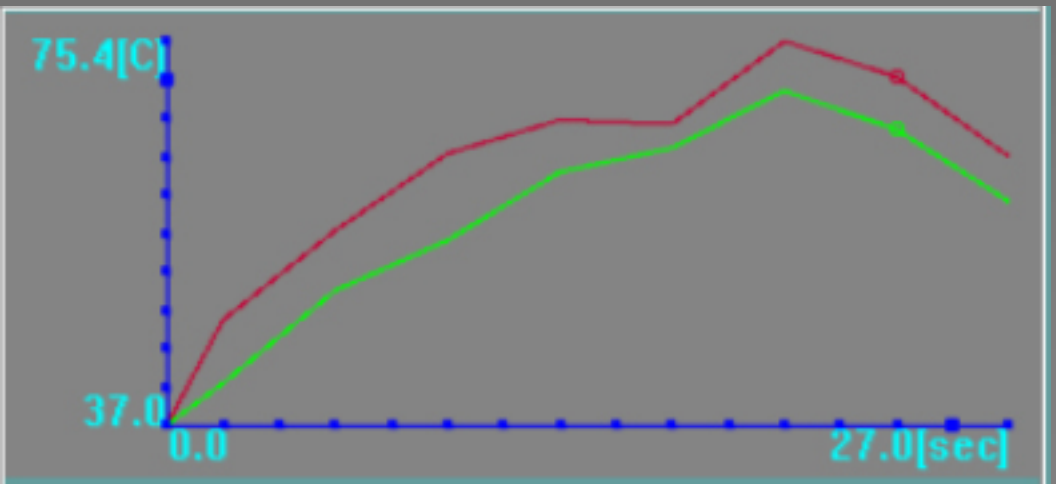
MR thermometry



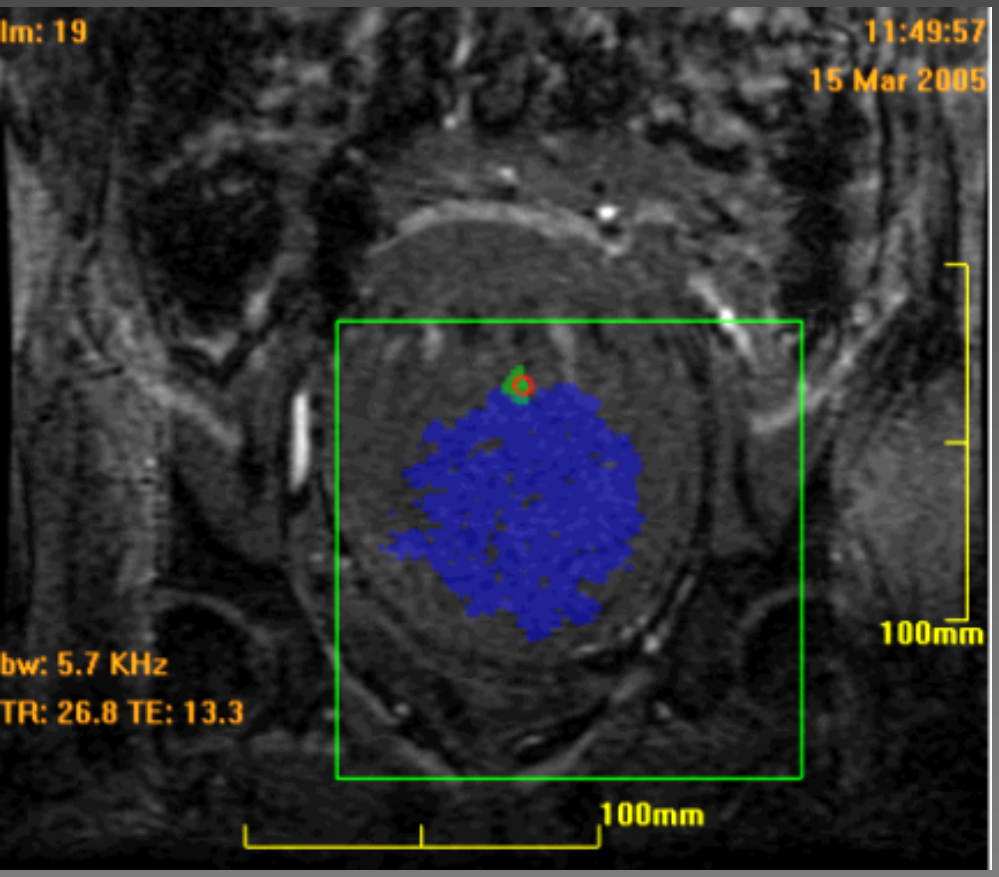
thermal dose sufficient
for tissue ablation



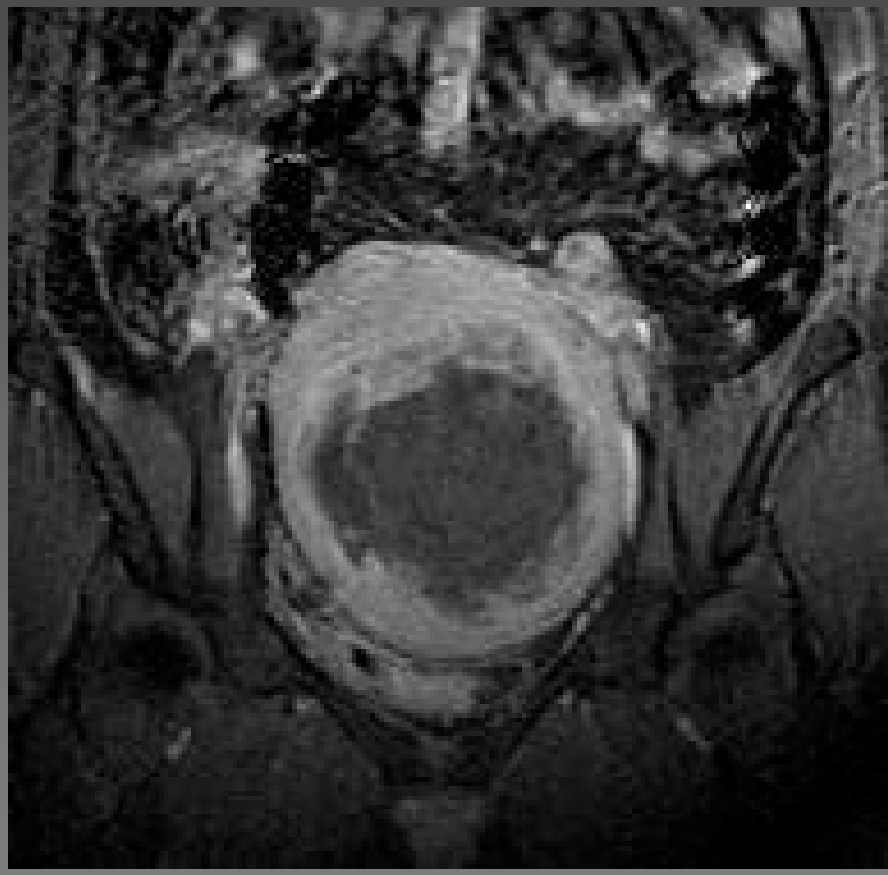




MRI-guided Focused Ultrasound
(MRgFUS)



T2w image with dose overlay



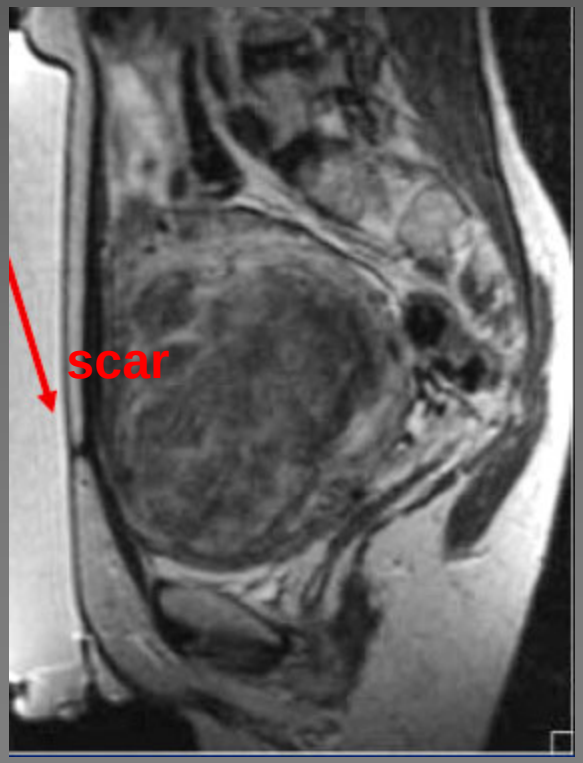
post treatment T1w image with Gd

Contrast enhanced T1-weighted images are acquired for treatment assessment.

