MRI SAFETY

ACR White Paper on Safety

(Published in June 2002, updated in 2004, 07,10,12, 2013)

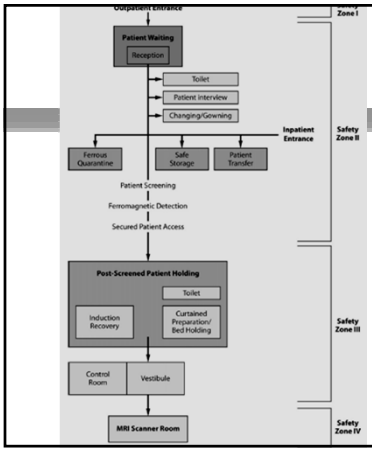
- Intended to be used as a template for MR facilities to follow in the development of an MR safety program

ACR recommendations

- Maintain safety policies and procedures
- Name an MRI medical director responsible for safety
- Mechanism for reporting adverse effects

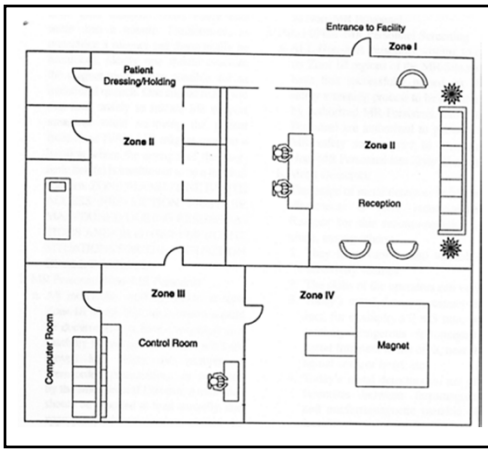
ACR recommendations

- Site access restrictions
  - Zone I – free access
  - Zone II – interface between free access zone and restricted zones
  - Zone III – this area is the region in which free access by non-screened persons can result in serious damage or death (this zone is under the supervision of MRI personnel)
  - Zone IV – MRI scanner room. Should be clearly marked with "magnet is on" sign



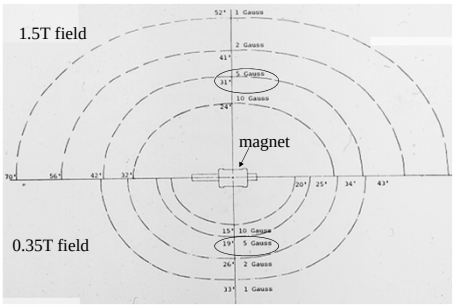
From 2013 MRI safety update

MRI functional diagram



MRI safety zones

fringe field at .35T and 1.5T



Magnet Accidents

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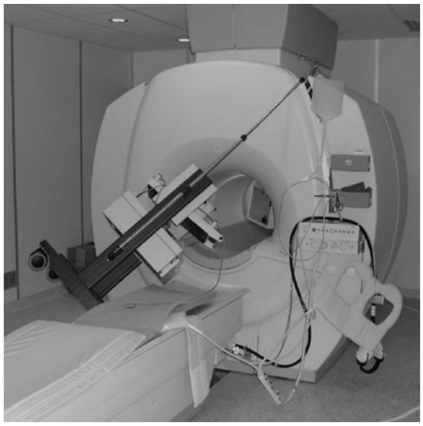
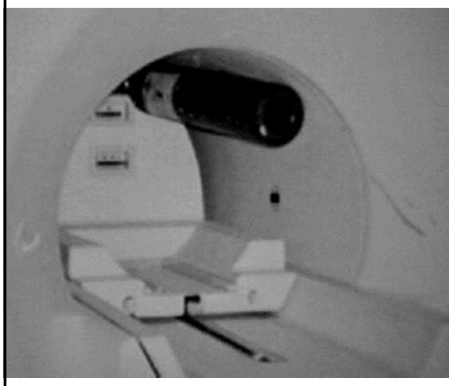


Magnet Accidents



Magnet Accidents

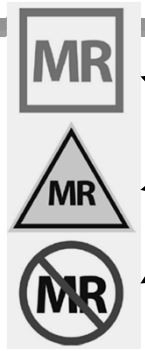
Zone III and IV

- Access restriction to these areas must be strictly maintained even during resuscitation
- Individuals working within these zones should have documentation of having received MRI safety training: level 1 and 2.
  Level 1 individuals should not go into zone IV
- Level 2 personnel have a more in depth training in MRI safety

Zones III and IV

- Non MRI personnel wishing to enter these zones must be screened and accompanied by a level two MR person
- All patients must wear a gown

device and object screening



Objects are to be identified as:

MR safe

MR conditional

MR unsafe

ferromagnetic detectors

The use of ferromagnetic detectors is recommended but “their use is in no way meant to replace a thorough screening practice”

personnel

- MR techs should be ARRT Registered Technologist and they must be trained as Level II MR personnel prior to being permitted free access to Zone III
- MR technologist will maintain current CPR certification
- Except for emergent coverage, there will be a minimum of two MR technologists or one MR technologist and one other Level II

pregnant personnel

- Pregnant health care practitioners are permitted to work in and around the MR environment throughout all stages of their pregnancy, however, they are requested not to remain within the MR scanner bore or Zone IV during actual data acquisition

pregnant personnel

- Pregnant patient are permitted to have MRI's at any time during their pregnancy after careful consideration of risks versus benefits

- Hearing protection is necessary
- Remove all medication patches since some have a metallic foil that can result in thermal injury

Joint Commission
Sentinel Event Alert, Feb 2008

Reports types of injuries that can occur in MRI:

- Missile effect
- Dislodged ferromagnetic implants
- Burns – from wires, improper positioning, staples, etc
- Equipment or devise malfunction due to MRI
- Injury to patient left unattended
- Acoustic injury
- Adverse events related to contrast administration
- Adverse event related to cryogen handling

Joint Commission Sentinel Event Alert, Feb 2008

- Joint commission data base has 5 MRI related deaths
  - 5 deaths – 4 adult and 1 child
    - 1 projectile
    - 3 cardiac events
    - Delay in MRI report leading to delayed treatment

2005 study of FDA's Manufacturer and User Facility Device Experience Database (MAUDE)

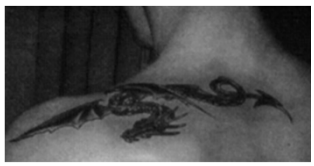
- 389 reports of MRI related adverse events
  - 9 deaths –
    - 3 pacemaker related
    - 2 insulin pump malfunction
    - 4 related to implant disturbance, a projectile and an asphyxiation from cryogenics

2005 study of FDA's Manufacturer and User Facility Device Experience Database (MAUDE)

- 389 reports of MRI related adverse events:
  - 70% of reported adverse events were burns
  - 10% projectiles
  - 10% other adverse events
  - 4% acoustic injuries
  - 4% fires
  - 2% internal heating-related

2005 study of FDA's Manufacturer and User Facility Device Experience Database (MAUDE)

- 389 reports of MRI related adverse events: 70% of reported adverse events were burns



ELSEVIER journal homepage: www.elsevier.com/locate/burns

Case report

MRI induced fourth-degree burn in an extremity, leading to amputation

Josef Haik[a], *Simon Daniel*[b,*], *Ariel Tessone*[a], *Arie Orenstein*[a], *Eyal Winkler*[a]

[a] *Department of Plastic & Reconstructive Surgery and Burn Unit, The Chaim Sheba Medical Center at Tel HaShomer 52600, Israel*
[b] *Sackler School of Medicine, Tel Aviv University, Israel*

ARTICLE INFO

Article history:
Accepted 13 November 2007

2. Case report

A 5-week-old girl with a medical history remarkable for multiple congenital anomalies, including a severe cardiac malformation, underwent MR imaging(Telsa 3) for evaluation of spina bifida. The patient was placed under general anesthesia (to prevent movement) for the length of the imaging session. Upon completion of the scan, a full thickness burn with evident demarcation between necrotic tissue and viable skin was diagnosed, encompassing her right forearm and wrist in the area where a non-MR-compatible pulse oximeter was attached. A circular metal electrode was affixed on either side of the patient's forearm and in direct contact with the skin. These electrodes were continuous with exposed wiring (without protective insulation most likely due to simple wear and tear) that joined to form a cable which connected to a monitor (Fig. 1). Though we have no record regarding the exact orientation of the wires attaching the pulse oximeter electro-

burns

: Radiology. 1996 Aug;200(2):572-5. Links

Unusual burns of the lower extremities caused by a closed conducting loop in a patient at MR imaging.

Knopp MV, Essig M, Debus J, Zabel HJ, van Kaick G.

Department of Radiology, German Cancer Research Center, Heidelberg, Germany.

