AHC Media

June 15, 2016

MRI Safety: Maneuvering the Maze of ACR, CMS and TJC Standards

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Objectives

- Give recommendations to improve MRI safety including establishing policies and procedures for identifying implants in patients.
- Explain new and revised standards, regulations, and laws put forth by CMS, TJC and the federal government.
- Evaluate compliance requirements and penalties.

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This Webinar Will Cover

- CMS MRI Standards implemented July 2015
- TJC MRI Standards effective July 2015
- American College of Radiology MRI Guidance Document for Safe MR Practices
- TJC Sentinel Event Alert (SEA) on MRI Safety
- Guidelines for Screening Patients for MR Procedures 2014 by Institute for MR Safety, Education, and Research or IMRSER
- MRI Safety, Credentialing, Legal, Risk Management, Patient Safety Issues and more

Introduction
Headlines, History, Patient Injuries

Headlines You Don't Want to See

- Hoag Hospital in California fined by state Dept of Public Health after patient was taken to MRI on a metal gurney
- Patient was pulled into the imaging machine breaking her lower leg
- Leg was trapped for three minutes and spent 3 days in the hospital and magnet quenched
- Now have adopted new procedure and checklist before entering MRI room
- Has installed cameras for monitoring
- Fined $50,000 in 2010

Headlines You Don't Want to See

Published: Jan. 22, 2010
Updated: 7:13 p.m.

Hoag fined in MRI accident

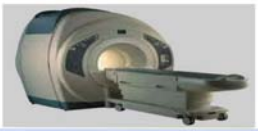
By COURTNEY PERKES
THE ORANGE COUNTY REGISTER
cperkes@ocregister.com

COMMENTS | RECOMMEND | PRINT | EMAIL | SHARE

ARTICLE

Hoag Hospital has been fined $50,000 by the state Department of Public Health after an MRI patient on a metal gurney was magnetically pulled into the imaging machine, the hospital said Friday.

In a memo to staff, Dr. Richard Afable, chief executive officer of Hoag Memorial Hospital Presbyterian, described the scenario and policy changes to prevent future incidents. He was in Los Angeles on Friday and could not be reached for comment.



Afable said that last January a woman was taken into an MRI room on a metal gurney that was not compatible with the machine. The powerful magnet in the MRI pulled the gurney into the machine and the patient's leg was trapped for about three minutes. She was taken to the emergency room and spent three days in the hospital for treatment of fractures in her lower leg and foot.

Hoag failed to follow its policy of not allowing gurneys that are not MRI safe in the hallways outside the testing room, Afable said. The hospital has adopted new procedures including a checklist that must be done before entering

MAUDE EVENT REPORT (FOI)

SORTED BY: DATE OF EVENT

This output contains the medical device adverse event reports currently available to the public, in accordance with the Freedom of Information Act and the requested search criteria. Submission of a report does not constitute an admission that medical personnel, user facility, importer, manufacturer or product caused or contributed to the event.

MFR Report No: 2240869-2009-00002 Mfr Name: SIEMENS MEDICAL SOLUTIONS USA, INC.

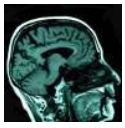
Event Date (E3): 12-Jan-2009
Report Date (E4): 13-Jan-2009
Report Date (F8):
Date Mfr Rec'd (G4): 13-Jan-2009
Event Report Type: INJURY
Event Outcome (E2): OTHER SERIOUS (IMPORTANT MEDICAL EVENTS)
Reporter Occupation (E3): NA - NOT APPLICABLE
Device Operator: HEALTH PROFESSIONAL
Adverse Event (E1): Y
Problem (E1): N
Event Location (F12):
Report Source (G3): USER FACILITY

Product Code: (RA)-SYSTEM, NUCLEAR MAGNETIC RESONANCE IMAGING (LNH)
Device Age (F3):
Expiration Date:
Manufacture Date (H4):
Single Use (H5): N
Device Usage (H8): *

Event Description (B5):
Mfr 23-JAN-2009: SITE BROUGHT PATIENT INTO SCAN ROOM ON A FERROMAGNETIC GURNEY. THE PATIENT WAS THROWN INTO THE MAGNET WITH THE GURNEY. THE TECHNICIAN IMMEDIATELY QUENCHED THE MAGNET IN ORDER TO RELEASE THE PATIENT AS WELL AS THE GURNEY FROM THE MAGNET. THE PATIENT SUSTAINED FRACTURES TO THE FOOT, ANKLE AND LEG.

Concomitant Medical Products:

Mfr Name: SIEMENS AG
Address: 127 HENKESTRASSE
ERLANGEN,
GERMANY



Device Available for Evaluation: Y
Device Evaluated by Manufacturer (H3): Yes

Remedial Action (H7):
Correction/Removal No (H8):
Additional Mfr Narrative (H10 & H11):
23-JAN-2009: SIEMENS SERVICE ENGINEER EVALUATED THE EQUIPMENT ON JANUARY 13, 2009. THE EQUIPMENT WAS OPERATING ACCORDING TO SPECIFICATIONS. THE ENGINEER REPAIRED THE BROKEN COVERS ON THE FRONT OF THE MAGNET AND THE SYSTEM WAS RETURNED TO SERVICE.

Headlines We Don't Want to See

HEALTHCARE FINANCE

Single safety incident caused the issue that could present major risk to patients.

Susan Morse, *Associate Editor*

Single safety incident caused the issue that could present major risk to patients.

It was human, not mechanical error, that sparked last week's recall notice of close to 13,000 MRI devices , GE Healthcare said on Tuesday.

Recall of 13,000 MRIs

- GE said the recall was due to human error
- Instructed MRI customers to perform a five-minute check weekly to make sure no one disconnected the machine's magnetic rundown unit or MRU
- This is effectively an emergency off switch for the magnet
- This 5 minute check is the substance of the recall notice and MRIs are not being returned or replaced
- The FDA said the MRU must be on at all times or it could delay removal of a ferrous object from the magnet resulting in life threatening injury

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Prevention Costs Less

- "The costs of the safety provision to help prevent these accidents are peanuts when compared to the costs of accidents"
- Do you use a ferromagnetic detector?
- Cost to restore the magnet after the quench, cost of down time, and lost revenue, lawsuit costs, fines, and the cost to investigate is greater than cost of prevention
- Source: Gurney Crashes MRI, Patient Injured, Hospital Fined $50 K, Tobias Gilk, MRI Safety Director, Mednovus Inc., MRI Metal Detector Blog

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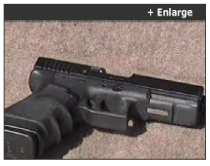
Officer Hurt When MRI Pulls Gun

Police Say Off-Duty Officer Was At Beaches Open MRI With Her Mom

POSTED: Thursday, October 1, 2009



JACKSONVILLE, Fla. -- An off-duty Jacksonville Sheriff's Office deputy was hurt Wednesday when her hand was trapped between her police-issued Glock handgun and the powerful magnet inside an MRI machine.

Police said Joy Smith was in the MRI room with her mother when she apparently forgot about her gun, which was pulled by the magnetic force of the machine, trapping her hand between the gun and the MRI.

Smith was able to free herself, but the gun remained stuck for hours while the machine was powered down, which takes 24 hours. Jacksonville Beach police said Smith's hand was injured and she had difficulty bending her thumb, but it was not known if she sought medical treatment.

"It's a huge magnet. The whole thing just has a plastic case around it," said Beth Ratliff, who operates the MRI machines at Shands.

Scissors in Forehead

- Flying scissors had be surgically removed from technologist's forehead
- This is not the real x-ray of the injury that occurred
- http://mrimetaldetector.com /blog/tag/maude/
- Thanks to Tobias Gilk for his input on this presentation

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Death of Engineer by MRI

- Field engineer called to fix blower motor due to MRI making noise
- Arrived at 2100 and guard check and no response and he left after making no investigation
- Found next day dead pinned by MRI machine
- Reported to GE Healthcare
- Source FDA Maude AE Report, March 2010 at http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/detail.cfm?mdrfoi__id=1648230

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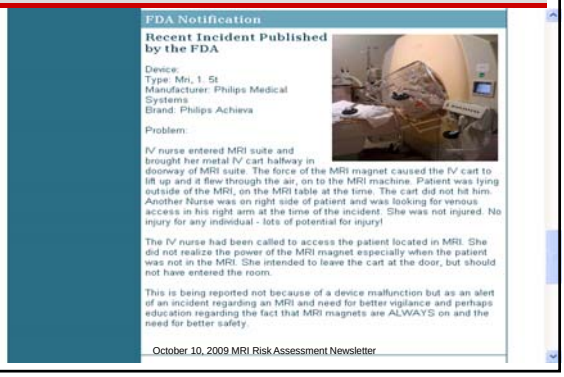
IV Cart in MRI Machine



FDA Notification

Recent Incident Published by the FDA

Device:
Type: Mri, 1. 5t
Manufacturer: Philips Medical Systems
Brand: Philips Achieva

Problem:

IV nurse entered MRI suite and brought her metal IV cart halfway in doorway of MRI suite. The force of the MRI magnet caused the IV cart to lift up and it flew through the air, on to the MRI machine. Patient was lying outside of the MRI, on the MRI table at the time. The cart did not hit him. Another Nurse was on right side of patient and was looking for venous access in his right arm at the time of the incident. She was not injured. No injury for any individual - lots of potential for injury!

The IV nurse had been called to access the patient located in MRI. She did not realize the power of the MRI magnet especially when the patient was not in the MRI. She intended to leave the cart at the door, but should not have entered the room.

This is being reported not because of a device malfunction but as an alert of an incident regarding an MRI and need for better vigilance and perhaps education regarding the fact that MRI magnets are ALWAYS on and the need for better safety.

October 10, 2009 MRI Risk Assessment Newsletter

FDA's Data from Maude

- 4th consecutive year with substantial increases in rates of MRI accidents
  - A 30 percent increase from last year
  - This was an increase in the number of reports to FDA of MRI accidents
- There was a 240 percent increase from 2004 to 2008
- There are at least 148 reports from MRIs
- One expert suggests this represents about 14,800 real world accidents

Source: http://mrimetaldetector.com/blog/?p=329

Source: http://mrimetaldetector.com/blog/?p=329 and FDA website is http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/detail.cfm?mdrfoi__id=996580

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MRI Scanner Eats an ICU Bed

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FDA MAUDE Database

www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/PostmarketRequirements/ReportingAdverseEvents/ucm127891.htm

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FDA MRI Website

- The FDA has a MRI website that includes information on the following:
- Uses and description
- Risks and benefits
  - Dyes from tattoos or tattooed eye liner
- Information for patients
- Information for professionals, laws, standards
  - MRI safety, MRI contrast agents containing gadolinium, and nephrogenic fibrosis dermopathy, injuries with implanted stimulators, burns with transdermal patches, cable and electrode burns

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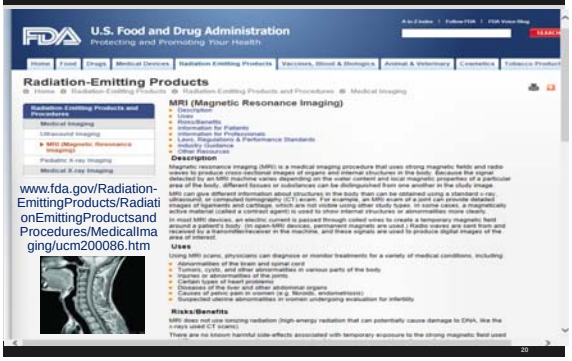
FDA MRI Website



www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/MedicalImaging/ucm200086.htm

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Primer on Medical Devices Interaction & MRI

www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm107721.htm

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What is an MRI?