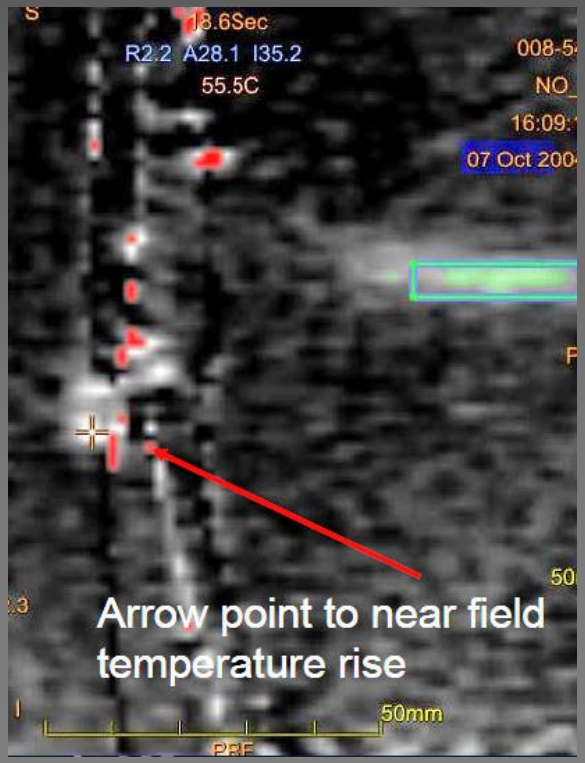
MRI-guided Focused Ultrasound (MRgFUS)

Treatment-related risks

- Skin Burns (c-section scars, bad acoustic interface at patient skin)



T2-weighted image



MR-thermometry

Post-treatment T1 with contrast

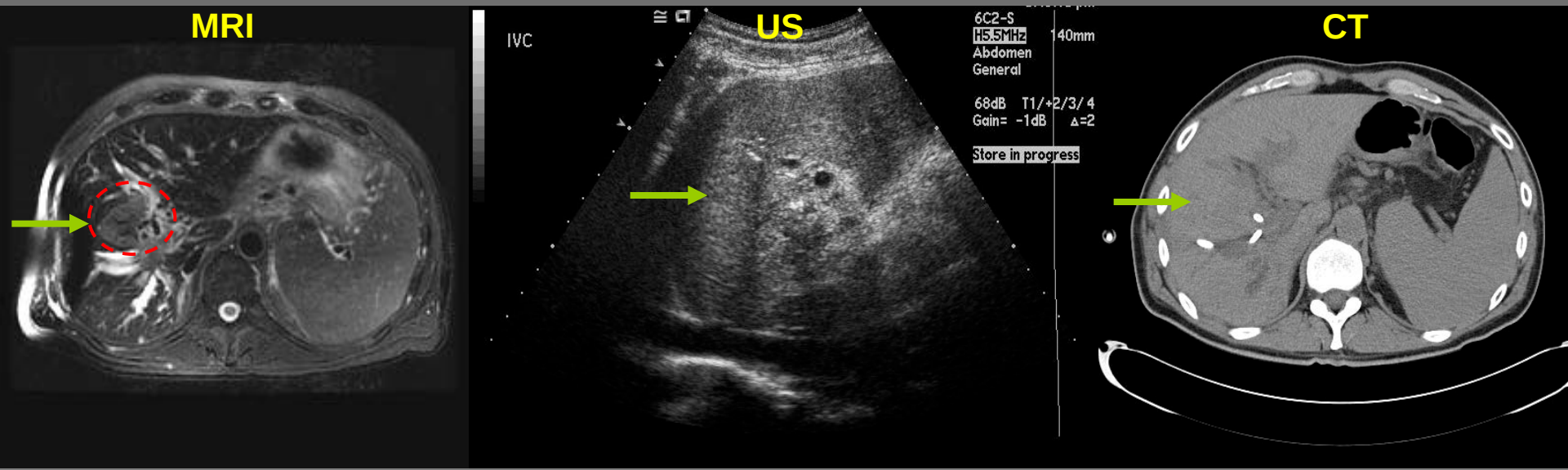
MRI-guided Focused Ultrasound (MRgFUS)

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 od sedation, adjustments of patient position, catheter manipulation)

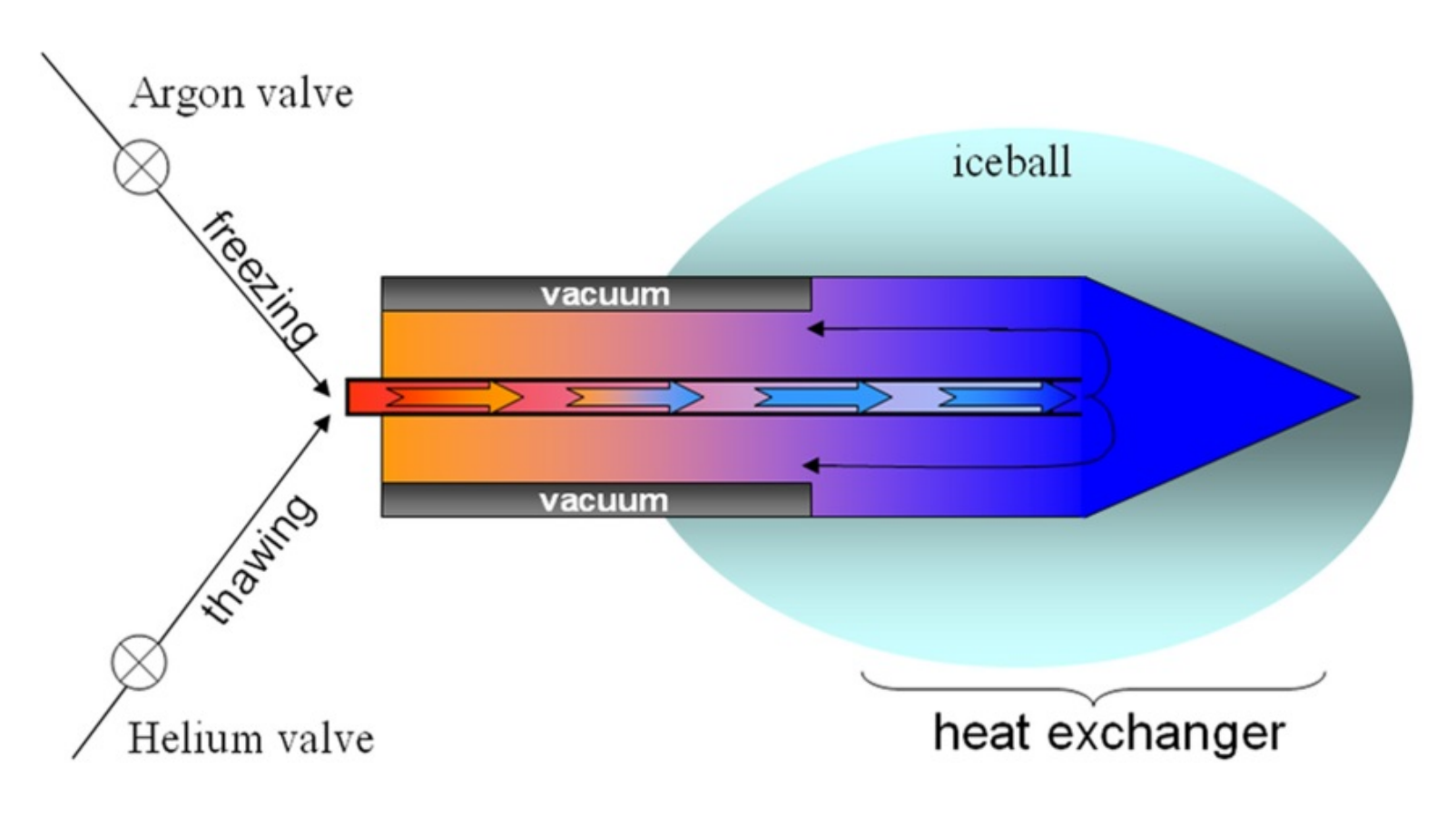
MR guided Cryoablation

- 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

Joule-Thomson effect (adiabatic expansion of gas)

