MRI Safety
Level 1 MR Personnel

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William Faulkner & Associates
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JOURNAL OF MAGNETIC RESONANCE IMAGING 000:000–000 (2013)

Special Communication

ACR Guidance Document on MR Safe Practices: 2013

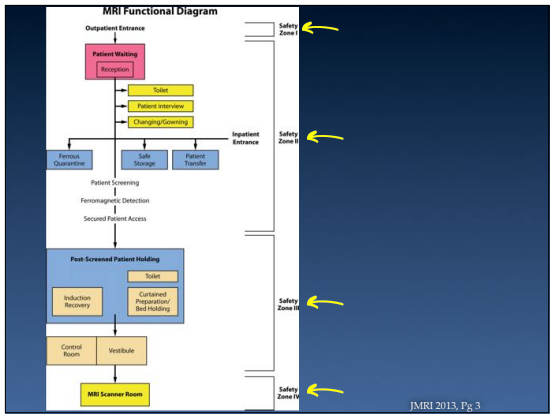
Expert Panel on MR Safety: Emanuel Kanal, MD,[1]* A. James Barkovich, MD,[2] Charlotte Bell, MD,[3] James P. Borgstede, MD,[4] William G. Bradley Jr, MD, PhD,[5] Jerry W. Froelich, MD,[6] J. Rod Gimbel, MD,[7] John W. Gosbee, MD,[8] Ellisa Kuhni-Kaminski, RT,[1] Paul A. Larson, MD,[9] James W. Lester Jr, MD,[10] John Nyenhuis, PhD,[11] Daniel Joe Schaefer, PhD,[12] Elizabeth A. Sebek, RN, BSN,[1] Jeffrey Weinreb, MD,[13] Bruce L. Wilkoff, MD,[14] Terry O. Woods, PhD,[15] Leonard Lucey, MD,[16] and Dina Hernandez, BSRT[16]

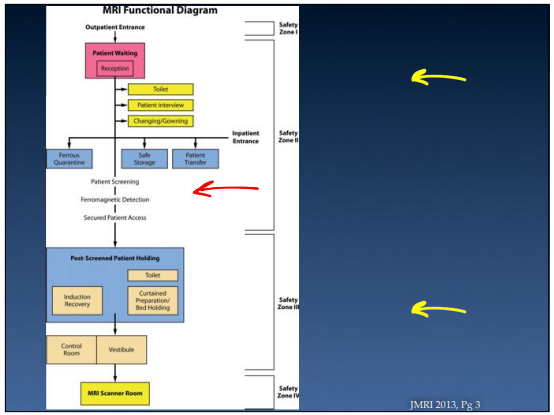
Because there are many potential risks to the MR environment, not only for the patient but also for the accompanying family members, attending health care professionals, and others who find themselves only occasionally or rarely in the magnetic fields of MR scanners, such as security or housekeeping personnel, it is important that all facilities be aware of reports in the medical literature and print media detailing Magnetic Resonance Imaging (MRI) adverse incidents involving patients, equipment and personnel that spotlighted the need for a safety review by an expert panel. To this end, the American College of Radiology originally formed the Blue Ribbon Panel on MR Safety, which published a white paper in 2002 charged with reviewing existing MR safe practices and guidelines (5–8) and issuing new ones as appropriate for MR examinations. Published initially in 2002 (9), the ACR MR Safe Practice Guidelines established de facto industry standards for safe practices in the MR environment and have served the test of time. These were subsequently reviewed and updated in May of 2004 (3). After reviewing substantial feedback from the field and installed base, as well as changes that had transpired throughout the MR industry since the publication of the 2004 version of the document, the panel determined that it was modified, and updated the guidelines in 2008-2007.

The present panel consists of the following members: A. James Barkovich, MD, Charlotte Bell, MD, (American Society of Anesthesiologist), James P. Borgstede, MD, FACR, William G. Bradley, MD, PhD, FACR, Jerry W. Froelich, MD, FACR, J. Rod Gimbel, MD, John W. Gosbee, MD, Ellisa Kuhni-Kaminski, RT (RSNA), Emanuel Kanal, MD, FACR, FISMRM (chair), James W. Lester Jr., MD, John Nyenhuis, PhD, Daniel Joe Schaefer, PhD (Engineer, Elizabeth A. Sebek, RN, BSN, CSN, Jeffrey Weinreb, MD, FACR, Bruce L. Wilkoff, MD, FACR, Terry O. Woods, MS, MBA (ACR Staff), Leonard Lucey, JD, LLM (ACR Staff), and Dina Hernandez, RT (R) (CT) (MR) (ACR Staff). The following represents the most recently

Terminology

- ✓Zones
- ✓Personnel





Terminology

- ✓Zones
- ✓Personnel

Level 1 Personnel

Level 1 MR personnel: Those who have passed minimal safety educational efforts to ensure their own safety as they work within Zone III

Level 2 Personnel

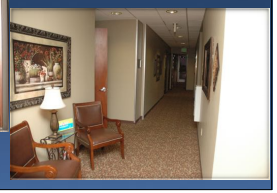
Level 2 MR personnel: Those who have been more extensively trained and educated in the broader aspects of MR safety issues, including, for example, issues related to the potential for thermal loading or burns...