- Noninvasive medical imaging technique used primarily in radiology
  - Can be used to image anatomy in multiple planes or slices
  - Uses magnetic fields and not x-rays or ionizing radiation
  - Used to investigate the brain, spinal cord, and vertebrae and surrounding tissue
- Originally named **zeugmatography**
  - In Greek it means "that which is used for joining"

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The Case that Everyone has Heard

- Six year old child had an MRI in a hospital in Valhalla, New York on July 31, 2001
- Metal oxygen cylinder brought into room
- Nurse thought canister was made of nonmagnetic material like aluminum
  - No special marking on tank
- 2011 was 10 year anniversary and it was MRI week
- Oxygen tank became a missile and was drawn into the magnetic core while boy still in the machine in 2001

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The Case that Everyone has Heard

- Tank struck Michael Colombini in the head
  - Caused a fractured skull
  - Child died of fatal cerebral hemorrhage

- First fatal MRI accident of its kind
- Settlement agreement wants opportunity for others to learn from this incident (settled nine years later)
- Feb 2010 article states case is settled for $2.9 Million [1]
- 2011 was 10 year anniversary and has MRI week

[1] http://mrimetaldetector.com/blog/2010/02/2-9-million-settlement-closes-colombini-mri-death-case/

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MRI Metal Detector Blog

Info on ferromagnetic detection and MRI safety & screening

« Gurney Crashes MRI, Patient Injured, Hospital Fined $50K
Colombini, Codes, Metal Detectors And MRI Safety »

$2.9 Million Settlement Closes Colombini MRI Death Case

This week the settlement documents were released — closing the chapter on the lawsuit that arose from the seminal event in MRI safety, the 2001 oxygen tank fatality of then-six-year-old Michael Colombini.

Nearly nine years after the accident, the lawsuit was settled for $2.9 million, a settlement that was likely both diminished by, and made possible by, a pre-trial motion which excused GE Healthcare as a defendant to the suit.

The county-owned hospital, which almost immediately asserted its responsibility for the accident, ultimately settled the case on behalf of all of the remaining defendants, which included the head of radiology and the technologist who administered the boy's scan.

Perhaps now, with the lawsuit resolved, we can actually ***learn*** something about the events that precipitated this tragedy, beyond the fragmentary slivers of information gleaned from court documents and news accounts.

That's right, despite the fact that this one event has become the touchstone for MRI safety, there has not been a single root-cause analysis to inform MRI suite design, departmental operations, regulatory and accreditation frameworks... at least not one that has been shared with the public.

Hopefully, with the lawsuit resolved and jeopardy attached for all defendants, we can have an open conversation about what contributed to the accident and what can be done, at the thousands of MRI suites across the country, to help see that this

Other Cases

- Off-duty policeman arrived to have MRI done
- He told technician he was carrying a firearm so Tech intended to meet him in the waiting area to secure the weapon
- Officer entered the MR scan room and put his gun on the cabinet 3 feet from the 1.5 T magnet bore
- Gun was pulled from his hand
- Gun hit left side of bore (inside) of MRI and fired a round into the back wall of the scan room
- Luckily no one was injured

Source: Safety Concerns in the MR environment, ECRI, May 2006

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Other Cases

- Patient came into ED with sweatpants and track shoes and was sent to MRI
  - The patient was moved to the MRI scanner head first
  - His legs were lifted up so his face was in the MRI doughnut
  - The Patient had sandbag ankle weights
  - When his legs were lifted up, he screamed in pain
  - The magnet was quenched (quenching can cause asphyxiation, frostbite, fire hazard and can cost $20,000 to $500,000)

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History

- First adult MRI occurred in 1977
- Today more than 10 million MRIs are done in the US every year
- MRI is among safest compared to many other diagnostic procedures (Strokowski, 2005)
- Many believe number of actual adverse events is higher than reported
- Numbers of adverse events are low considering how many are done
- Field of magnetic resonance imaging has seen tremendous progress in last 20 years[1]
- [1]Dr. Emanuel Kanal, University of Pittsburg Medical Center, MR Safe Practice Guidelines

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MRI- Related Events

- Many hardware and software advances and improvements in contrast agents
- In 2005, ECRI analyzed FDA's data
  - MAUDE (Manufacturer and User Facility Device Experience Database) reported data over a 10-year time span or MRI injuries
- Study found 389 reports of MRI-related events
- Nine deaths from MRI studies
  - Three related to pacemaker failure, 2 incidents of insulin pump failure and 4 implant disturbances
  - One asphyxiation from a cryogenic mishap during installation of an MR imaging system

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So What Happened? NQF Never Event

- Static magnetic field generated by MR systems attracts ferromagnetic objects with considerable force
- Material can be magnetized in the presence of an external magnetic field
- This causes the object, like the oxygen tank, to move toward it
  - Called the projectile effect
- 2011 NQF updates never events or serious reportable errors to **include from metallic object into the MRI area**

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So What Happened?

- Every hospital should show the video of the oxygen cylinder crashing or the patient gurney crashing
- It is said that a picture is worth a thousand words
- Two-minute video to show the projectile effect
- Items pulled into MRIs
  - IV poles, mop buckets, chair, ladder, laundry cart, floor buffer, pulse ox, transformer, tools, scissors, sand bags, and traction weights
  - Noted on MDR reports at the time of this occurrence (ECRI Hazard Report)

[1] http://www.mri-planning.com/home.html

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Other Cases

- Woman who had an aneurysm clip in her brain died after undergoing MRI
- Welder with piece of metal embedded in his eye blinded in that eye after MRI
- 60 year old man sustained fractures to face when oxygen canister became wedged in machine against his face (awarded $100,000 in damages)
- Source: Web MD article August 1, 2001

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The CMS Hospital CoPs on MRI

CMS MRI Guidelines

- CMS rewrites all the hospital radiology and nuclear medicine CoPs effective July 2015
- First issues 42 page advance copy on May 15, 2015
- Publishes final one in manual July 10, 2015 and in current manual
- Includes requirement specific to MRI for the first time
- Must make sure staff is appropriately trained
- Must make sure equipment is inspected

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Radiology and Nuclear Medicine

DEPARTMENT OF HEALTH & HUMAN SERVICES
Centers for Medicare & Medicaid Services
7500 Security Boulevard, Mail Stop C2-21-16
Baltimore, Maryland 21244-1850

CMS CENTERS FOR MEDICARE & MEDICAID SERVICES

Center for Clinical Standards and Quality/Survey & Certification Group

Ref: S&C-15-38-Hospitals

DATE: May 15, 2015

TO: State Survey Agency Directors

FROM: Director
Survey and Certification Group

SUBJECT: Revised Hospital Radiologic and Nuclear Medicine Services Interpretive Guidelines—State Operations Manual (SOM) Appendix A

Memorandum Summary

Updated Guidance for Hospital Services: The Centers for Medicare & Medicaid Services (CMS) has updated the interpretive guidelines for the hospital Conditions of Participation (CoPs) for the below to reflect current accepted standards of practice:

- Radiologic Services at 42 CFR 482.26, and
- Nuclear Medicine Services at 42 CFR 482.53

Background

Radiologic and nuclear medicine services have improved the ability to detect and treat a wide variety of conditions and diseases, and advanced diagnostic and therapeutic procedures have become routine in many hospitals throughout the country. While these services provide

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Final Radiology in July Manual

State Operations Manual
Appendix A – Survey Protocol, Regulations and Interpretive Guidelines for Hospitals

Table of Contents
(Rev. 141, 07-10-15)

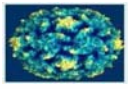
Transmittals for Appendix A

www.cms.hhs.gov/manuals/downloads/som107_Appendixtoc.pdf

Survey Protocol

Introduction
- Task 1 - Off-Site Survey Preparation
- Task 2 - Entrance Activities
- Task 3 - Information Gathering/Investigation
- Task 4 - Preliminary Decision Making and Analysis of Findings
- Task 5 - Exit Conference
- Task 6 – Post-Survey Activities

Psychiatric Hospital Survey Module
Psychiatric Unit Survey Module
Rehabilitation Hospital Survey Module
Inpatient Rehabilitation Unit Survey Module
Hospital Swing-Bed Survey Module



Regulations and Interpretive Guidelines

§482.2 Provision of Emergency Services by Nonparticipating Hospitals

§482.11 Condition of Participation: Compliance with Federal, State and Local Laws

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Location of CMS Hospital CoP Manual

Medicare State Operations Manual

Appendix

Questions to hospitalscg@cms.hhs.gov

- Each Appendix is a separate file that can be accessed directly from the SOM Appendices Table of Contents, as applicable.
- The appendices are in PDF format, which is the format generally used in the IOM to display files. Click on the red button in the 'Download' column to see any available file in PDF.
- To return to this page after opening a PDF file on your desktop, use the browser "back" button. This is because closing the file usually will also close most browsers

New website

www.cms.hhs.gov/manuals/downloads/som107_Appendixtoc.pdf

App. No.	Description	PDF File
A	Hospitals	2,185 KB
AA	Psychiatric Hospitals	606 KB

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CMS MRI Guidelines

- CMS provides a definition of MRI
- Need a MRI policy to ensure safety and that acceptable standards are met (Tag 535)
- CMS notes that MRIs don't use ionizing radiation but can cause burns, adverse events, and risk of flying magnetic items
- Need an order for the MRI (535)
- Must comply with standards of care and specifically mentions ACR and they have standards on MRI
  - ACR has the MR safety standards

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Definition of MRI

Magnetic resonance imaging *(MRI) is a medical imaging procedure that uses strong magnetic fields and radio waves to produce cross-sectional images of organs and internal structures in the body. Because the signal detected by an MRI machine varies depending on the water content and local magnetic properties of a particular area of the body, different tissues or substances can be distinguished from one another in the study image.*

MRI can give different information about structures in the body than can be obtained using a standard x-ray, ultrasound, or computed tomography (CT) exam. For example, an MRI study of a joint can provide detailed images of ligaments and cartilage, which are not visible using other modalities. In some cases, an MRI contrast agent is given by vein to show internal structures or abnormalities more clearly.

In most MRI devices, an electric current is passed through coiled wires to create a temporary magnetic field in a patient's body. (In open-MRI devices, permanent magnets are used.) Radio waves are sent from and received by a transmitter/receiver in the machine, and these signals are used to produce digital images of the area of interest.

MRI scans facilitate diagnosis or monitoring of treatments for a variety of medical conditions, including:

- *Abnormalities of the brain and spinal cord;*
- *Tumors, cysts, and other abnormalities in various parts of the body;*
- *Injuries or abnormalities of the joints;*

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CMS Hospital MRI CoPs P&P

- Many things must be in the policy such as must identify patients at high risk of an adverse event; pregnant, allergic to contrast, implanted devices
- P&P should address steps to be taken such as notify the ordering physician, cancel the procedure, etc (535)
- Procedures to address risks associated with MRI and many other things that must be in the MRI P&P and screening
- Training required by staff to enter area where services are provided

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CMS Hospital MRI CoPs

- Policy to address how to respond to an emergency and must have emergency equipment such as crash cart (535)
- Radiologist must sign report after interpreting it
- Need to take measures to prevent magnetic materials from being closer than is safe to the MRI suite, per nationally recognized guidelines and include in P&P
  - If equipment and supplies, such as fire extinguishers and oxygen tanks, are located in the MRI area, they must be MR-safe, i.e., meaning they are non-ferromagnetic;

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CMS Hospital MRI CoPs

- Provision of adequate and effective hearing protection to patients, staff and others who might be in the MRI suite while the scans are taking place and
- Measures to reduce the risk of thermal injuries/burns during MRI and include in P&P
  - Screen patients to identify those who may have metallic tattoos or metal in them
  - Proper patient positioning, ensuring implants are MR Conditional

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CMS Hospital MRI CoPs P&P

- Check for electrically conductive materials that might be in close proximity to the patient
- Instruct the patient to immediately report any burning sensations experienced during the scan
- Training required by personnel permitted to enter areas where radiologic services are provided
- Areas where radiologic services are provided must be equipped with the necessary equipment or materials to immediately respond to potential AE such as crash cart or emergency stop mechanisms,

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TJC MRI Standards

TJC MRI Safety Standards EC.02.01.01

- TJC implements safety standards for hospitals to manage the safety risks with MRI (Diagnostic Imaging)
- Was to be effective July 1, 2014 but delayed and became effective July 1, 2015
- Must manage safety risks regarding;
  - Patients with anxiety or claustrophobia
  - Patients who need urgent or emergent medical care
  - Patients with medical implants, devices, or imbedded FO such as shrapnel
  - Acoustic noise and ferromagnetic objects entering the room