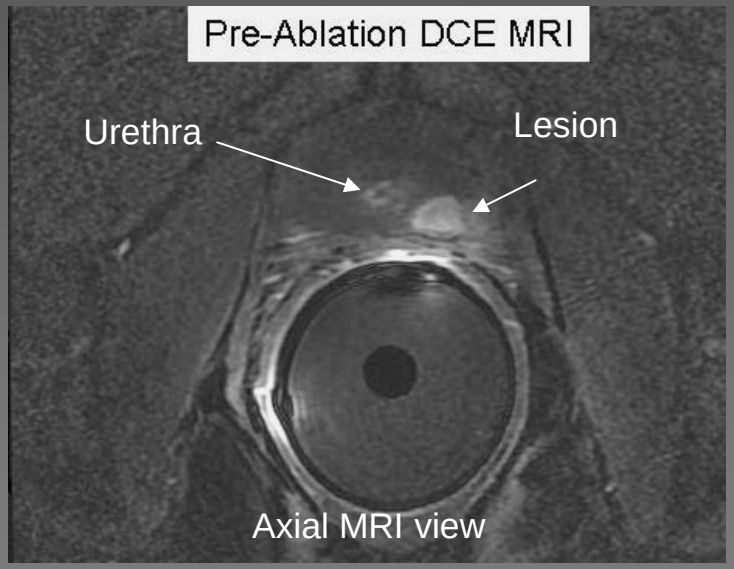


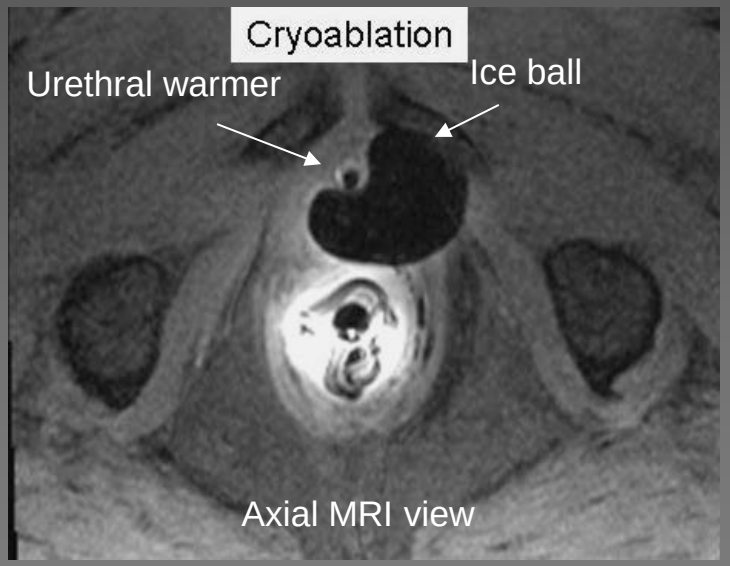
- Cryoneedles inserted into sites of cancer recurrences
- Argon cools to -186ºC (freezing). Helium warms to +33ºC (thawing).
- Saline used to increase separation between rectal walls and prostate bed
- Warming catheter inserted into urethra to protect urethral tissues

MR guided Cryoablation

Joule-Thomson effect (adiabatic expansion of gas)