An extremely rare occurrence of third-degree burns was induced in the medial calves of a male patient with unusual anatomy (after resection and radiation therapy of a liposarcoma) during conventional magnetic resonance (MR) imaging on a clinical 1.5-T MR system that operated without any external conductor present and within safe limits. A closed conducting loop was inadvertently created, which caused focal increased temperature at the junction of his calves.

burns

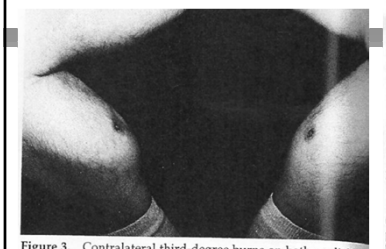


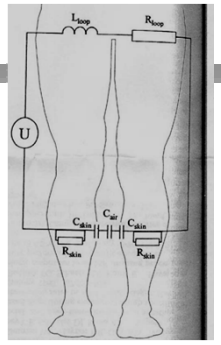
Figure 3. Contralateral third-degree burns on both medial aspects of the calf 2 weeks after MR imaging.

Radiology 1996; 200:572-575

was performed with the whole-body resonator. Figure 2 demonstrates the localizer images with the corresponding cross section in the coronal and axial plane. No unusual event occurred during tuning. The examination protocol with the sequence parameters is summarized in the Table. Contrast material enhancement was achieved with intravenous bolus administration of gadopentetate dimeglumine (Magnevist; Berlex Laboratories, Wayne, NJ) (0.1 mmol per kilogram of body weight). After each sequence, the patient was informed about the next sequence through the intercom. The patient did not report any difficulties during the examination. The total examination time was 53 minutes.

The patient was taken from the MR table by the radiologist and did not report any difficulties. Fifteen minutes after the MR imaging examination, the patient was seen by the radiation oncologist, who noted skin discoloration on the medial aspects of both calves, suggestive of third-degree burns. In direct questioning, the patient reported that he noted increased warmth in his calves but no severe pain.

burns



Radiology 1996; 200:572-575

circuit of this loop. The average power absorbed in the skin-fat layer with a volume of less than 1 cm^3 is estimated to be as high as 1.5 W, a value that could clearly lead to RF-induced burns. Even a fraction of that local power density could lead to an intolerable local increase in temperature, with the potential of causing tissue necrosis if the increase continued for the entire time of a typical MR examination. Only the presence of an air gap of at least several millimeters between a patient's calves would limit the loop current to acceptable values.

In this patient, the local temperature in the skin and subcutaneous fat layer could have reached just over 43°C, which would not have caused immediate pain but was high enough to cause tissue necrosis. Third-degree electrical burns are known to initially destroy the subcutaneous pain receptors and, therefore, typically occur without pain (21).

In conclusion, it is conceivable that a closed conducting loop can be created if focal conductance occurs, which may

INCIDENT REPORTS

- Be specific – include all facts about the event
- If outcome of event is known document it
- Do not discuss report of incident with family
- Document the facts not opinions
- Do not place blame on department of individual
- Be factual about what you witnessed

ANOTHER INCIDENT

Health care on msnbc.com

Woman left in CT scanner after clinic closes

67-year-old spent hours trying to free herself from machine

ANOTHER INCIDENT

Associated Press
updated 9/28/2007 5:13:41 PM ET

Print | Font: A A + −

TUCSON, Ariz. — A cancer patient says she was left alone in a CT scanner for hours after a technician apparently forget about her, and she finally crawled out of the device, only to find herself locked in the closed clinic.

Elvira Tellez of Tucson said she called her son in a panic, and he told her to call 911.

Pima County sheriff's deputies arriving at the oncology office had her unlock the office door to let them in, said Deputy Dawn Hanke, a department spokeswoman. The deputies contacted the office manager, who was not aware of the situation.

A.E. Araiza / Arizona Daily Sta

Cancer patient Elvira Tellez says she's had trouble sleeping since being left alone for hours in a CT scanner.

Tellez was taken to a hospital as a precaution, then released early the next day.

DISCHARGE OF A FIREARM IN AN MRI SCANNER

Case Report

An off-duty police officer went to an outpatient imaging center (not affiliated with our institution) in western New York State to have an MR imaging examination. The facility housed a 1.5-T MR unit (Signa; General Electric Medical Systems, Milwaukee, WI) with active shielding. The officer was carrying a model 1991 A-1 compact .45 caliber semiautomatic pistol (Colt's Manufacturing, Hartford, CT).

The officer notified the technologist that he was carrying the weapon before entering the MR dressing room. The technologist told the officer to take the gun with him. The technologist intended to meet the officer in the MR patient waiting area before the examination and secure the weapon in that room, where he felt it would be safe. However, the officer apparently misunderstood and took the gun into the MR suite. The technologist was entering the officer's personal data into the computer and did not see him entering the MR suite.