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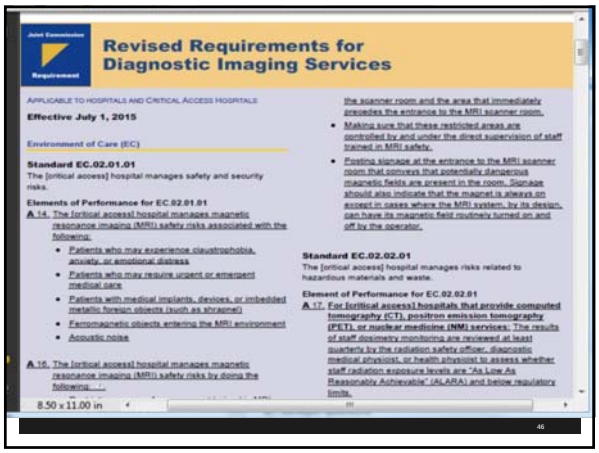

Hospital Manages MRI Safety Risks

- Hospital must restrict access to room of those not screened or trained in MRI safety
- Anyone not trained in MR safety or screened by MRI trained staff have restricted access to the scanner room and area immediately preceding the entrance to the scanner room
- Make sure restricted areas are controlled by and under direct supervision of MRI trained staff

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Hospital Manages MRI Safety Risks

- Put signs by entrance to scanner about dangers of the magnet and that it is always on
  - Except when MRI system, by design, can have the magnetic field turned off

- Also statement related to PET scan, CT, or nuclear medicine services that staff dosimetry results are reviewed quarterly by the radiation safety officer or medical physicist to assess staff radiation exposure levels to be as low as possible

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Manage the Medical Equipment EC.02.04.01

- This standard is about managing the risks specific to the medical equipment
- The hospital needs to identify quality control and maintenance activities of the MRI scanner
- This is necessary to maintain the quality of the MRIs produced
- The hospital needs to identify how often this should be done
- They want the MRI scanner to be in good working condition

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Inspect, Test, Maintain the Equipment EC.02.04.03

- This standard is about inspecting, testing, and maintaining the medical equipment
- At least annual, a diagnostic medical physicist or a MRI scientist needs to evaluate all the MRI equipment to make sure it is in good working order
- The evaluation must be documented
- Any recommendation must be documented
- There needs to be documentation that the problem was fixed
- There is a list of things that have to be evaluated

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Staff Training & Education HR.01.05.03

- This standard is all about education and training for the staff
- HR must make sure technologist who does MRI safe MRI practices has ongoing education along with annual education on the following:
- Patient screening criteria that addresses ferromagnetic item, medical implants and devices
- Proper positioning to prevent burns (thermal injury)
  - Don't forget use of padding, positioning aids, and coils to reduce burn risks

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Staff Training & Education

- Risk for nephrogenic systemic fibrosis (NSF)
  - Assess patients for altered renal functions
  - Calculated (eGFR) is more accurate than creatinine
  - ACR Contrast Manual 2015 has a section on risk factors in their chapter on Gadolinium based contrast media
  - Also chapter on Nephrogenic Systemic fibrosis
  - Risk is patient with end-stage chronic kidney disease (CKD) , especially on dialysis, who gets gadolinium-based contrast agent (GBCA)
  - Increased if these patients have a metabolic acidosis or medication to predispose them to this (elevated iron, calcium, phosphates, high dose erythropoietin, or infection)

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Staff Training & Education

- Equipment and supplies that are acceptable to use in MRI suite
  - Such as MR Safe or MR Conditional
- Safety response procedures if the patient needs urgent or emergency procedures
  - Know what to do if patient codes in scanner room or what if patient has an allergic reaction to the dye?

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Staff Training & Education

- How to do an emergency shutdown such as MRI system quench and cryogen safety procedures
- Patient hearing protection
  - Such as disposable ear plugs
  - Headphones
  - Anti-noise system
  - Quiet pulse sequences

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Acoustic Noise and MRI

Staff Training & Education

- How to manage claustrophobia, anxiety, or emotional stress
  - Use open MRI, educate patient, allow relative or friend to stay with, sedatives, stereo system,
  - Use fan inside MR system, maintain verbal or visual contact with patient,
  - Position patient feet first, use blindfold, vanilla scented oil,
  - Relaxation techniques, or medical hypnosis

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Claustrophobia, Anxiety, Emotional Distress

TJC MRI Safety Standards

- Hospital orients technologist on safe MRI practice including:
  - MRI safety response procedures for patient who require urgent or emergency medical treatment
  - MRI equipment emergency shutdown procedures such as quench and cryogen safety procedures
  - Patient hearing protection
  - Management of patients with claustrophobia, anxiety, or emotional distress
  - References ASTM standards

58

Diagnostic Testing PC.01.02.05

- When doing MRI need to verify:
  - Right patient
  - Right image site
  - Right positioning
- Consider the patient's age and recent imaging exams when deciding on the most appropriate type of imaging exam
  - Knowledge of the patient's recent imaging exams can help to prevent unnecessary duplication of exams

59

Data Collection PI.01.01.01

- The hospital collects data to monitor its performance
- Collect data on thermal injuries (burns) that occurring during the MRI (EP 46)
- Collect data on the following: (EP 47)
  - If any ferromagnetic objects unintentionally enter the scanner room
  - Use of ferromagnetic detection devices can prevent failed screening
  - Any injuries that resulted from this

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TJC Sentinel Event Alert on Preventing Accidents and Injuries in the MRI

TJC Sentinel Event Alert

- The Joint Commission issued a 3 page Sentinel Event Alert (SEA) 38, February 14, 2008
- Preventing accidents and injuries in the MRI suite
  - Review all SEAs and implement
  - Have a committee to review and address
  - Institute a policy based on the Alert
  - This and ACR MR safety are the two industry recognized MRI safety practice standards
- Sign up to receive e-mail notice when Alerts are published[1] www.jointcommission.org

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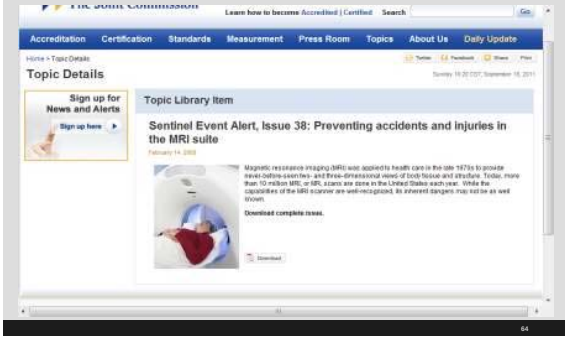
TJC Sentinel Event Alerts (SEA)

www.jointcommission.org/sentinel_event.aspx

63

TJC SEA on MRI Safety



64

TJC Sentinel Event Alert MRI Safety

- TJC set out 10 recommendations which are discussed in detail later
  - Use 4 zones for safety
  - Use trained staff to screen any non-emergent patients twice
  - Provide ear plugs and hearing protection to all patients
  - Provide at least annual training regarding MRI safety to MR personnel
    - Provide non-MR staff and patients with material, such as a flier, that explains potential for adverse events

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TJC 10 MRI Safety Recommendations

- Ensure there is complete medical history to ensure patient is safe to scan
- Have specially trained MR staff who are knowledgeable about all 4 zones and the MRI safety environment issues
- Take precautions to prevent burns
  - Cold compress or ice pack on EKG leads, surgical staples, tattoos or electrically conductive material
  - Ensure no electrically conductive loops are formed in the MR scanner bore
  - Use nonconductive foam pads to insulate patient's skin

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TJC 10 MRI Safety Recommendations

- Never code a patient in the MRI magnet room
- Proactively plan for managing critically ill patients who require monitoring
  - This may include monitoring of life sustaining drugs or other medications
- Use only MR safe equipment
  - Oxygen, fire extinguishers, physiologic monitors, wheelchairs etc.
- The article recognized there are 3 more recommendations

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3 Additional Recommendations

- Recommended by Dr Emanuel Kanal, leading expert on MR Safety
  - Appoint a patient safety officer who is responsible for enforcing safety procedures in MRI suite
  - Implement safe practices system such as MRI safety P&P and periodically assess compliance with P&P
  - Do not bring anything into the MRI room unless proven to be MR safe or MR conditional

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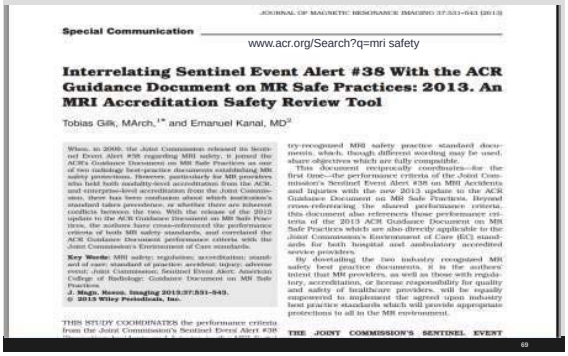
SEA 38 and the 2013 ACR MR Safety



JOURNAL OF MAGNETIC RESONANCE IMAGING 37:531–543 (2013)

Special Communication

www.acr.org/Search?q=mri safety

Interrelating Sentinel Event Alert #38 With the ACR Guidance Document on MR Safe Practices: 2013. An MRI Accreditation Safety Review Tool

Tobias Gilk, MArch,[1]* and Emanuel Kanal, MD[2]

When, in 2000, the Joint Commission released its Sentinel Event Alert #38 regarding MRI safety, it joined the ACR's Guidance Document on MR Safe Practices as one of two radiology best-practice documents establishing MR safety protections. However, particularly for MR providers who hold both modality-level accreditation from the ACR, and enterprise-level accreditation from the Joint Commission, there has been confusion about which institution's standard takes precedence, or whether there are inherent conflicts between the two. With the release of the 2013 update to the ACR Guidance Document on MR Safe Practices, the authors have cross-referenced the performance criteria of both MR safety standards, and correlated the ACR Guidance Document performance criteria with the Joint Commission's Environment of Care standards.

Key Words: MRI safety; regulation; accreditation; standard of care; standard of practice; accident; injury; adverse event; Joint Commission; Sentinel Event Alert; American College of Radiology; Guidance Document on MR Safe Practices

J. Magn. Reson. Imaging 2013;37:531–543.
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THIS STUDY COORDINATES the performance criteria from the Joint Commission's Sentinel Event Alert #38

try-recognized MRI safety practice standard documents, which, though different wording may be used, share objectives which are fully compatible.

This document reciprocally coordinates—for the first time—the performance criteria of the Joint Commission's Sentinel Event Alert #38 on MRI Accidents and Injuries with the new 2013 update to the ACR Guidance Document on MR Safe Practices. Beyond cross-referencing the shared performance criteria, this document also references those performance criteria of the 2013 ACR Guidance Document on MR Safe Practices which are also directly applicable to the Joint Commission's Environment of Care (EC) standards for both hospital and ambulatory accredited service providers.

By dovetailing the two industry recognized MR safety best practice documents, it is the authors' intent that MR providers, as well as those with regulatory, accreditation, or license responsibility for quality and safety of healthcare providers, will be equally empowered to implement the agreed upon industry best practice standards which will provide appropriate protections to all in the MR environment.