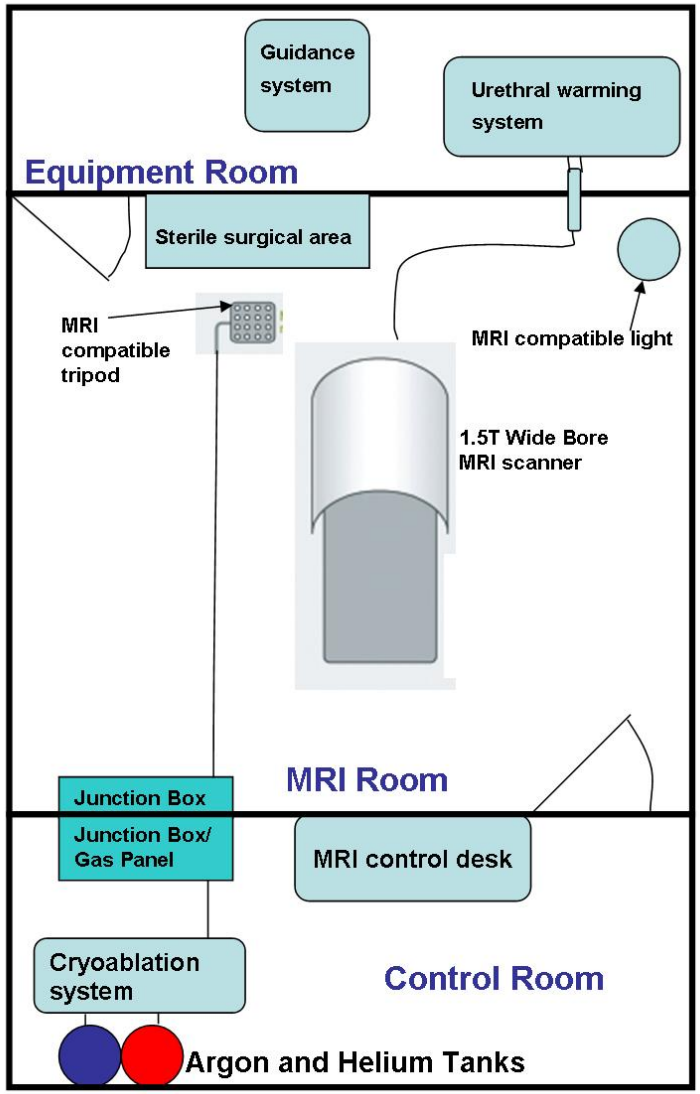
- MRI used to monitor ice ball growth





MR guided Cryoablation

Set-Up



MR guided Cryoablation

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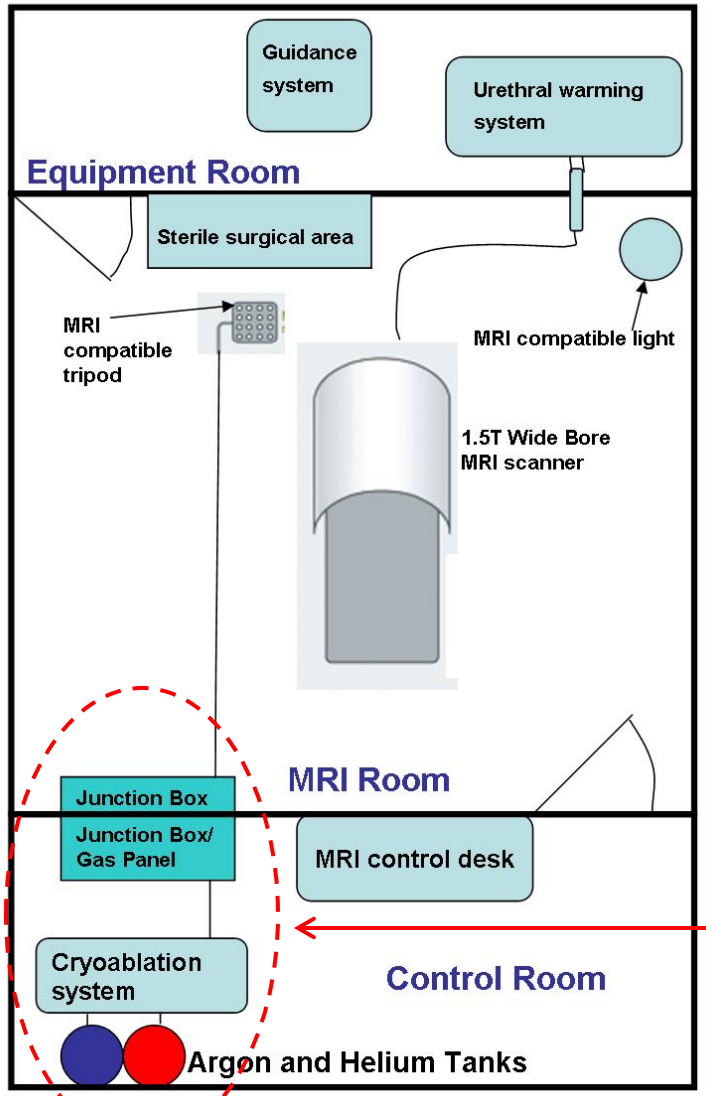
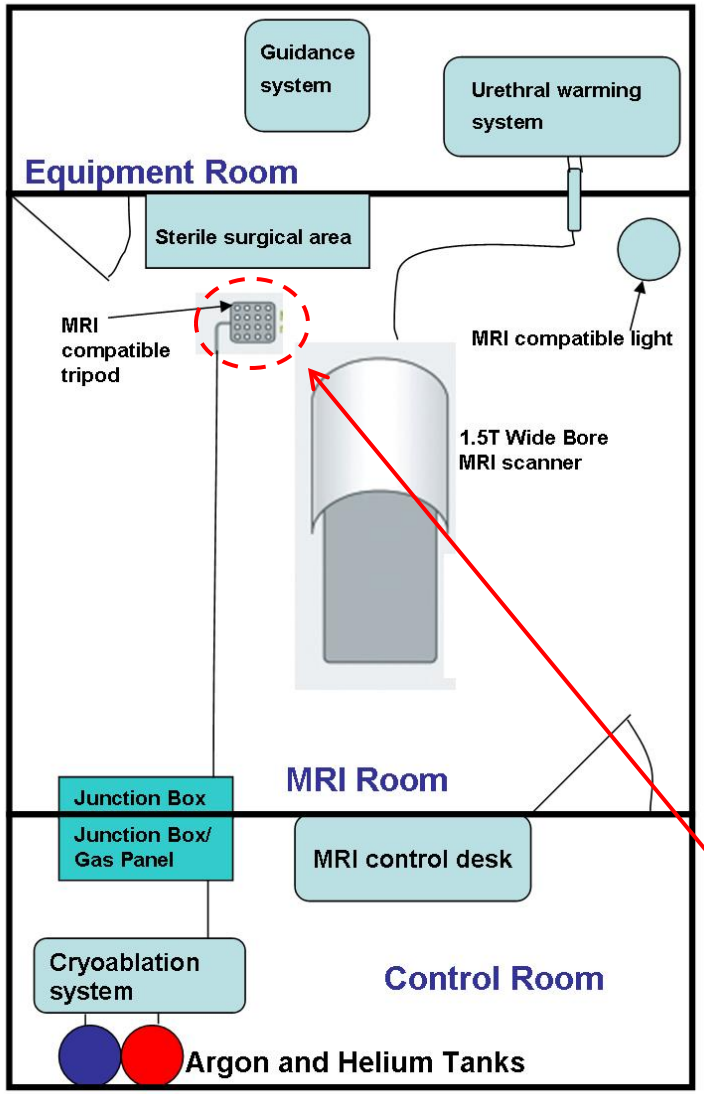


Cryoablation system

- Seednet Machine with connector panels
- Argon and Helium gas tanks

MR guided Cryoablation

Set-Up

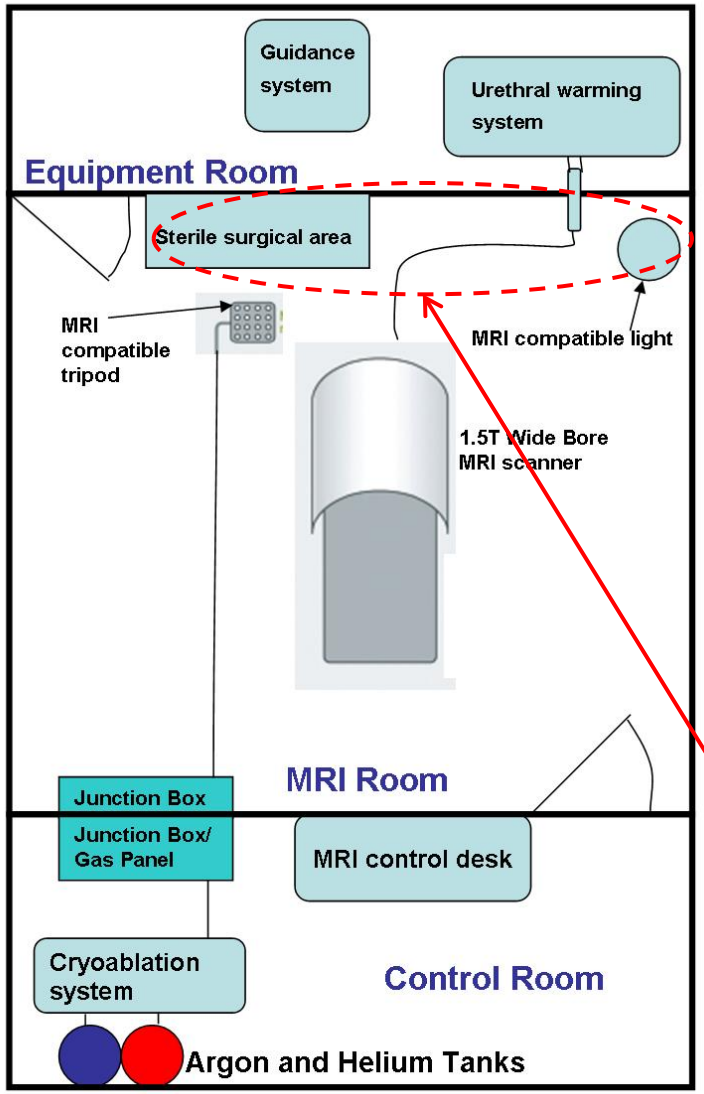


Cryoablation system

- Seednet Machine with connector panels
- Argon and Helium gas tanks
- MRI-compatible tripod with cryoneedles