- MR Technologists
- MR Radiologists / Medical Director

JMRI 2013, Pg 5

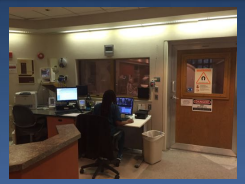
Zone II

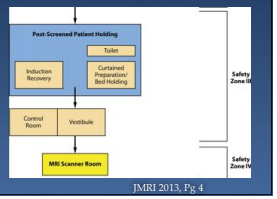
- ✓Screening takes place
- ✓Ferromagnetic objects left here



Zone III Restrictions

"All access to Zone III is to be strictly restricted, with access to regions within it (including Zone IV see below) controlled by, and entirely under the supervision of, MR personnel"

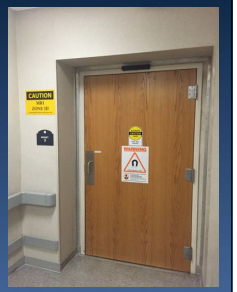




JMRI 2013, Pg 4

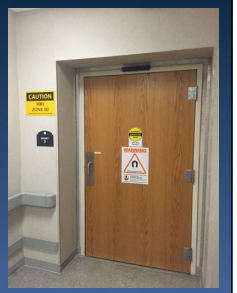
Zone III Restrictions

- ✓Free access to Zone III strictly restricted to MR personnel ONLY (those who have successfully completed Level 1 or Level 2 training)



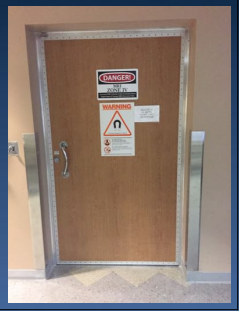
Zone III Restrictions

- ✓All others must be accompanied by MR personnel.
- ✓Non-MR personnel may not enter Zone III unless screened and cleared by MR personnel



Zone IV: MR Scan Room

May not be freely accessed by anyone other than MR Technologists (Level 2 Personnel)



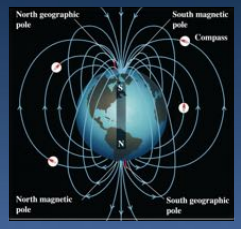
THE MAGNET IS ALWAYS ON

Superconductivity

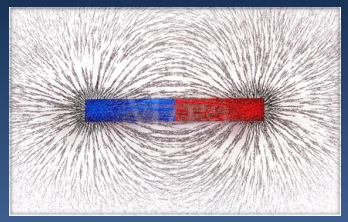
The electrical resistivity of a metallic conductor decreases gradually as temperature is lowered. In ordinary conductors, such as copper or silver, this decrease is limited by impurities and other defects. Even near absolute zero, a real sample of a normal conductor shows some resistance. In a superconductor, the resistance drops abruptly to zero when the material is cooled below its critical temperature. An electric current flowing through a loop of superconducting wire can persist indefinitely with no power source

THE MAGNET IS ALWAYS ON

The earth's magnetic field is approximately 0.5 Gauss



Small bar magnet is approximately
100 Gauss



Powerful Persistent Magnetic Field

1.5 Tesla MRI system is
15,000 Gauss
(1 Tesla = 10,000 Gauss)

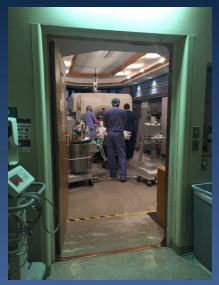
Powerful Persistent Magnetic Field

1.5 Tesla MRI system is
15,000 Gauss
30,000 x the earth's magnetic field

THE MAGNET
IS ALWAYS ON

Zone IV: MR Scan Room

Even if the door is open and it is not actively "scanning"...



THE MAGNET IS ALWAYS ON

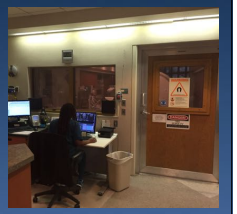
Zone IV: MR Scan Room

Even if there is a complete power outage...