THE JOINT COMMISSION'S SENTINEL EVENT

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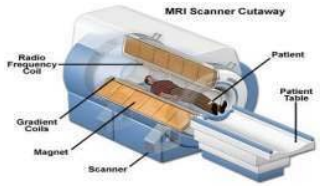
Seven Injuries that Can Occur in an MRI Suite



Missile or Projectile Effect

- Ferromagnetic or metal objects are pulled into the MRI scanner
- Patients must be instructed on what should be removed
- Check under the sheets if brought to MR on cart (canes, purses etc.)
- 10 percent of 389 adverse events were projectile related

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Patients Should Remove

- Purse, wallet, money clip, credit cards, cards with magnetic strips
- Electronic devices such as beepers or cell phones
- Hearing aids
- Metal jewelry, watches
- Pens, paper clips, keys, coins
- Hair barrettes, hairpins
- Eye make up

72

Patients Should Remove

- Articles of clothing that have a metal zipper, buttons, snaps, hooks, under wires, or metal threads
- Shoes (especially ones with roller skates inside), belt buckles, safety pins

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Projectile Objects

- The following have become projectiles in VA facilities as listed in their HR Hazard Summary
  - Oxygen cylinder, IV pole, transport stretcher, traction weight, floor buffer, wheelchair, file cabinet, drill, and patient walker
  - Patient lifts, stethoscopes, infusion pumps, pulse oximeters, tools, laundry carts, scissors, pens, hair barrettes, and more
- Hairpins and paper clips near a 1.5 Tesla MRI can reach speeds of 40 mph

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Prevention of Missile Effect

www.mrisafety.com/safety_article.asp?subject=39

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Dislodged Implants Implant Motion

- Injury can occur from dislodged (or twisting) ferromagnetic implants
- Implants include clips, like cerebral aneurysm clips, pins in joints, magnetic cochlear implants, and drug infusion devices
- Long list of devices is on the screening form
- Patients should be screened before MRI is done to prevent injury

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Implant Motion

- Especially a concern with implants that are strongly ferromagnetic
  - Implant can move or dislodge
  - Determine if can wait several weeks for fibrous scarring to set in
- Implants that are nonferrous in nature the risk is reduced to those resulting from Lenz's forces alone
  - Less important to have a waiting period

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Burns

- Patients have been burned from objects that can heat up during the MR procedure
  - Called RF heating–induces currents in electrically conductive material
  - Burns from contact with conductive medical equipment cables (looped and unlooped EKG cables or pulse oximeter cable)
- Other objects that can cause burns
  - Surgical staples, the inside walls (the bore) of the MRI scanner during the scan, site of pulse ox sensor that touches patient's skin, Nitro patches which contain foil and other transdermal patches or those that deliver testosterone
  - ISMP and FDA Safety News reported

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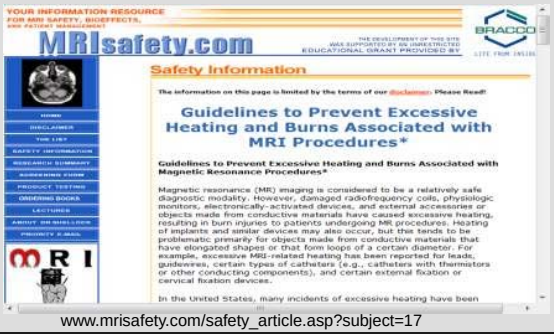
Burns

- Rare reports of burns
  - At tattoo site (including eyeliner tattoo) since tattoos contain iron oxide or other substances that can thermally and electrically conductive
  - At or near the site of implantable infusion pumps
  - At conductive looped formed with body, such as finger touched their thigh, patient's arms were crossed, or thighs were touching
- 70 percent of the 389 adverse events were burns!

79

Guidelines to Prevent Burns with MRI



www.mrisafety.com/safety_article.asp?subject=17

80

Device Malfunction

- Injury or complications related to equipment or device failure
  - Magnetic field can seriously affect operation, reliability, and accuracy of medical devices
  - Battery powered devices suddenly fail to operate
  - Monitors (increased t-wave or ST segment), infusion pumps, PCA pump, ventilator, and even laryngoscopes

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Device Malfunction

- Injury or complications related to equipment or device failure
  - Programmable pumps may perform erratically
  - Pacemakers and implantable defibrillators may not behave as programmed (can pace at wrong point in cycle and rapid pacing can occur)
  - Otologic implants can become demagnetized, such as neurostimulators, cochlear implants, or ocular prostheses

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Device Malfunction Recommendations

- American College of Radiology (ACR) recommends that implanted cardiac pacemakers and implantable cardioverter/defibrillators should be considered a relative contraindication for MRI
  - Later will cover website that lists each device and its risks
- Use ferromagnetic detectors that may help in screening patients for objects left on them
  - Recent study shows they are about 99 percent effective

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Acoustic Injury

- Can be caused by the loud knocking of the MRI scanner
  - Patients should be given ear plugs or other hearing protection
- Sound can reach 130 decibels
  - Equivalent to jet engine take off
- Four of 380 TJC adverse events were acoustic injuries
- FDA MR Guidance Document says manufactures must state hearing protection is required for all patients

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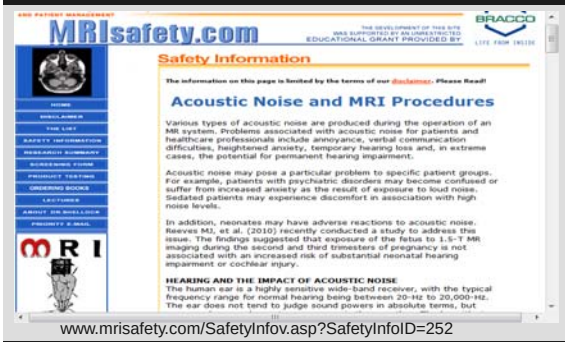
Acoustic Noise and MRI



www.mrisafety.com/SafetyInfov.asp?SafetyInfoID=252

85

Image Artifacts

- Image artifacts can cause changes to MRI images due to:
  - RF emission from equipment picked up by the MR RF receiver
  - Examples include strips on the image or decrease in contrast
  - Presence of needles near imaging site (metal biopsy needles or mascara) can produce image artifacts and mask pathology
  - Unanticipated ferromagnetic implant or FB
    - Notify medical director, safety officer or physician in charge

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Patient Support Systems

- Injury or complications can occur from failure to attend to patients during the procedure
  - Especially patients who have had sedation or anesthesia in the MRI arena
- Complications include:
  - Oxygen supply is depleted
  - IV solution on infusion pump is used up
- Never run a code in the MRI suite

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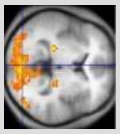
Adverse Events from MRI Contrast



- Patients with severe renal failure are at risk for contrast-induced nephropathy
  - Can cause Nephrogenic Systemic Fibrosis (NSF) or Nephrogenic Fibrosing Dermopathy (NFD)
- Important to know if patient has a history of renal or liver failure
- Important to have kidney function test like patient in the ED has a BUN and creatinine before test done

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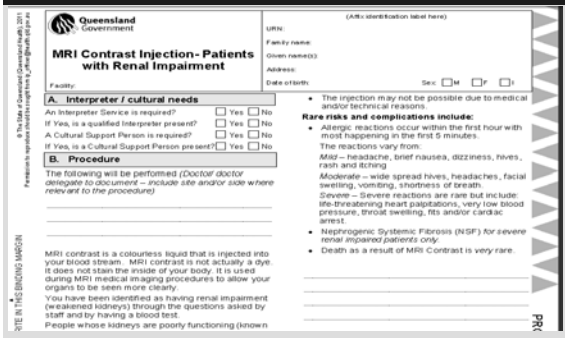
Consent Form Contrast with Renal Impairment



Queensland Government

MRI Contrast Injection- Patients with Renal Impairment

Facility:

(Affix identification label here)

URN:
Family name:
Given name(s):
Address:
Date of birth: Sex: M F I

A. Interpreter / cultural needs

An Interpreter Service is required? Yes No
If Yes, is a qualified Interpreter present? Yes No
A Cultural Support Person is required? Yes No
If Yes, is a Cultural Support Person present? Yes No

B. Procedure

The following will be performed *(Doctor/ doctor delegate to document – include site and/or side where relevant to the procedure)*

MRI contrast is a colourless liquid that is injected into your blood stream. MRI contrast is not actually a dye. It does not stain the inside of your body. It is used during MRI medical imaging procedures to allow your organs to be seen more clearly.

You have been identified as having renal impairment (weakened kidneys) through the questions asked by staff and by having a blood test.

People whose kidneys are poorly functioning (known

- The injection may not be possible due to medical and/or technical reasons.

Rare risks and complications include:

- Allergic reactions occur within the first hour with most happening in the first 5 minutes.

The reactions vary from:

Mild – headache, brief nausea, dizziness, hives, rash and itching.

Moderate – wide spread hives, headaches, facial swelling, vomiting, shortness of breath.

Severe – Severe reactions are rare but include: life-threatening heart palpitations, very low blood pressure, throat swelling, fits and/or cardiac arrest.

- Nephrogenic Systemic Fibrosis (NSF) *for severe renal impaired patients only.*
- Death as a result of MRI Contrast is *very rare.*

PRINT BLEED MARGIN

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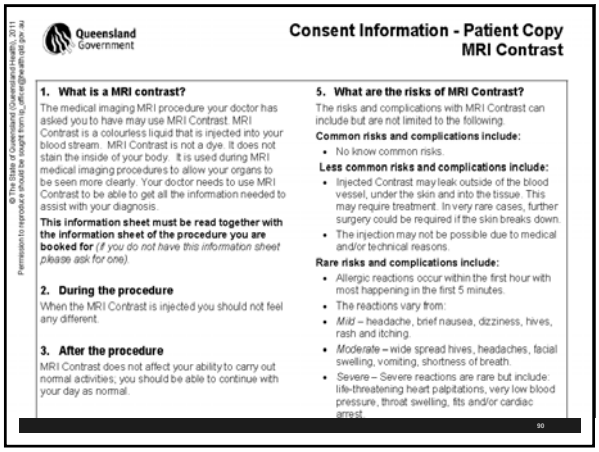

Queensland Government

Consent Information - Patient Copy
MRI Contrast

1. What is a MRI contrast?

The medical imaging MRI procedure your doctor has asked you to have may use MRI Contrast. MRI Contrast is a colourless liquid that is injected into your blood stream. MRI Contrast is not a dye. It does not stain the inside of your body. It is used during MRI medical imaging procedures to allow your organs to be seen more clearly. Your doctor needs to use MRI Contrast to be able to get all the information needed to assist with your diagnosis.

This information sheet must be read together with the information sheet of the procedure you are booked for *(if you do not have this information sheet please ask for one).*

2. During the procedure

When the MRI Contrast is injected you should not feel any different.

3. After the procedure

MRI Contrast does not affect your ability to carry out normal activities; you should be able to continue with your day as normal.

5. What are the risks of MRI Contrast?

The risks and complications with MRI Contrast can include but are not limited to the following.

Common risks and complications include:

- No know common risks.

Less common risks and complications include:

- Injected Contrast may leak outside of the blood vessel, under the skin and into the tissue. This may require treatment. In very rare cases, further surgery could be required if the skin breaks down.
- The injection may not be possible due to medical and/or technical reasons.

Rare risks and complications include:

- Allergic reactions occur within the first hour with most happening in the first 5 minutes.
- The reactions vary from:
- *Mild* – headache, brief nausea, dizziness, hives, rash and itching.
- *Moderate* – wide spread hives, headaches, facial swelling, vomiting, shortness of breath.
- Severe – Severe reactions are rare but include: life-threatening heart palpitations, very low blood pressure, throat swelling, fits and/or cardiac arrest.