MR guided Cryoablation

Set-Up

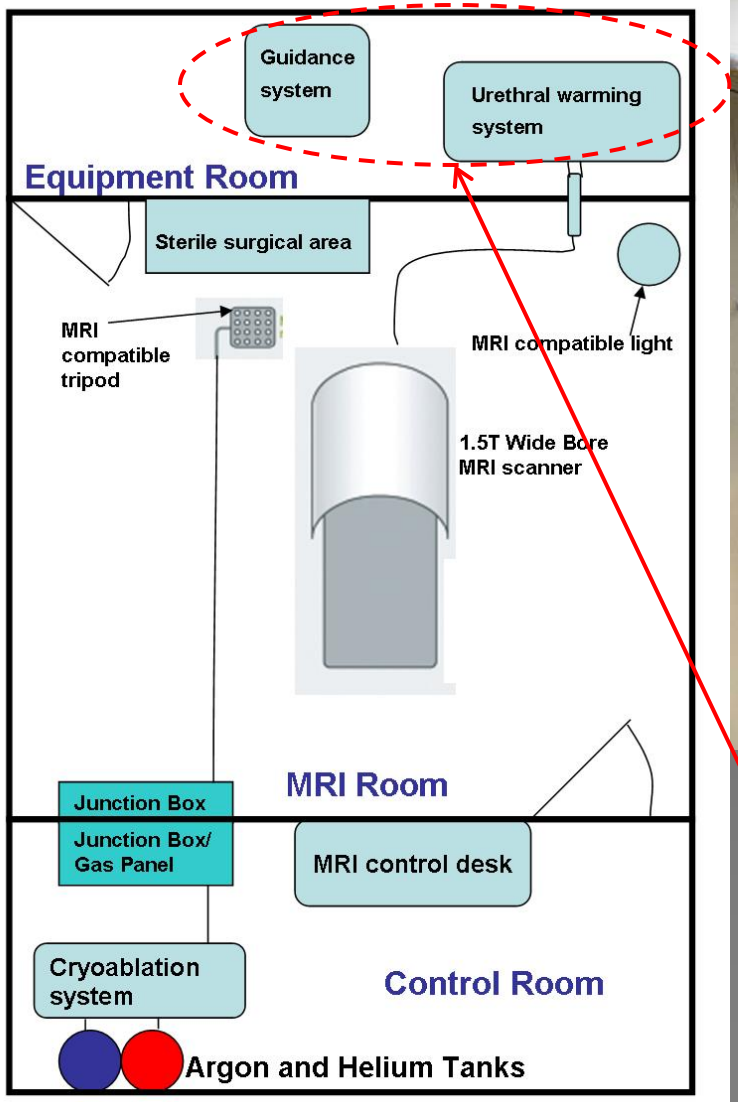


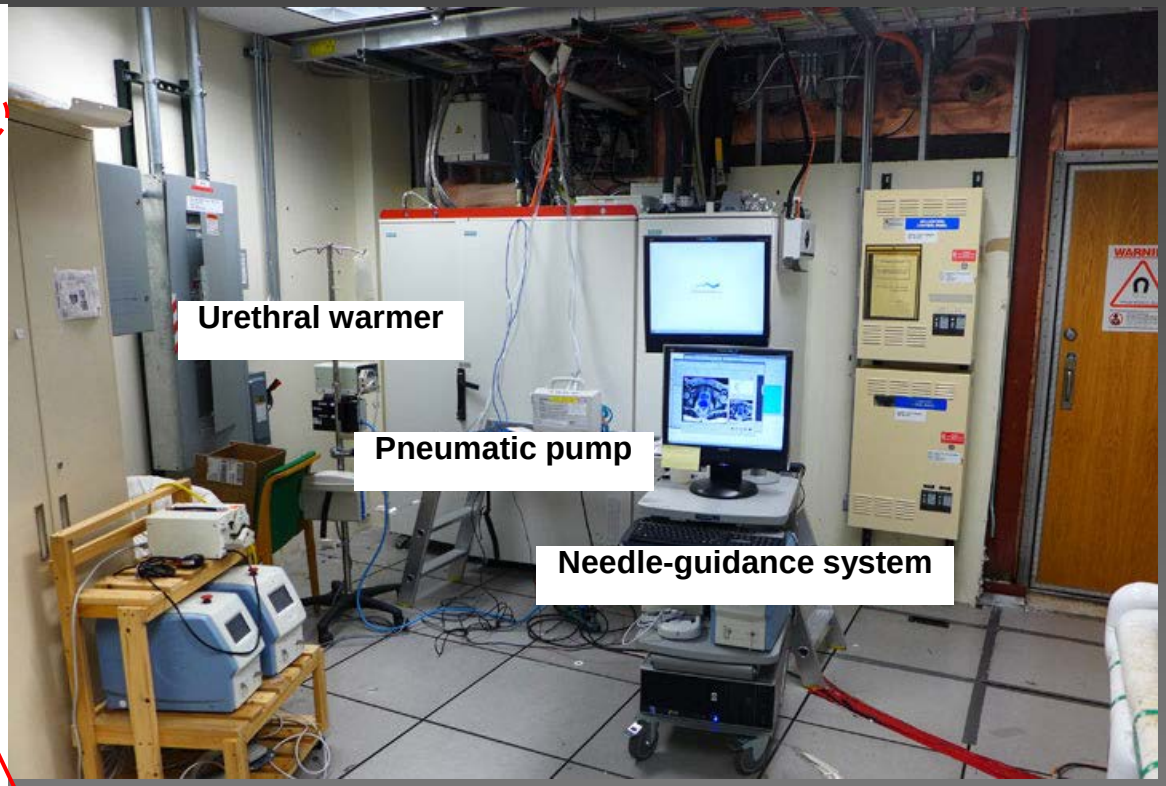
In-room setup

- Sterile area (arranged on MRI-safe cart)
- MRI-compatible in-room monitor
- MRI-compatible surgical light