THE MAGNET IS ALWAYS ON

Zone IV: MR Scan Room

Do not, under any circumstances, enter the scan room unless you have been screened and are supervised by an MRI Technologist



THE MAGNET IS ALWAYS ON

This powerful and invisible magnet field is always present

This powerful and invisible magnet field is always present

1.5 Tesla

30,000 x earth's magnetic field

This powerful and invisible magnet field is always present

3.0 Tesla

60,000 x earth's magnetic field

This powerful and invisible magnet field is always present

The Magnet is Always On

The Journal News .com

NEWS

WBI

Tuesday July 31, 2001 07:43:40 AM

Health

Boy, 6, killed in MRI accident

By MELISSA KLEIN AND OLIVER W. PRICHARD
THE JOURNAL NEWS

VALHALLA — A 6-year-old boy died two days after he was smashed in the head by a metal oxygen canister that was pulled by magnetic force into the MRI machine where he was being examined, Westchester Medical Center officials said yesterday.

An unidentified hospital employee brought the oxygen tank within reach of the 10-ton magnet's field, and it shot through the air to the center of the machine, the hospital said.

The boy, Michael Colombini of Croton-on-Hudson, died Sunday at the hospital, where he had undergone surgery before the MRI. An autopsy revealed that he died of a blunt force trauma to the head with a fractured skull and brain hemorrhage, the Westchester County Medical Examiner's Office said.

Alternative Medicine: A world of choices

- Remove all removable items
- Dress all patients in MR-appropriate attire

AJR:188, June 2007; pg 5

Importance of MR Appropriate Attire

Event Description

A female patient was undergoing a scan of the left shoulder. During the first sequence (3. 5 mins), the patient's blouse caught on fire producing a flame of approximately 20 centimeters. The scan was stopped immediately and the patient was evacuated. The patient suffered 3rd degree burns to the forearm. The customer continued to use the device and scan additional patients before requesting a system check. Initial investigation revealed that the blouse of the patient was apparently electrically conductive. Incident was not caused by system failure.

Blouse catches fire during 1st sequence of a shoulder exam. 3rd degree burns to forearm.

- FDA MAUDE database

Importance of MR Appropriate Attire

Importance of MR Appropriate Attire

Published December 15, 2011 as 10.3174/ajnr.A2827

TECHNICAL NOTE

Invisible Metallic Microfiber in Clothing Presents Unrecognized MRI Risk for Cutaneous Burn

J.A. Pietryga
M.A. Fonder
J.M. Rogg
D.L. North
L.G. Bercovitch

SUMMARY: We report a case of a thermal burn that occurred during MR imaging likely caused by invisible silver-embedded microfibers in the fabric of an undershirt. As the prevalence of fabric containing nondetectable metallic microfiber increases in athletic and "tech" clothing, the importance of having patients change into safe facility-provided garments before MR imaging is emphasized.

ABBREVIATIONS: ACR = American College of Radiology; SAR = specific absorption rate; SMF = silver microfiber

Sports attire

11-year-old girl presented for outpatient MR imaging of the spine for evaluation of scoliosis, wearing a gray undershirt under a long-sleeved white tee shirt and gray sweat pants

Man stabbed in eye during brain scan

Sunday, 16 November 2014

The hospital apologised to the man after the horrifying accident. Photo / Jason Oxenham

By Kirsty Wynn

A knife flew out of a man's pocket and became stuck in his eye when he was having a brain scan.

Middlemore Hospital has apologised to the man and reviewed its procedures after the horrifying accident, which happened when he took a belt, keys and a knife in a magnetic resonance imaging (MRI) scan.

Loose metallic items are prohibited in the MRI unit as they are attracted by the magnet, which is so strong patients with pacemakers, stents, shunts, surgical screws or plates cannot be scanned.

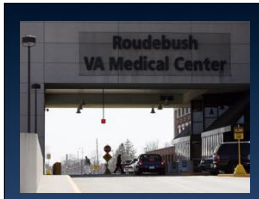
The man, in his 70s, had the closed knife in his pocket but it flew out at high speed and hit him in the face causing serious eye trauma and an orbital fracture.

Hospital spokeswoman Lauren Young said it had reviewed how the knife was missed during routine checks.

When the scan started, the technician noticed the man was moving. He removed keys from his pocket then he removed the pocketknife.

"The pocketknife was attracted with force into the MRI scanner and hit him in the face, where it stayed

http://m.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11379190



IndyStar
December 31, 2015

A veteran was wounded Wednesday at Richard L. Roudebush Veterans Affairs Medical Center when a handgun he brought into the Indianapolis hospital accidentally discharged in his pocket while he was in a procedure room — possibly an MRI suite.

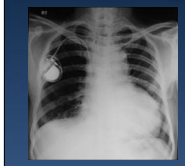
Hospital officials confirmed the accidental shooting in a statement issued Thursday and reported the victim, whose name was not released, received immediate medical attention. The statement added the man's wound did not threaten his life.