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Cryogen Handling

- Adverse events related to cryogen handling, storage, or inadvertent release
  - The magnetic scanners are always left on
  - Turning them off or quenching is expensive and dangerous
  - Cryogenic gases (cooled liquid helium) can be released and are deadly
    - Can appear as white clouds or fog around the scanner
  - For superconducting systems, in event of system quench need to evacuate everyone out of the room (ACR, 2013)

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Parts of MRI and Principles of Operation

- **Magnet** creates the static magnetic field
- **Gradient coils** are three sets of coils located inside the faceplate of the machine and allow spatial localization of the data obtained in the MRI process
- **Radio-frequency (RF)** coils are used to transmit and receive RF radiation as part of the image acquisition. Coils are located under the thin plastic covering in the bore (inside walls) of the magnet.
- **Patient table and computer system** and **operator console**

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MR Field Strength

- Strength of the static magnetic field for clinical MR scanners is usually in the range of 0.0064 to 3.0 T
- Measured from the center of the bore where the imaging occurs
- Systems with field strength of 3.0 T and **higher** have been approved by the FDA and these are now more common (ACR 2013)
  - Higher field strength increases the risk of injury from both static and time varying magnetic field considerations
  - There are several magnet types such as permanent, resistive, superconductive, or hybrid

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MRI Safety Credentialing Test and MRI Information for the Patient

MRI Safety Credentialing Test

- The American Board of Magnetic Resonance Safety has put together a test to make sure staff are competent about their knowledge of MRI safety
- 160 medical specialists took the first test to evaluate their knowledge in Las Vegas in June 2015
  - Radiologists, MRI technologist and medical physicists from 29 states, Canada, and Qatar
- Scheduled to be administered electronically is 2017
- Board plans to publish information about the trends in exam performance related to MRI safety

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Radiology Information for Patients

- There is a website on radiology information for patients
- It explains how MRIs and other procedures are performed
- Contains information on over 200 procedures
- Reviewed by ACR and RSNA (Radiology Society of North America)
- Has a section on MRI Safety
- Discusses what it is, how safe is it, what is used for, how to prepare for it and more

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Radiology Information for Patients

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MRI Safety Website

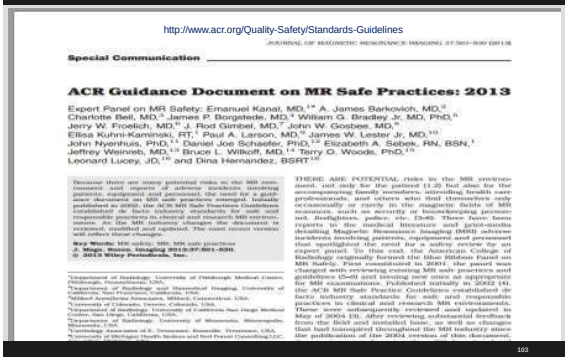
ACR MR Safe Practices

ACR Guidance on Safe MR Practices

- ACR has 29 page document called ACR Guidance Document for Safe MR Practices: 2013
  - Free on their website
  - Published in the Journal of Magnetic Resonance Imaging 37:501-530 (2013)
  - Replaces 2002 , May 2004, and June 2007 edition
  - ACR has a website on MR safety and includes MRI safety website, safety screening form, and more at www.acr.org

ACR MR Safe Practices

http://www.acr.org/Quality-Safety/Standards-Guidelines



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. Grosbee, MD,[8] Elisa 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, JD,[16] and Dina Hernandez, BSRT[16]

ACR Practice Guidelines & Standards

ACR 2013 MR Guidance

- Includes information on the 5 G line
- Need for P&P
- MRI 4 zones
- Training of those to enter MRI magnet room
- Patient and staff assessments
- What to do if a code occurs
- Fight fighters, police, and security safety considerations
- Device and object screening and more

The 5 G Line (The Safe Line)

- The distance from the MR system at which the static magnetic field is diminished sufficiently to **pose no physical threat** to the general public
- Distance from MR imager where the static magnetic field has decreased to 5 gauss
- FDA requires posting warning signs if magnetic field is more than 5 G
- MRI room is shielded to protect MR system from equipment or devices that emit frequency similar to those emitted by protons in patient's tissue

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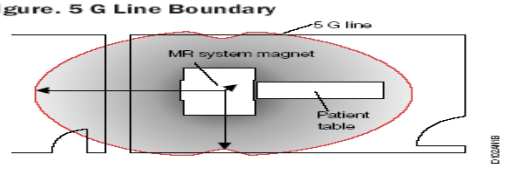
5 G Line Boundary

Figure. 5 G Line Boundary



Simplified illustration of an MR scan room showing the location of the 5 G line for one type of MR system. The 5 G line delineates the boundary between areas where the MR system's static magnetic field strength is either greater than 5 G (the field strength increases dramatically as the distance to the magnet decreases) or less than 5 G. Within the 5 G line, some objects could be pulled into the magnet, and many devices will not operate properly. (Note that the static magnetic field extends in all directions around the magnet, including above and below the system.)

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Zones in the MRI Suite

- Restrict access to the MRI site by implementing four zones
  - Provide for progressive restriction in access to the MRI scanner and discussed in ACR document
- ACR has 29 page document called ACR Guidance Document for Safe MR Practices: 2013
  - Free on their website and in Journal of Magnetic Resonance Imaging 37:501-530 (2013)
  - ACR has a website on MR safety and includes MRI safety website, safety screening form, and more at www.acr.org
  - Discusses four zones and has MRI functional diagram

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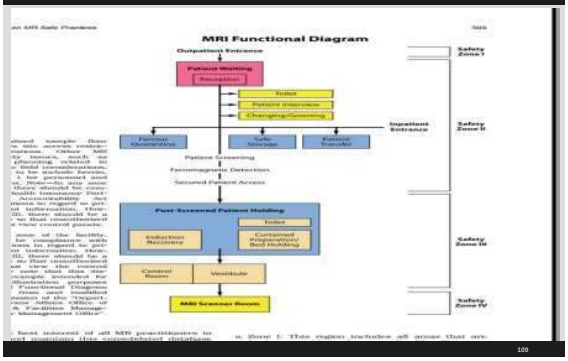
Four Zones



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ACR MR Safe Practices 2013

www.acr.org/Quality-Safety/Standards-Guidelines

Special Communication

http://onlinelibrary.wiley.com/doi/10.1002/jmri.24011/pdf

ACR Guidance Document on MR Safe Practices: 2013

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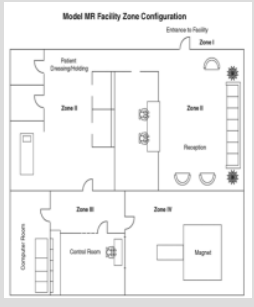
Four Zones



- Zone I: General public
- Zone II: Unscreened MRI patients
- Zone III: Screened MRI patients and personnel
- Zone IV: Screened MRI patients under constant direct supervision of trained MR personnel

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Four Zones

- **Zone II–**Unscreened MRI patients–obtain information:
  - Patients are greeted
  - Patients are not free to move throughout zone II at will
  - Answers to MR screening questions
  - Patient histories and medical insurance questions

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Four Zones

- **Zone III–**Screened MRI patients and personnel
  - Access is strictly restricted since injury can occur from ferromagnetic objects or equipment
  - Includes the control room
  - Physical restriction from general public entering
    - Key locks, passkey locking systems or other reliable system to restrict access (not combination lock)
  - Prohibit physicians, non-MR personal access until trained
  - Area where strength exceeds 5 gauss should be clearly marked

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Four Zones

- **Zone IV–**Screened MRI patients under constant direct supervision of trained MR personnel
  - This is the MRI scanner magnet room
  - Clearly marked as being potentially hazardous due to the presence of very strong magnetic field
  - Clearly marked with red light and lighted sign that says “The Magnet is On.”
    - On at all time with backup energy source in event of power loss

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Four Zones

- **Zone IV** (continued)–MR scanner room emergency
  - In case of cardiac or respiratory arrest the certified MR personnel start basic life support or CPR while patient is moved to predetermined safe location
  - Do not recommend quenching the magnet (turning magnet off) since it takes more than a minute and this could be dangerous
  - Maintain restriction to Zones III and IV during resuscitation and other emergent situations

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Types of Personnel

- There are three classifications and two levels of MR personnel
  - Non-MR personnel
  - MR personnel
    - –Level 1 MR personnel
    - –Level2 MR personnel

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Non-MR Personnel

- Any person (patient, visitor, staff, etc.) who has not completed sufficient training to qualify as either level one or level two MR personnel
  - Includes any individual who has not had the designated training in MR safety issues in past 12 months
- Must be under the immediate supervision and visual contact of a specifically identified level two MR staff member at all times when they are within MR zones III and IV

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MR Personnel

- **Level 1–**Staff, including departmental office staff and patient aides who have undergone minimal safety education efforts, sufficient to ensure their own safety as they work in Zone III areas.
  - These staff may move freely throughout all MR zones. These people cannot be responsible for non-MR personnel in Zone IV.
- **Level two–**Staff, including MR technologists, radiologists, and radiology department nursing staff, who have undergone more extensive MR safety training.
  - These staff members are also free to move throughout all MR zones.

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Level Two MR Personnel

- Must supervise and be able to visualize or talk to any non-MR person in zones III and IV
- Should be trained and educated in broader safety programs
  - Include the potential for thermal loading or burns and direct neuromuscular excitation from rapidly changing gradients
- Medical Director's job is to make sure these people have education and experience to qualify as Level two MR personnel

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Non-MR Personnel Nurse or Physician

- Any non-MR personnel, like a nurse or physician, who wants to enter Zone III must first pass an MR safety screening process
- Must be performed by the MR personnel before putting the non-MR person into Zone III
  - Like a ticket to enter
- Screening process and forms is identical for both patients and non-MR personnel
  - Then physicians and nurses can enter the bore of the MR imager during the MRI such as child who leans into the bore or anesthetist who leans into bore to bag patient if problem occurs

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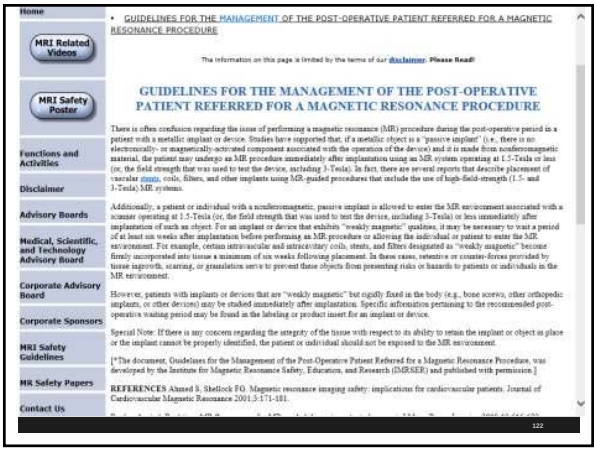
Monitoring Patients in the MRI Scanner

- Is sometimes necessary to monitor patients
- Monitoring methods should be chosen carefully
  - Concern about the risk of thermal injury associated with the monitoring equipment
- Sedated patients may not be about to tell you about any symptoms of injury
  - Potential is greater for whole body scanners of 1 Tesla and above
- Use MR conditional EKG electrodes and don't let leads touch patient during the scan
  - Ice packs or cold compresses on electrically conductive material

121



122

Screening of Non-emergent Patients

- Outpatients or patients whose conditions are not life threatening are called non-emergent
- Should be screened on site and by at least **two** separate individuals (ACR 2013)
  - At least one of these people should be Level II MR personnel
- At least one of these two screenings should be performed verbally or interactively

123

Conscious Non-emergent Patients

- Review written MR safety screening questions prior to their introduction to Zone III
- Review questions orally with patient or family
- If patient is non responsive discuss with family
- They must provide yes or no to each question
- Patient or family must sign these forms with no empty responses
  - Note: Sample pre-MR forms are provided by ACR, MRIsafety.com, www.ismrm.org, ECRI Institute, and several other sources listed in reference

124

Non-emergent Patients

- Must remove all metallic personal belongings including:
  - Jewelry, cell phones, watches, contraceptive diaphragms, body piercing (if removable), pagers, metallic drug delivery devices, hooks, zippers, metallic threads, metallic particles such as make up and eye makeup, contraceptive diaphragms, metallic drug patches, etc.
- Recommend wearing hospital gown with no metal fasteners

125

Emergency Patients

- Emergency department critically ill or ICU critical patients
  - If ED patient is unconscious and no one present to give reliable information and test is urgent then should be physically examined by level 2 MR personnel
  - Looking for scars or deformities which might indicate an implant and can x-ray unless old films are available
- Emergent patients and their accompanying non-MR personnel may be screened only once
  - Level two MR personnel should provide the screening
  - There should be no exceptions

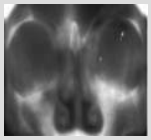
126

Safe MR Practices

- Any patient and non-MR personnel (nurses, physicians) with a history of potential ferromagnetic foreign object penetration must undergo further investigation prior to being permitted entrance to Zone III
- Investigation includes:
  - History, plain x-rays, prior CT or MR studies of the questioned anatomical area, or
  - Written documentation as to the type of implant or foreign object that might be present
- Determine MR compatibility or MR safety of the implant or foreign object

127

Safe MR Practices



- All patients with history of orbital trauma by potential ferromagnetic FB must have their orbits cleared
- This can be done by plain X-ray views of orbit films or by radiology review and assessment of contiguous cut prior CT or MR images obtained after trauma occurred

128

Metal Detectors Ferromagnetic Detectors

- ACR does not recommend metal detector use since traditional metal detectors do not differentiate between ferrous and nonferrous magnetic materials
  - They have varied sensitivity settings
  - Skills of operators can vary
- Ferromagnetic detection systems (highly developed magnetometer type instruments) are available and simple to operate
  - Capable of detecting very small ferromagnetic objects external to the patient
  - Still need to conscientiously screen the patient