MR guided Cryoablation

Set-Up



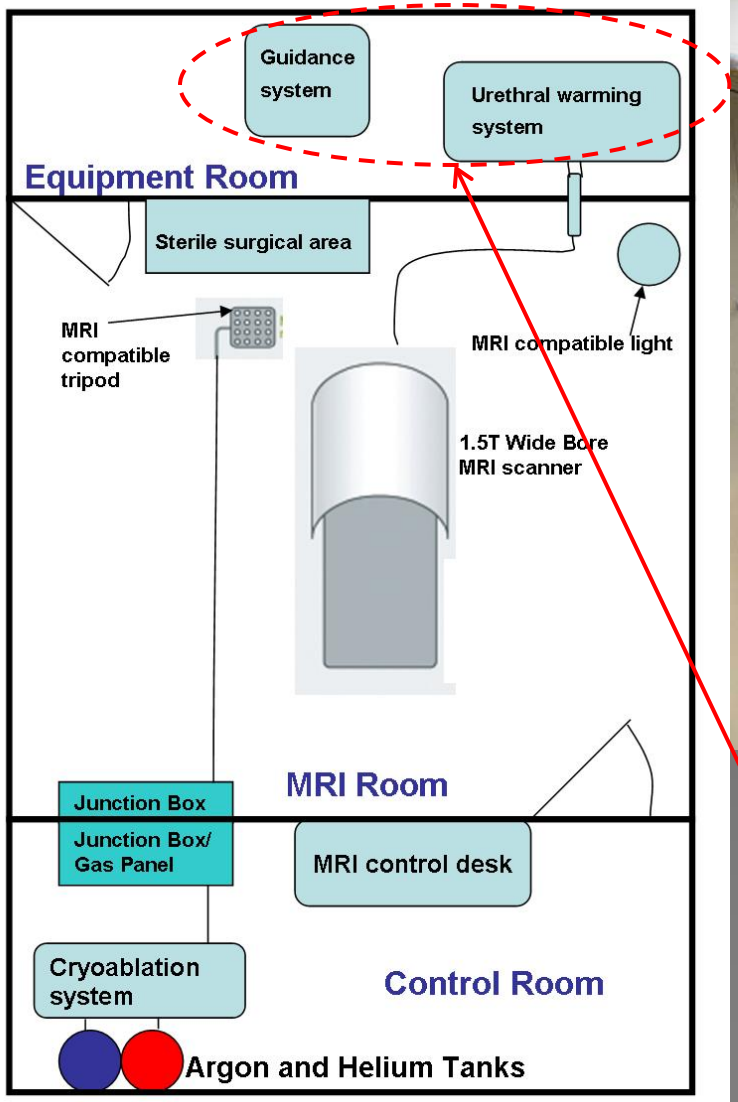


Cold room setup

- Urethreal Warmer
- Pneumatic pump (DVT prevention)
- Needle guidance system

MR guided Cryoablation

Set-Up



Cold room setup

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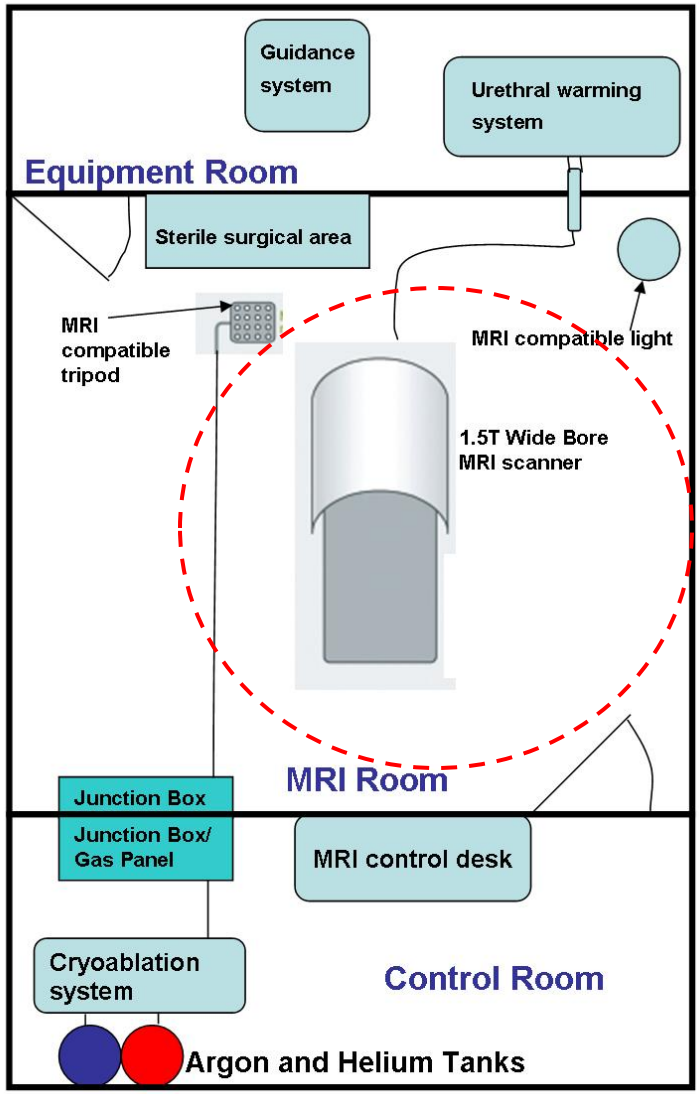
MR guided Cryoablation