Once the officer was inside the MR suite, the gun was pulled from his hand as he attempted to place the gun on top of a cabinet 3 ft (0.9 m) away from the magnet bore. The gun was immediately pulled into the bore, where it struck the left side and spontaneously discharged a round into the wall of the room at the rear of the magnet. Fortunately, no one was injured. Although the gun struck the magnet bore, only minimal cosmetic damage occurred to the magnet itself. The MR unit had full functional capability immediately after the gun discharged. The weapon's thumb safety was reportedly engaged when the gun discharged.

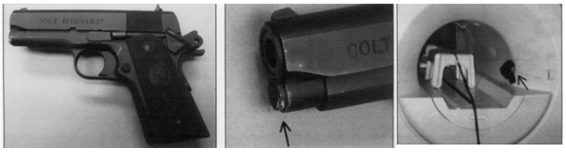
An unsuccessful attempt to remove the gun from the magnet resulted in the gun being pulled to the right side of the magnet (Fig. 1). The decision was then made to power down the magnet to remove the gun.

Case Report

Spontaneous Discharge of a Firearm in an MR Imaging Environment

Anton Oscar Beitia[1], Steven P. Meyers[1], Emanuel Kanal[2], William Bartell[3]

AJR 2002;178:1092–1094 0361–803X/02/1785–1092 © American Roentgen Ray Society



2005 study of FDA's Manufacturer and User Facility Device Experience Database (MAUDE)

- Risk reduction strategies:
  - Metal detectors (can give fall positives and are not 100% reliable). Ferromagnetic detectors are recommended
  - Implement protocols for housekeeping

2005 study of FDA's Manufacturer and User Facility Device Experience Database (MAUDE)

- Risk reduction strategies and recommendations:
  - Appoint a safety officer
  - Label equipment that is MR safe, etc
  - Restrict access to MRI
  - Train personnel
  - MRI training institution wide
  - Precautions against patient burns
  - Provide hearing protection
  - Place cold compresses when necessary

before doing an MRI

Always get a good history

always get a good history

Patient's clinical history

always get a good history

Patient's clinical history

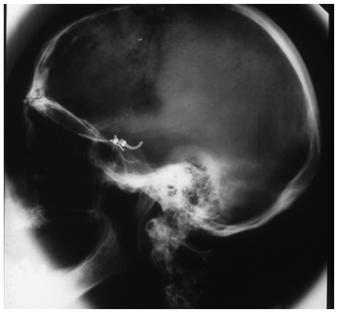
what are the patient's symptoms?
mass? pain? cancer? other problems?

always get a good history

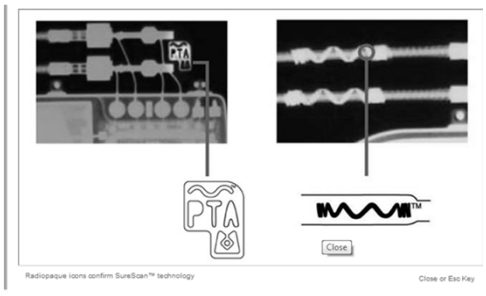
Patient's clinical history

what are the patient's symptoms?
mass? pain? cancer? other problems?
What happened to the patient?
accident / trauma, acute vs chronic
surgical history
allergies
Previous relevant imaging; available?

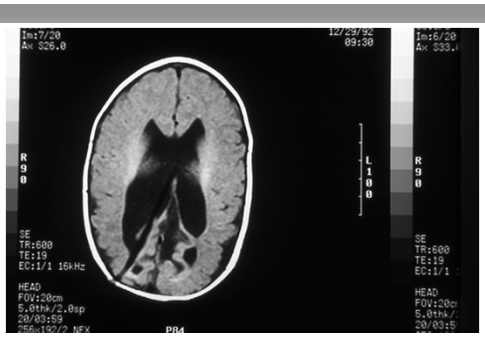
aneurysm clip



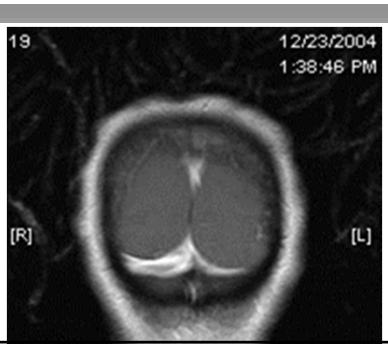
MRI Compatible pacemaker from Medtronics



ventricular shunt
(arnold chiary II)



hair beads



tumor or not tumor?