129

HIPAA Privacy

- If outpatient registered in radiology department, make sure NPP is given to patient once after April 14, 2003 and again after September 23, 2013
  - Medical record information is called protected health information and must be kept confidential
  - In all four zones need to be in compliance with HIPAA
  - In Zone III, there should be a privacy barrier so unauthorized person cannot view control panels (ACR 2013)
  - If patient wants copy of MR report sent to someone outside, other than ordering physician, should sign HIPAA compliant authorization form

130

HIPAA Privacy

- If attending physician orders MRI, and neurosurgeon comes into department to see film on outpatient, staff need to see documentation of physician-patient relationship
- HIPAA security rules also apply, so keep back-up of MRIs and have adequate security
- CMS Hospital CoPs on radiology and medical records apply to all MRIs
- Patients can now sue for money damages if HIPAA violations, secretary of state can sue, HIPAA HITECH law in effect

131

MRI Safety

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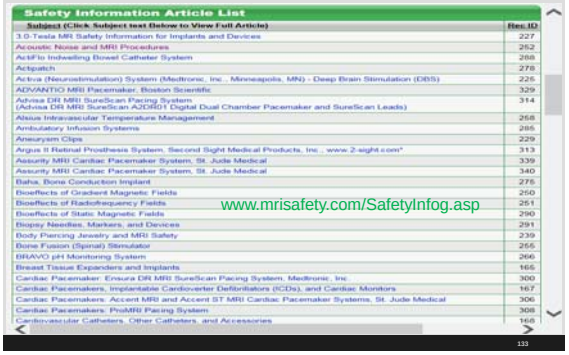
Safety Information on MRI



MRI Safety Poster

Guidelines for Screening Patients 2014

MRI Safety Poster

136

Searching the List

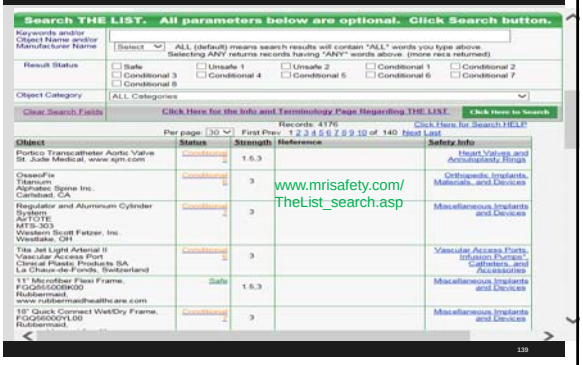
- Status of objects is listed as:
  - MR-safe, Unsafe 1 and 2, and Conditional 1 through 8
- List includes manufacturer name and object category
- Examples of objects on the list include:
  - Aneurysm clips, AccuRx implantable flow pump, cochlear implants, stents, carotid artery vascular clamps, insulin pumps, IUDs, etc.
  - If you click on insulin pumps it will show you it is in category of unsafe 1 status
    - Provides safety information and instructions on what to do

137

Search the List for MRI Safety

138

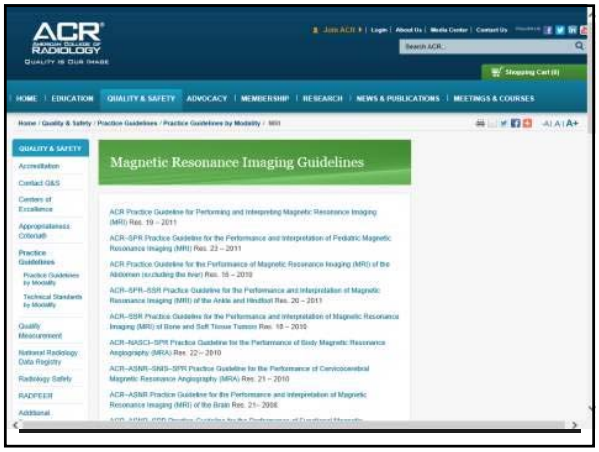
Search the List for MRI Safety



Follow ACR Guidelines and Standards 2013

- Guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients
- Guidelines are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care
- ACR cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question

Source: http://www.acr.org/, see Guidelines and Standards



ACR Guidelines and Standards Sections

- Continuing medical education
- General diagnostic radiology including:
  - Expert witness in radiology
  - Communicating findings
  - Use of intravascular contrast media
  - MRI

142

ACR Safety

- ACR has position statement on quality control and improvement, **safety, infection control**, and patient education concerns
- P&P to provide for the safety of patients and staff
- Attention to the physical environment
  - Proper use, storage, and disposal of medications and hazardous equipment
- Methods for responding to medical and other emergencies[1]

[1]ACR Guidance Document for Safe MR Practice 2013,

143

ACR Safe MR Practice

- Important document to review and every hospital should have a copy of this
- All facilities should have MR policies
  - Including clinical and research sites no matter the magnet format or field strength
- Review policy when any changes such as adding faster or stronger MRI machine
- Consider national and international standards and recommendations when drafting and updating P&P

144

ACR Safe MR Practice

- Each facility needs a Medical Director who's responsibilities include ensuring MR safe practice guidelines are established, current and followed
- All adverse events and near misses must be reported to Medical Director
  - Within 24 hours or 1 business day
  - May also need to be reported to risk management
  - CMS in hospital CoPs and TJC (LD standards) require reporting in incident reporting system
- All adverse events must be reported to the FDA via MedWatch program[1]

[1] http://www.fda.gov/medwatch/index.htmlm

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FDA MedWatch Program

www.fda.gov/Safety/MedWatch/default.htm

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ACR Safe MR Practice

- ACR supports this requirement
- If implant is strongly ferromagnetic, concern is that of magnetic translational and rotational forces upon the implant which might move or **dislodge** the device from its implanted position
- If implant demonstrated weak ferromagnetic forces on formal testing, may be prudent to wait several weeks for fibrous scarring to set in as this may anchor the implant in position

147

ACR Safe MR Practice

- It is possible to find unanticipated implant or FB during exam
- May be detected by sizable field distorting **artifact** seen on spin-echo imaging techniques that grows more obvious on longer TE studies and expands markedly on typical moderate or long TE gradient-echo imaging sequences
- Notify Medical Director, safety officer, or physician in charge of suspected findings

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ACR Safe MR Practice

- Review information and decide what course of action should be taken
- If need to remove patient go slowly in straight line
- Avoid temptation to have patient sit up as soon as out of bore
  - Wait until as far as physically possible from MRI imager

149

ACR Safe MR Practice

- Patients, volunteers, **staff**, or anyone else with implanted cardiac pacemaker, implantable cardiac defibrillator (ICD), diaphragmatic pacemaker or other electromechanically activated devices should never enter Zone IV
  - Should not go past 5 gauss line unless cleared in writing by Level 2 MR personnel, designated radiologist, or Medical Director of the MR site

150

Prisoners

- Prisoners or parolees with metallic devices such as handcuffs and shackles or RF tracking bracelets
  - RF ID or tracking bracelets interfere with MRI study and secondary image artifact
  - Bracelet can also heat up and burn the patient
  - These need to be removed before doing the test

151

Firefighters, Police, Security

- Persons who respond to an emergent call at the MR site
  - Specially designated MR personnel
  - Need to be on the site prior to the arrival of the firefighters or emergency response team
- Firefighters cannot have free access to Zones III and IV, so educate fire marshals and others in advance

152

Firefighters, Police, Security

- May train security staff to be designated as MR personnel
  - Designated person needs to be there before others show up
- In true fire, taking air tanks, crow bars, guns, and other firefighting equipment could be catastrophic
- Need clearly marked, readily accessible MR-conditional or MR-safe fire extinguishing equipment physically stored in Zone III or IV
- All conventional fire extinguishers and other firefighting equipment not tested and verified safe in the MR environment should be restricted from Zone III
  - Use this section to draft your P&P

153

MR Personnel Screening and HR

- All MR personnel must undergo an MR screening process as part of their employment interview
- MR personnel must report to the MR Medical Director any trauma, procedure, or surgery in which ferromagnetic object or device may have been introduced
- This is done to make sure it is safe for the employee to enter Zone III

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Device and Object Screening

- Don't let anyone bring in ferrous objects
- Should have access to a strong handheld magnet (over 1000 gauss) or handheld ferromagnetic detection device
- Magnet enables external and even some superficial internal testing of devices or implants
  - Presence of grossly detectable ferromagnetic attractive forces
  - Document testing and include date, time, and name of tester
  - Oxygen cylinders must be positively identified in writing as MRI safe (non-ferromagnetic and safe or conditionally safe in the MR environment) or Unsafe

155

Device and Object Screening

- Same testing for other objects such as MRI safe fire extinguishers and aneurysm clips
- All portable metallic or partially metallic objects that are to brought into Zone IV must be properly identified under current FDA labeling criteria developed by ASTM
- Remember the green safe sign on the label
- Treat a product marked as MR safe but with metal construction as suspicious

156

Device and Object Screening

- Be careful about old labeling of products with ill defined terminology
- For example, “non-magnetic,” or outdated classifications such as “MR-compatible,” should not be presumed to conform to a particular current ASTM classification
- If in doubt test it with handheld ferromagnetic detection device

157

Consent

- Patient with pacemaker or ICD that is not labeled as MR Conditional should be informed of the risk and provided informed consent
- If MRI is done on patients with these devices ACR recommends a fully stocked crash cart
- See additional detailed recommendations on page 517
- ACR also has detailed section on patients who may have an intracranial aneurysm starting on page 515

158

Screening

- Need effective screening procedure for patients before they have an MRI
- ACR has screening tool as does MRI Safety
- Should be conducted by health care worker who has been specially trained in MR safety
  - To determine if patient has an implant that may be contraindicated for the MR procedure (e.g., a ferromagnetic aneurysm clip, pacemaker, etc.)
  - To determine if there is any condition that needs careful consideration (e.g., the patient is pregnant, has a disability, etc.)

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Screening Tool MRI Safety 2014

MAGNETIC RESONANCE (MR) PROCEDURE SCREENING FORM FOR PATIENTS

Date ____/____/____ Patient Number _____

Name _____ Age _____ Height _____ Weight _____
Last name First name Middle Initial

Date of Birth ____/____/____ Male ❒ Female ❒ Body Part to be Examined _____
month day year

Address _____ Telephone (home) (____) ____-____

City _____ Telephone (work) (____) ____-____

State _____ Zip Code _____

www.mrisafety.com/SCREENING_FORM/PreScrnF.pdf

Reason for MRI and/or Symptoms _____

Referring Physician _____ Telephone (____) ____-____

1. Have you had prior surgery or an operation (e.g., arthroscopy, endoscopy, etc.) of any kind? ❒ No ❒ Yes
   If yes, please indicate the date and type of surgery:
   Date ____/____/____ Type of surgery _____
   Date ____/____/____ Type of surgery _____
2. Have you had a prior diagnostic imaging study or examination (MRI, CT, Ultrasound, X-ray, etc.)? ❒ No ❒ Yes
   If yes, please list: Body part Date Facility

MRI			
CT/CAT Scan			
X-Ray			
Ultrasound			
Nuclear Medicine			
Other			

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3. Have you experienced any problem related to a previous MRI examination or MR procedure? ❒ No ❒ Yes
   If yes, please describe: _____
4. Have you had an injury to the eye involving a metallic object or fragment (e.g., metallic slivers, shavings, foreign body, etc.)? ❒ No ❒ Yes
   If yes, please describe: _____
5. Have you ever been injured by a metallic object or foreign body (e.g., BB, bullet, shrapnel, etc.)? ❒ No ❒ Yes
   If yes, please describe: _____
6. Are you currently taking or have you recently taken any medication or drug? ❒ No ❒ Yes
   If yes, please list: _____
7. Are you allergic to any medication? ❒ No ❒ Yes
   If yes, please list: _____
8. Do you have a history of asthma, allergic reaction, respiratory disease, or reaction to a contrast medium or dye used for an MRI, CT, or X-ray examination? ❒ No ❒ Yes
9. Do you have anemia or any disease(s) that affects your blood, a history of renal (kidney) disease, renal (kidney) failure, renal (kidney) transplant, high blood pressure (hypertension), liver (hepatic) disease, a history of diabetes, or seizures? ❒ No ❒ Yes
   If yes, please describe: _____

For female patients:

10. Date of last menstrual period: ____/____/____ Post menopausal? ❒ No ❒ Yes
11. Are you pregnant or experiencing a late menstrual period? ❒ No ❒ Yes
12. Are you taking oral contraceptives or receiving hormonal treatment? ❒ No ❒ Yes
13. Are you taking any type of fertility medication or having fertility treatments? ❒ No ❒ Yes

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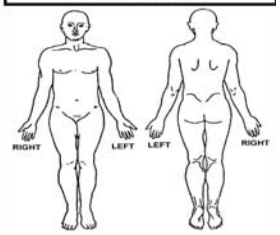
WARNING: Certain implants, devices, or objects may be hazardous to you and/or may interfere with the MR procedure (i.e., MRI, MR angiography, functional MRI, MR spectroscopy). Do not enter the MR system room or MR environment if you have any question or concern regarding an implant, device, or object. Consult the MRI Technologist or Radiologist BEFORE entering the MR system room. The MR system magnet is ALWAYS on.