Set-Up

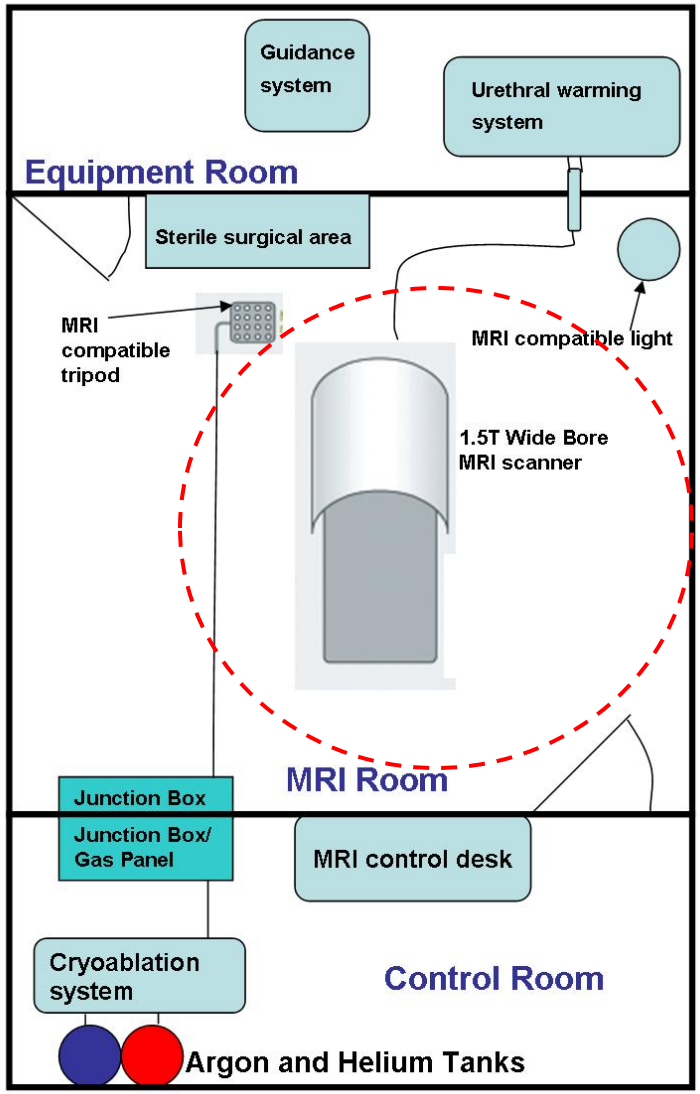


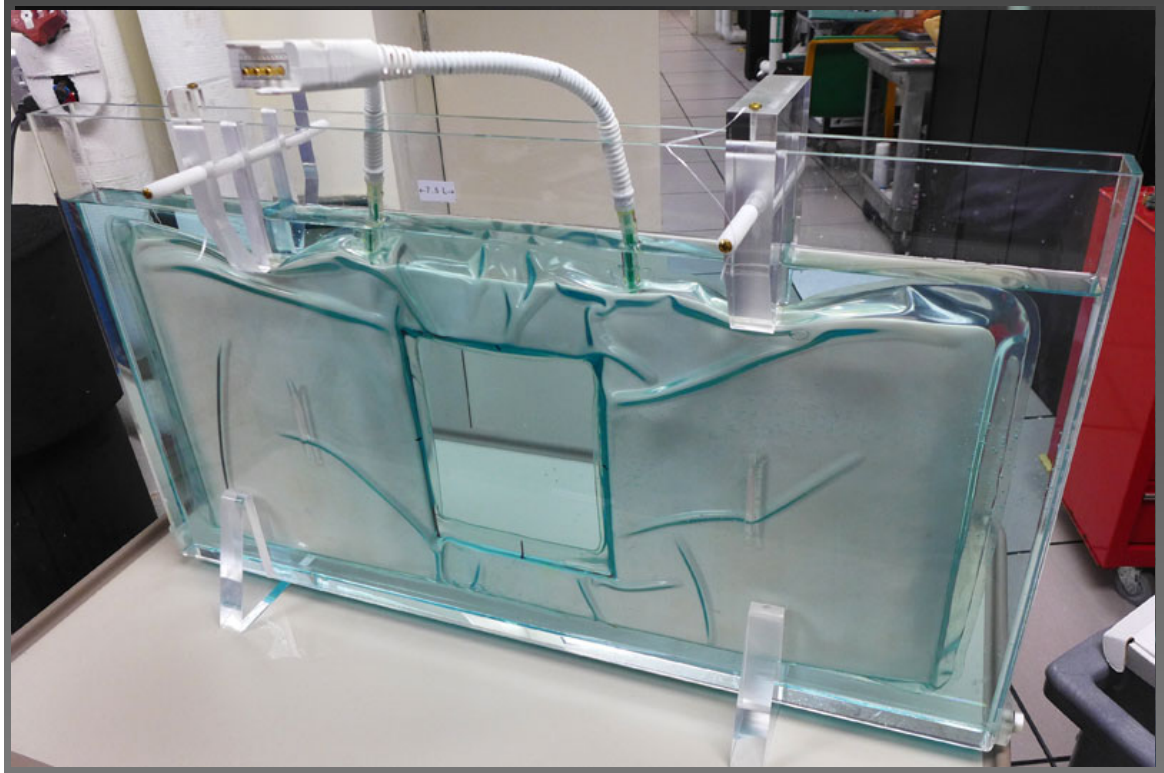
Procedure

- Anesthesia equipment

MR guided Cryoablation

Set-Up



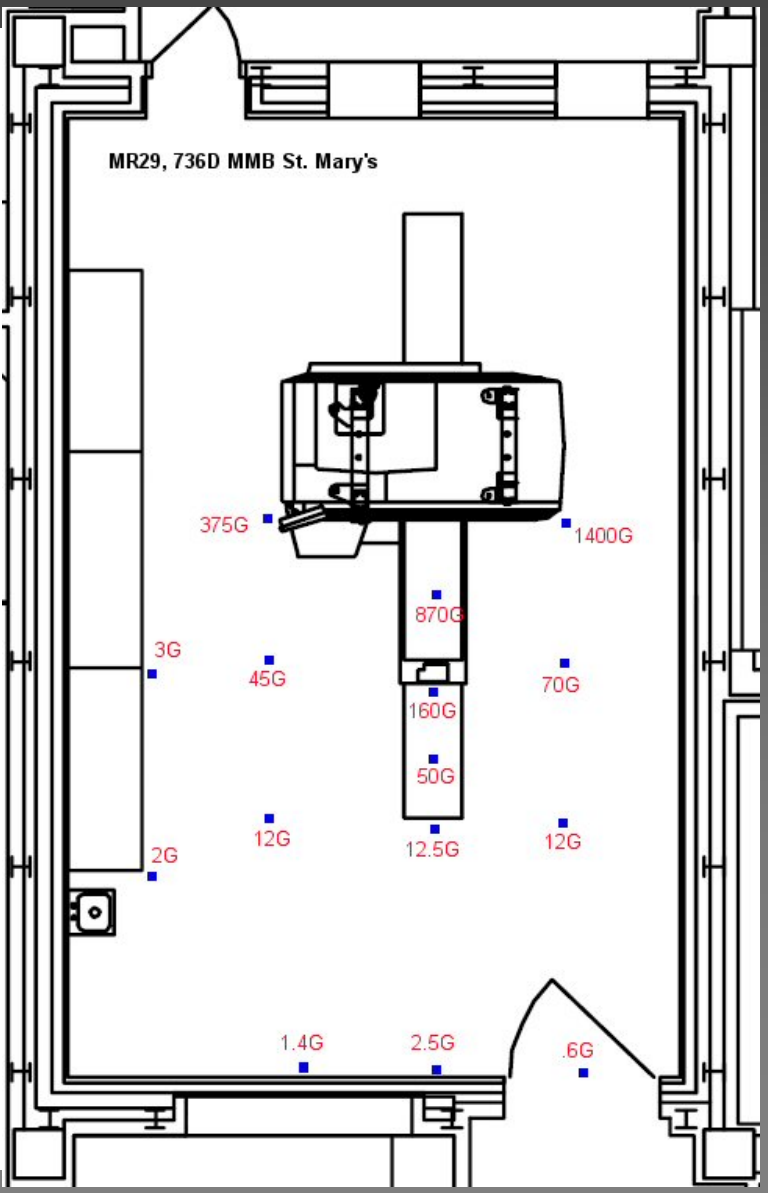


Procedure

- Anesthesia equipment
- Specialized MRI coil (requires sterilization)

MR guided Cryoablation

Set-Up



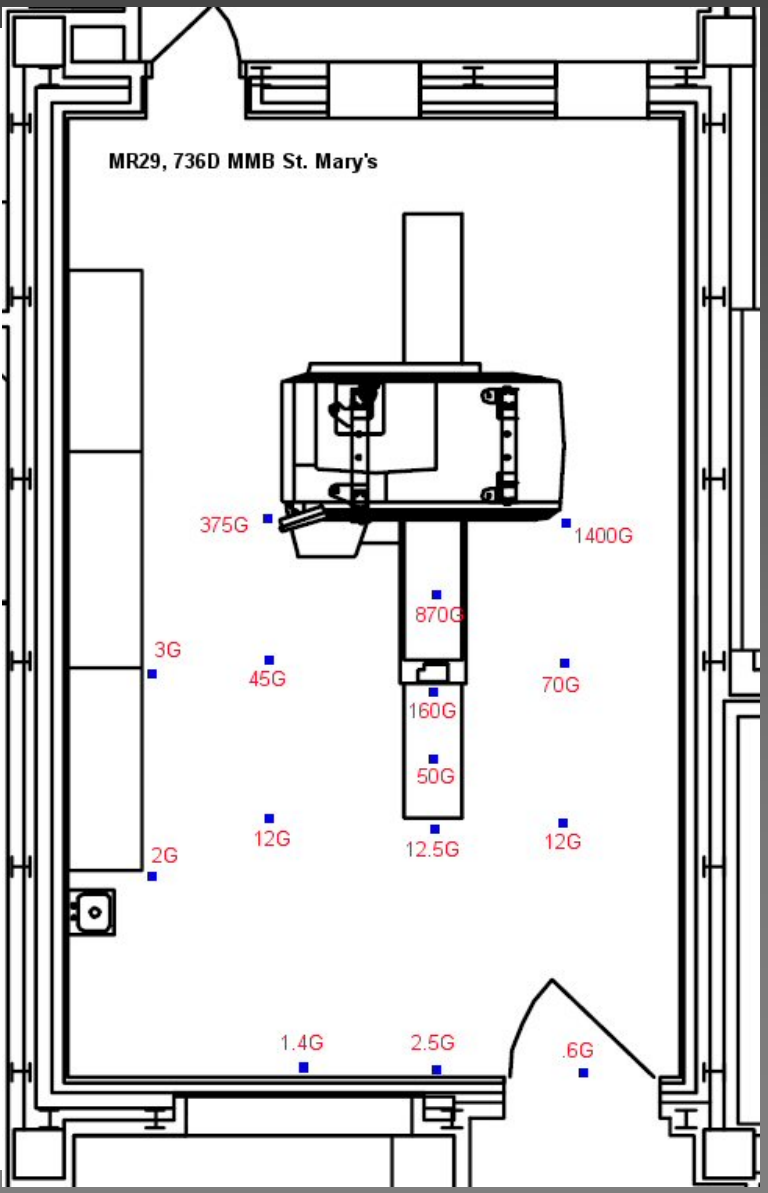
Need to bring non MRI-compatible equipment into scanner room