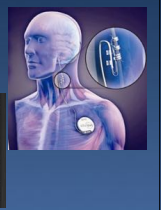
A hospital spokesman initially confirmed in a telephone call from The Indianapolis Star that the incident involved an MRI, but the subsequent statement said only that the incident occurred "in a procedure room." When asked for clarification about the involvement of the MRI, the spokesman said in an email that the statement "is our response at this time."

The statement noted it is a violation of federal and state law to bring a firearm into the hospital and "notification of this law is posted at every entrance."

http://www.indystar.com/story/news/2015/12/31/gun-discharges-mri-va-hospital/78136982/

Critical Importance of Screening for Implants and Devices





Multiple Potential Issues

Implants and Devices

	Static	Gradient	RF
Case Heating		✓	✓
Force & Torque	✓		
Vibration	✓	✓	
Device Interactions	✓	✓	✓
Lead Heating			✓
Stimulation		✓	✓

Labeling

ASTM Standard F2503* Defines Three Terms:

MR Safe

MR Unsafe

MR Conditional

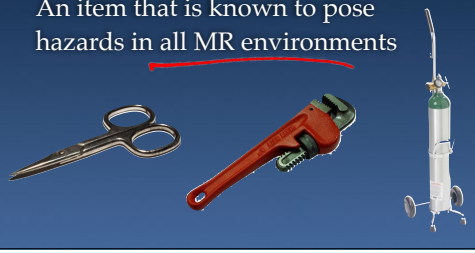
*ASTM standard F2503: Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment

MR Safe

An item that poses no known hazards in all MR environments

MR Unsafe

An item that is known to pose hazards in all MR environments



MR Conditional

An item that has been demonstrated to pose no known hazards in a specified MR environment with specified conditions of use

MR Conditional

The exact make, model, etc. of an implant or device must be known in order to find the conditions of use

Some pacemakers are now labeled as MR Conditional

No MR Labeling

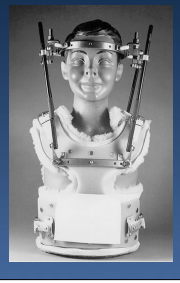
Unintended Cardiac Stimulation

MRI Induced – High Rate Pacing

Canine Test

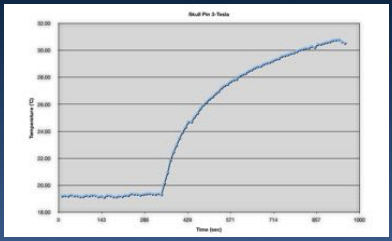
The MRI scanner is pacing the heart

Some metal devices can heat when exposed to the RF used during the scan



Courtesy Frank Shellock, Ph.D.

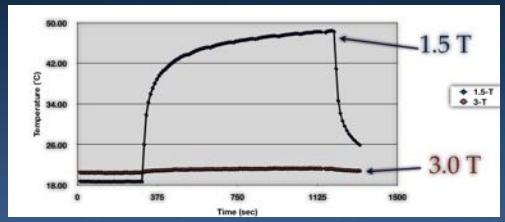
Cervical Fixation Device at 3 T



Courtesy Frank Shellock, Ph.D.

MRI-Related Lead Heating: Pacing Lead, No IPG

1.5 (1.4-W/kg) vs. 3-T (3-W/kg)



For certain lead lengths, less heating at 3-T/128MHz vs. 1.5-T/64MHz due to differences in resonant wavelength.

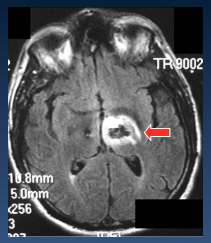
Courtesy Frank Shellock, Ph.D.

Some devices may be conditionally safe at one field but not at another

Guidelines not followed


CASE REPORTS

PERMANENT NEUROLOGICAL DEFICIT RELATED TO MAGNETIC RESONANCE IMAGING IN A PATIENT WITH IMPLANTED DEEP BRAIN STIMULATION ELECTRODES FOR PARKINSON'S DISEASE: CASE REPORT



1.5 T ONLY
T/R Head coil ONLY
Head SAR 0.1 W/kg

Courtesy Frank Shellock, Ph.D.

Multiple Potential Issues

Implants and Devices

	Static	Gradient	RF
Case Heating		✓	✓
Force & Torque	✓		
Vibration	✓	✓	
Device Interactions	✓	✓	✓
Lead Heating			✓
Stimulation		✓	✓

Summary

- ✓MRI is a powerful diagnostic tool
- ✓It is very safe unless it is used or managed inappropriately
- ✓The powerful and invisible magnetic field is always present
- ✓MR safety zones III and IV are under the direct control of the MRI technologists at all times
- ✓It is critical to determine as much information about any implants and/or devices a patient may have

MRI Safety
Level 1 MR Personnel

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