Please indicate if you have any of the following:

❒ Yes	❒ No	Aneurysm clip(s)
❒ Yes	❒ No	Cardiac pacemaker
❒ Yes	❒ No	Implanted cardioverter defibrillator (ICD)
❒ Yes	❒ No	Electronic implant or device
❒ Yes	❒ No	Magnetically-activated implant or device
❒ Yes	❒ No	Neurostimulation system
❒ Yes	❒ No	Spinal cord stimulator
❒ Yes	❒ No	Internal electrodes or wires
❒ Yes	❒ No	Bone growth/bone fusion stimulator
❒ Yes	❒ No	Cochlear, otologic, or other ear implant
❒ Yes	❒ No	Insulin or other infusion pump
❒ Yes	❒ No	Implanted drug infusion device
❒ Yes	❒ No	Any type of prosthesis (eye, penile, etc.)
❒ Yes	❒ No	Heart valve prosthesis
❒ Yes	❒ No	Eyelid spring or wire
❒ Yes	❒ No	Artificial or prosthetic limb
❒ Yes	❒ No	Metallic stent, filter, or coil
❒ Yes	❒ No	Shunt (spinal or intraventricular)
❒ Yes	❒ No	Vascular access port and/or catheter
❒ Yes	❒ No	Radiation seeds or implants
❒ Yes	❒ No	Swan-Ganz or thermodilution catheter
❒ Yes	❒ No	Medication patch (Nicotine, Nitroglycerine)
❒ Yes	❒ No	Any metallic fragment or foreign body
❒ Yes	❒ No	Wire mesh implant

Please mark on the figure(s) below the location of any implant or metal inside of or on your body.



IMPORTANT INSTRUCTIONS

162

Screening

- Have P&P on screening
- Use a screening tool
- After the preliminary screening, then the patient goes through comprehensive screening
- Comprehensive patient screening uses a printed form to document this procedure
- Form includes a statement that indicates hearing protection is “advised” or “required” to prevent possible problems or hazards related to acoustic noise
- MR safety trained person reviews the form’s contents. If patient is unable to answer the questions, then discuss with closest family members.

163

Screening

- If no family members, then with person who is most likely to know the information
  - Technician can also look for scars or deformities
  - Can use ferromagnetic detectors
  - Can also use plain film radiography to assist in the screening process

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Screening Things that Create a Hazard

- Pacemaker (new pacemaker safe one)
- Implantable cardioverter defibrillator (ICD)
- Neurostimulators, tissue expanders, hearing aid
- Aneurysm clip, surgical clips, staples
- Metal implant, artificial limbs, shunts
- Implanted drug infusion device, penile implant
- Foreign metal objects, especially if in or near the eye, artificial heart valve, coils and stents
- Radiation seeds, IUD, pessary, eyelid spring

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Screening Things that Create a Hazard

- Shrapnel or bullet wounds, internal electrodes
- Permanent cosmetics or tattoos, tattooed eyeliner
- Dentures/teeth with magnetic keepers
- Other implants that involve magnets
- Medication patch (i.e., transdermal patch) that contains metal foil, cochlear implant, halo vest
- Pillows may contain metal springs
- Sandbags may contain iron pellets
- Wigs, hair implants, body piercing, surgical mesh

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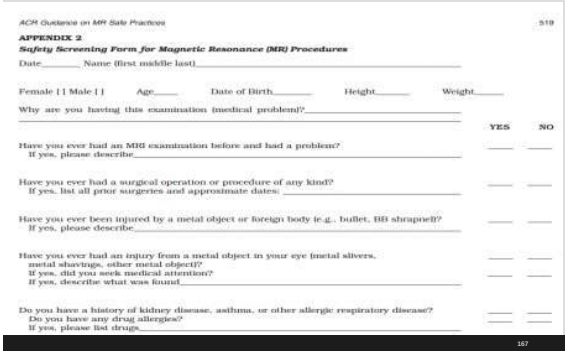
ACR Safety Screening Form 2013 Page 519



ACR Guidance on MR Safe Practices 519

APPENDIX 2

Safety Screening Form for Magnetic Resonance (MR) Procedures

Date_____ Name (first middle last)_____

Female [ ] Male [ ] Age_____ Date of Birth_____ Height_____ Weight_____

Why are you having this examination (medical problem)?_____

	YES	NO
Have you ever had an MRI examination before and had a problem? If yes, please describe_____	____	____
Have you ever had a surgical operation or procedure of any kind? If yes, list all prior surgeries and approximate dates: _____	____	____
Have you ever been injured by a metal object or foreign body (e.g., bullet, BB shrapnel)? If yes, please describe_____	____	____
Have you ever had an injury from a metal object in your eye (metal slivers, metal shavings, other metal object)? If yes, did you seek medical attention? If yes, describe what was found_____	____ ____	____ ____
Do you have a history of kidney disease, asthma, or other allergic respiratory disease? Do you have any drug allergies? If yes, please list drugs_____	____ ____	____ ____

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ACR Hazard Checklist

Do you have a history of kidney disease, asthma, or other allergic respiratory disease?
Do you have any drug allergies?
If yes, please list drugs_____

Have you ever received a contrast agent or X-ray dye used for MRI, CT, or other X-ray or study?

Have you ever had an X-ray dye or magnetic resonance imaging (MRI) contrast agent allergic reaction?
If yes, please describe_____

Are you pregnant or suspect you may be pregnant?

Are you breast feeding?

Date of last menstrual period_____ Post-menopausal?

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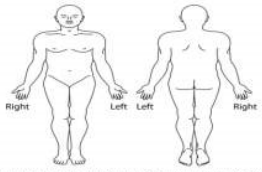
ACR 2013 MR Hazard Checklist

MR Hazard Checklist

Please mark on the drawings provided the location of any metal inside your body or site of surgical operation.



The following items may be harmful to you during your MR scan or may interfere with the MR examination. You must provide a "yes" or "no" for every item. Please indicate if you have or have had any of the following:

YES NO

___ ___ Any type of electronic, mechanical, or magnetic implant

Type_____

___ ___ Cardiac pacemaker

___ ___ Aneurysm clip

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ACR Hazard Checklist

___ ___ Implanted cardiac defibrillator

___ ___ Neurostimulator

___ ___ Biostimulator

Type_____

___ ___ Any type of internal electrodes or wires

___ ___ Cochlear implant

___ ___ Hearing aid

___ ___ Implanted drug pump (e.g., insulin, Baclofen, chemotherapy, pain medicine)

___ ___ Halo vest

___ ___ Spinal fixation device

___ ___ Spinal fusion procedure

___ ___ Any type of coil, filter, or stent

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ACR Hazard Checklist

ACR Guidance on MR Safe Practices

___ ___ Any type of metal object (e.g., shrapnel, bullet, BB)

___ ___ Artificial heart valve

___ ___ Any type of ear implant

___ ___ Penile implant

___ ___ Artificial eye

___ ___ Eyelid spring

___ ___ Any type of implant held in place by a magnet

Type_____

___ ___ Any type of surgical clip or staple

___ ___ Any IV access port (e.g., Broviac, Port-a-Cath, Hickman, Picc line)

___ ___ Medication patch (e.g., Nitroglycerine, nicotine)

___ ___ Shunt

___ ___ Artificial limb or joint

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ACR Hazard Checklist

___	___	Tissue Expander (e.g., breast)
___	___	Removable dentures, false teeth or partial plate
___	___	Diaphragm, IUD, Pessary
		Type_____
___	___	Surgical mesh
		Location_____
___	___	Body piercing
		Location_____
___	___	Wig, hair implants
___	___	Tattoos or tattooed eyeliner
___	___	Radiation seeds (e.g., cancer treatment)
___	___	Any implanted items (e.g., pins, rods, screws, nails, plates, wires)
___	___	Any hair accessories (e.g., bobby pins, barrettes, clips)
___	___	Jewelry

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ACR Safety Screening Form

Instructions for the Patients

1. You are urged to use the ear plugs or headphones that we supply for use during your MRI examination because some patients may find the noise levels unacceptable, and the noise levels may affect your hearing.
2. Remove all jewelry (e.g., necklaces, pins, rings).
3. Remove all hair pins, bobby pins, barrettes, clips, etc.
4. Remove all dentures, false teeth, partial dental plates.
5. Remove hearing aids.
6. Remove eyeglasses.
7. Remove your watch, pager, cell phone, credit and bank cards and all other cards with a magnetic strip.
8. Remove body piercing objects.
9. Use gown, if provided, or remove all clothing with metal fasteners, zippers, etc.

I attest that the above information is correct to the best of my knowledge. I have read and understand the entire contents of this form, and I have had the opportunity to ask questions regarding the information on this form.

Patient signature_____

MD/RN/RT signature_____ Date_____

Print name of MD, RN, RT_____

For MRI Office Use Only

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MRI Staff Verification ACR

For MRI Office Use Only

Patient Name_____

Patient ID Number_____ Referring Physician_____

Procedure_____ Diagnosis_____

Clinical History_____

Hazard Checklist for MRI Personnel

YES	NO	
___	___	Endotracheal tube
___	___	Swan-Ganz catheter
___	___	Extra ventricular device
___	___	Arterial line transducer
___	___	Foley catheter with temperature sensor and/or metal clamp
___	___	Rectal probe

174

Ferromagnetic Objects

- It is important to be aware of common ferromagnetic objects
- Buffing machines, janitor buckets, chest tube stands, and clipboards (patient charts), chairs, canes
- Gurneys, hairpins, hearing aids, identification badges, walkers
- Insulin pumps, keys, and medical gas cylinders, mops, IV poles

175

Ferromagnetic Objects

- Nail clippers and nail files, oxygen cylinders, pulse oximeter, pacemakers, and pagers
- Paper clips, jewelry, pens, and pencils
- Prosthetic limbs, shrapnel, sandbags (with metal filings)
- Steel shoes, stethoscopes, scissors, staples, and tools
- Vacuum cleaners, watches, and wheelchairs

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Pregnancy

- No harmful effects on the fetus have been demonstrated–does not use ionizing radiation
  - As precaution, pregnant women should only have MRI when essential
  - If they can wait until the end of pregnancy to have test, that is recommended
- Gadolinium is known to cross the placenta and enter fetal bloodstream, so contrast is not routinely provided if patient is pregnant
- Pregnant staff can work in and around MRI suite but asked not to remain in MRI scanner bore or Zone IV during actual scanning

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Pregnancy

- Determine if patient could have an ultrasound instead
- Despite concerns, MRI is growing in importance in diagnosing congenital defects of the fetus and open fetal surgery
- Look at risks verses benefits, give informed consent
- Level 2 MR personnel, designated attending radiologist, can decide the study is warranted

178

Pregnancy

- Document in the medical record
  - Radiologist should confer with the referring physician
- Include the following information:
  - Cannot be acquired through non-ionizing means such as by an ultrasound
  - Data is needed to affect care of patient or fetus, and
  - Referring physician does not feel it is prudent to wait

179

Sedation and Monitoring Issues

- Children form the largest group requiring sedation for MRI
  - Many are unable to stay still
- Sedation protocols vary among facilities
- CMS has anesthesia standards which discuss moderate sedation and deep sedation
  - VA has moderate sedation toolkit at www.patientsafety.gov
- Parent to accompany child must be screened
  - Use hearing protection

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Pediatric MR Safety Sedation & Monitoring

- There is a section on pediatric safety that any hospital that does MRIs on pediatric patients should read
- Should be incorporated into P&P
- Need to follow standards from the American Academy of Pediatrics, American Society of Anesthesiologist and TJC
- Fasting requirements, H&P, training and credentialing for staff, monitoring during and after procedure, observe child, charting, protocol for recovery and discharge, etc.