- 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

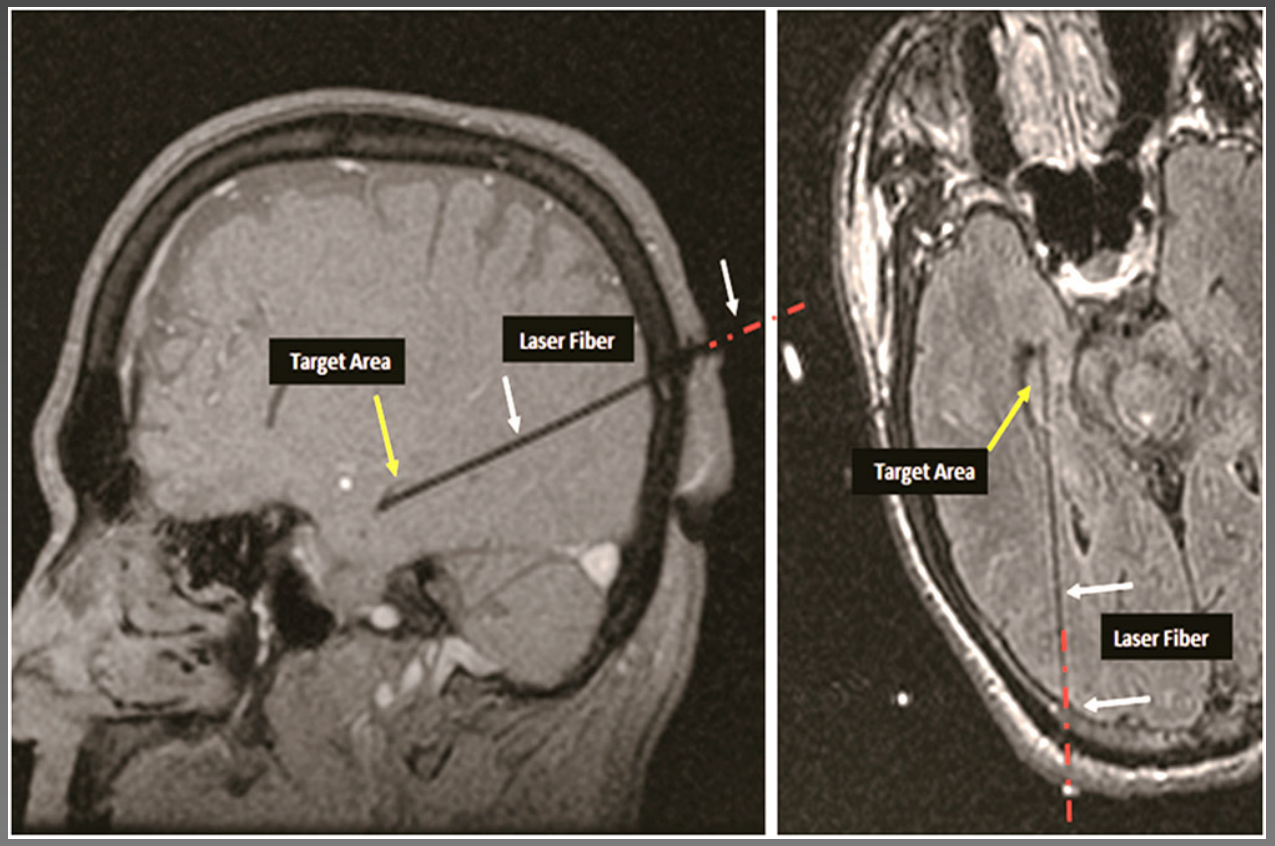
MR guided Cryoablation

Treatment-related risks

- Broken cryoneedles can result in patient death

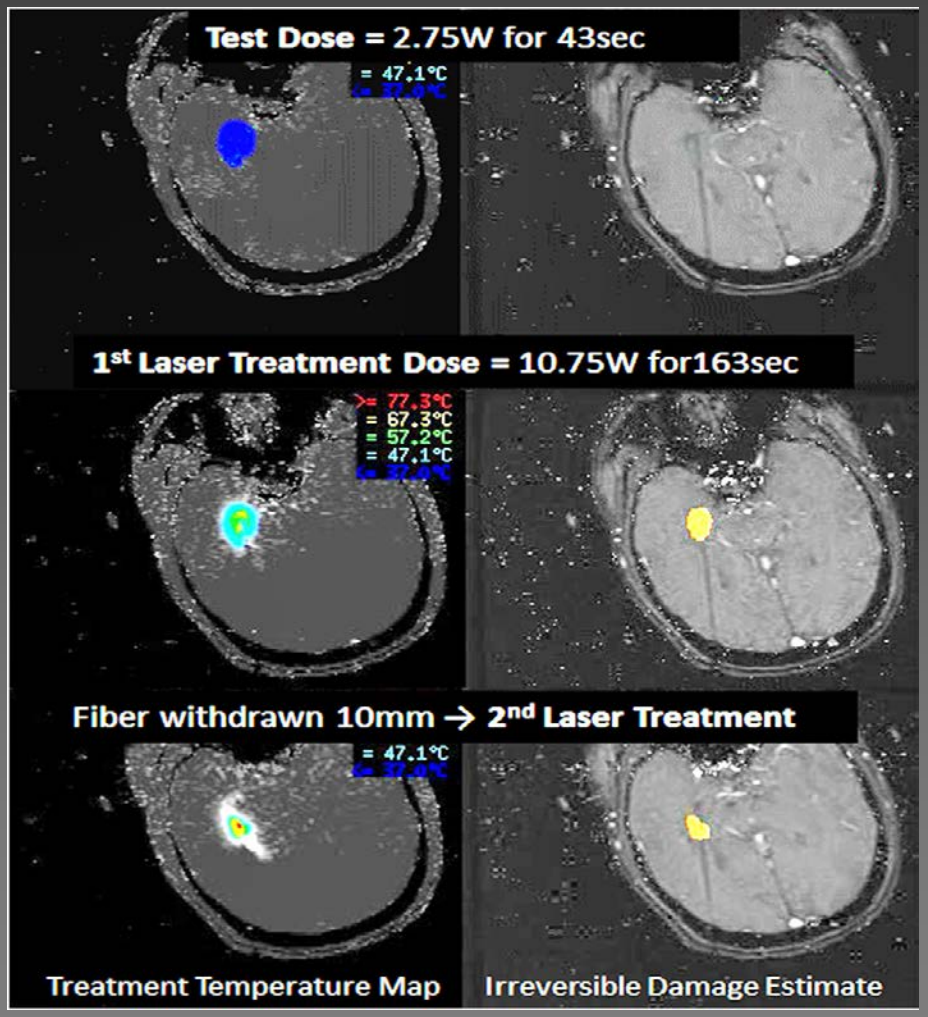
  (testing the needle integrity prior to insertion essential)
- Bowel injury (poor use of MR-guidance for needle insertion)
- Injury to rectal walls or nerves (poor use of MR-monitoring of ice growth)
- Injury to urethra (failure of urethral warmer system)
- Infection at the cryoneedle insertion site
- 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



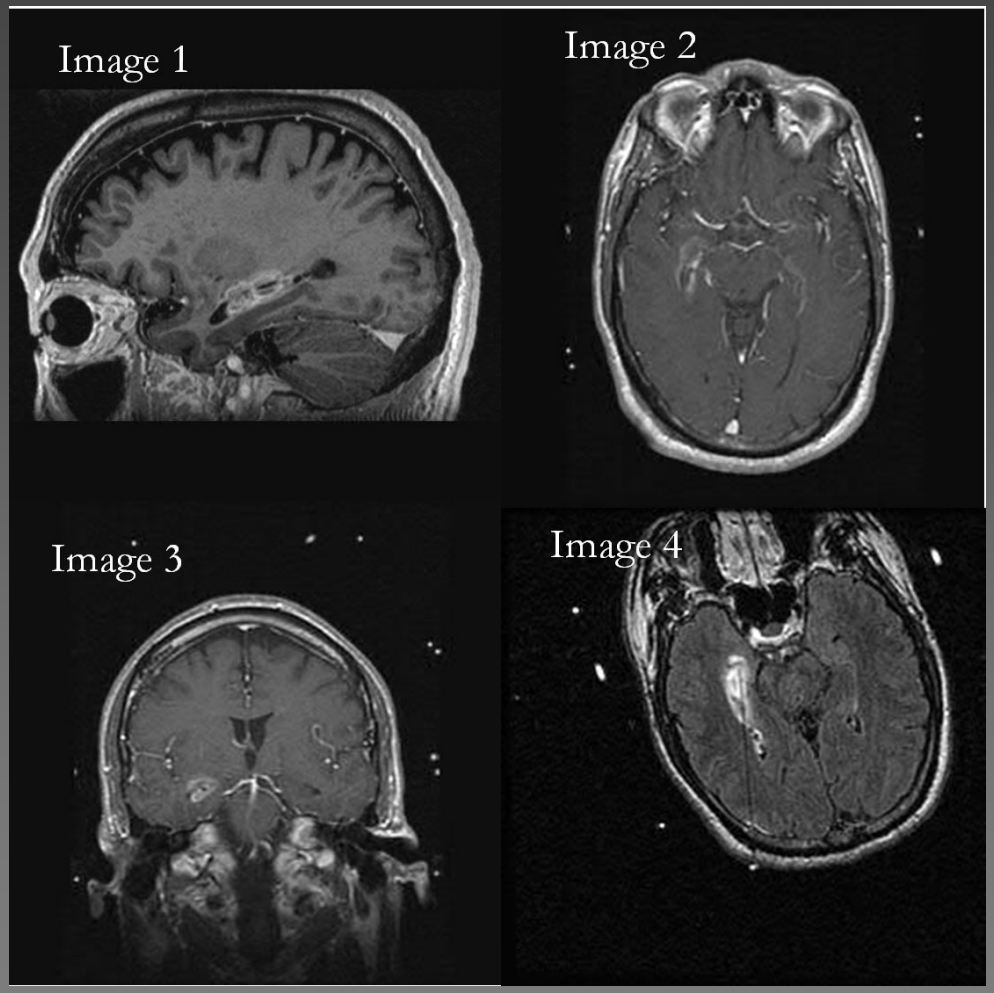
-- Using stereotactic frame a burr hole is made
-- Laser applicator is guided into the target lesion position
-- Position of the applicator is confirmed with MRI scan

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 doe 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!