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Claustrophobia

- Being in center of long narrow tube can be unpleasant and some patients are claustrophobic
  - Open MRIs and upright MRIs are an option
  - New scan rooms being developed with lighting, sounds and images on wall or ceiling
- Sedation or general anesthesia can be used
- Visualization or imagery techniques may help
- Holding panic button and listening to music on headphones, or watching a movie with head mounted displays while in MRI machine may ease stress

182

Disadvantages

- If sedation used follow TJC, ASA, and ACR recommendation
- Discuss issue of claustrophobia and hazards
  - Normally 20-30 minutes long but can take 60 minutes
  - Required to stay still and in an enclosed space can be hard for pediatric patients
- Movement can create motion artifact
  - Includes patients with tremors like Parkinson's disease or low back pain
  - Patients with pain can be instructed to take pain medication prior to the procedure

183

Thermal Issues

- Remove any unnecessary equipment
  - Unplugging unnecessary equipment is not enough
  - Electric current or voltage can be induced in electrically conducting materials
  - Can create heat which can result in a burn
  - MR tech must check all equipment first

184

Thermal Issues Burns

- If wires or leads have to remain on patient, take care that there are no large caliber conducting loops formed in the scanner
- Several cases reported of coma and permanent impairment in patients with neurologic stimulators
- Make sure there is insulation between the patient and the electrically conductive material (pads or air)

185

Thermal Issues

- Position leads or wires as far as possible from the inner walls of the scanner
  - If leads directly contact the patient, put cold compresses or ice packs to the area
- Make sure patients tissues and skin do not come into contact with the inside (bore) of the MR machine
- Make sure no loop so patient should not cross legs or arms

186

Thermal Issues

- Skin staples and superficial metallic sutures are okay if not ferromagnetic and not in anatomical volume of RF power deposition
  - Take several precautions if skin staples are ferromagnetic
  - Warn patient about warmth and may experience some burning along staples
  - Can place cold compresses or ice pack along skin staples or superficial metallic sutures

187

Thermal Issues

- Notify tech immediately of heat
  - Do not wait until end of test
  - Use cold compress or ice bags at site
- Use ice packs for dark tattoos, including permanent eyeliner
- Procedure can smear or smudge edges if new tattoo
- Drug delivery patches and pads with metallic foil can result in a burn
- Ice bag put on patch can affect delivery of medication

188

Education of Staff

- Provide education during orientation and annually for all staff who will be involved with MRIs
- Consider annual training during skills lab
- Don't forget to train on all the things listed in TJC standards and document
- Include environmental services (housekeeping) personnel, maintenance, transport, surgical, and emergency response teams for RRT and codes

189

MR Technologists

- MR technologist should be ARRT (American Registry of Radiologic Technologists)– registered technologist
- All MR tech should be trained as Level 2 MR personnel during orientation
- All MR techs need BLS certification
- Have a minimum of two MR techs, or one MR tech and one other individual, with designation of MR personnel for all zones, except for emergent coverage

190

SUBJECT: MRI SAFETY EFFECTIVE DATE: March 2007
REVISED DATE: 2008
Supersedes Page 1 of 3

APPROVED BY: Imaging Director **DATE:** March 2008

POLICY: Access to all MRI sites will be restricted to maintain the safety of the general public and staff.

PURPOSE: To designate appropriately trained MRI staff and the procedure for training and the safe utilization of Magnetic Imaging equipment.

PROCEDURE:

1. Restrict access to all MRI sites by four zone as defined in the ACR Guidance Document for Safe MR Practices: 2007.
   - Zone I: General public areas. This will be the Waiting Rooms and Business office areas.
   - Zone II: Unscreened MRI patients and personnel. This is the Interview & Education areas.
   - Zone III: Screened MRI patients and personnel This is the entrance or Control Room before entering the scan room.
   - Zone IV: Screened MRI patients and staff under constant direct supervision of trained

MRI Safety Policy

2. MRI patients are requested to complete a questionnaire which the MRI technologist screens and checks for accuracy by reviewing the patient's history. The MRI technologist performs the interview with all patients. This provides two separate opportunities for patients to answer questions about any metal objects they may have on them, any implanted devices, drug delivery patches, tattoos, and any electrically, magnetically, or mechanically activated devices they may have. If the patient is unconscious or unable to answer questions, the patient's family member or personal representative is questioned. If this person is unsure, other means are used to determine if the patient has implants or other devices that could be negatively affected by the MRI scan (e.g., look for scars or deformities, scrutinize the patient's history, use plain-film radiography, use ferromagnetic detectors to assist in the screening process, etc.). The MRI technologist should have the patient's complete and accurate medical history to ensure that the patient can be safely scanned. All implants should be checked against product labeling or manufacturer literature specific to that implant, or peer-reviewed published data regarding the device or implant in question. Technologists will be provided with ready access to this information by use of the internet. Specially trained staff person who is knowledgeable about the MRI environment will accompany any patients, visitors and other staff who are not familiar with the MRI environment inside the MRI suite at all times.
3. All medical and ancillary staff that may be expected to accompany patients to the MRI suite will have annual safety education about the MRI environment.
4. All staff and patients and their families will be provided with appropriate Education, signage, and information that explain the potential for accidents and adverse events in the MRI environment.

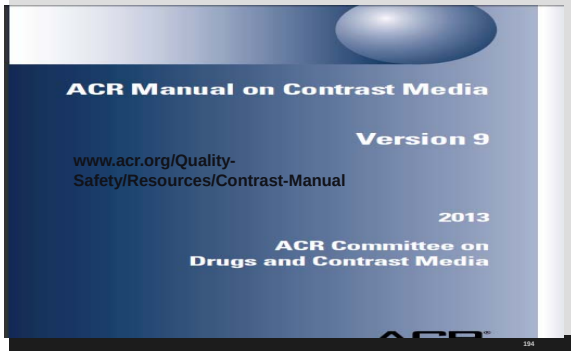
192

Contrast

- No patient should be given contrast without a physician order (ACR 2013)
  - ACR MR Guidelines refer to ACR Contrast Manual-the ACR Committee on Drugs and Contrast Material
- IV injection qualified MR technologists may start a peripheral IV if had the training and are competent
  - Make sure that the state scope of practice is consistent
- IV qualified MR technologists (certified and or licensed) or radiologic nurse may administer gadolinium based contrast in peripheral IV or as bolus
  - Must have and follow the P&P and should be consistent with the ACR policy

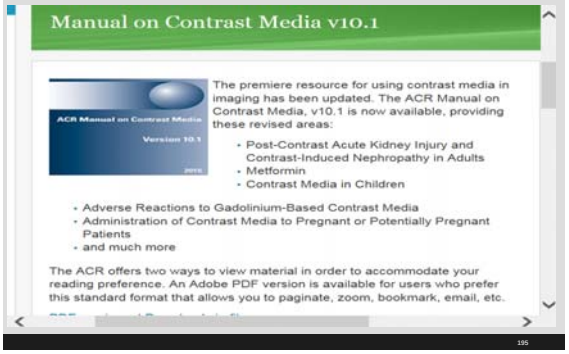
193

ACR Contrast Manual



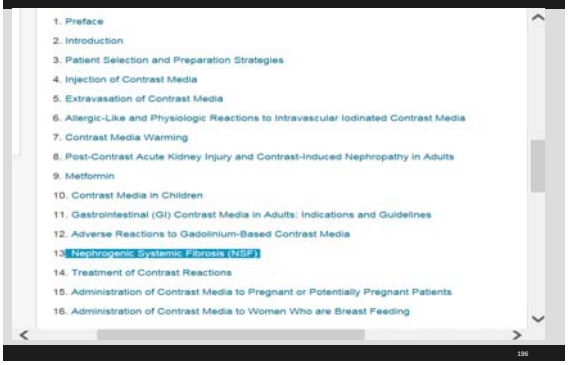
194

ACR Contrast Manual 2015



195

ACR Contrast Manual 2015



196

Contrast Media-Induced Renal Failure

- Utilize validated protocols to evaluate patients who are at risk for contrast media-induced renal failure
- Use a clinically appropriate method for reducing risk of renal injury based on the patient's kidney function evaluation
- Angiography, IVP, and CT scans that use contrast material containing iodine
  - Can have allergic reaction or kidney damage
  - Be careful in patients with renal impairment
  - Do RCA on all cases of contrast media induced renal failure

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Contrast Media-Induced Renal Failure

- Recommendations to prevent contrast media-induced renal failure
  - Make sure patient is adequately hydrated
  - Use low osmolality contrast (LOCM) in patients with renal failure
  - Check serum creatinine or eGFR (best) level prior to scheduling contrast studies
  - See ACR manual on Contrast Media 2015 for the use of intravascular contrast media
    - States patients scheduled for routine intravascular study who do not have risk factors identified on page 37 and 38 do not need baseline creatinine before iodinated contrast

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ACR Guidelines on Contrast Media

Revised 2007 (Res. 38)*

ACR PRACTICE GUIDELINE FOR THE USE OF INTRAVASCULAR CONTRAST MEDIA

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations on available resources, or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to

Therefore, it should be recognized that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

This guideline has been developed to promote the safe and effective administration of intravascular contrast media used for imaging studies.

Intravascular contrast media are used for a wide variety of imaging studies. The majority of intravascular contrast-enhanced imaging examinations involve iodinated contrast media, but other contrast media may be used for magnetic resonance imaging (MRI), ultrasonic imaging, and angiography.

II. GOAL

The goal of radiologists and other personnel

www.acr.org/SecondaryMainMenuCategories/quality_safety/RadSafety.aspx

199

Contrast Media-Induced Renal Failure

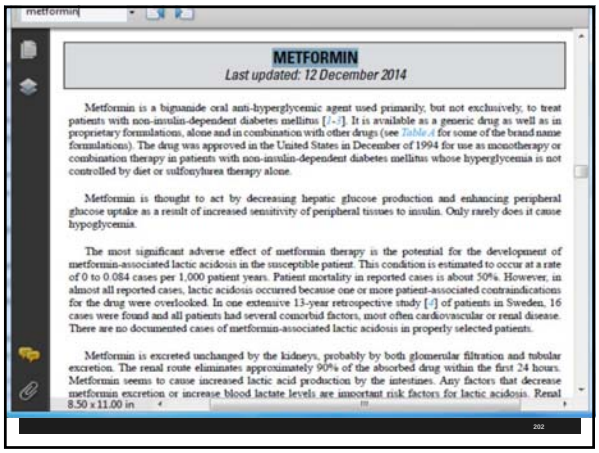
- Recommendations to prevent contrast media-induced renal failure (continued)
  - Need P&P on prevention of contrast media induced nephropathy
  - Document contrast media-induced renal failure assessment regarding its prevention
  - Double check order and make sure most current creatinine level is used

200

IV Contrast on Diabetic Patients

- Have a process for diabetics on Metformin with **abnormal** renal function or co-morbidity
  - Do you hold the medication temporarily (48 hours) if intravascular iodinated contrast is used in category II patients to prevent lactic acidosis?
  - Do you order a serum creatinine two days after the CT in category II patients?
  - Do you then notify the attending office to let the patient know to restart their medication?
- ACR also has Manual on Contrast Media

201



METFORMIN

Last updated: 12 December 2014

Metformin is a biguanide oral anti-hyperglycemic agent used primarily, but not exclusively, to treat patients with non-insulin-dependent diabetes mellitus [1–3]. It is available as a generic drug as well as in proprietary formulations, alone and in combination with other drugs (see *Table A* for some of the brand name formulations). The drug was approved in the United States in December of 1994 for use as monotherapy or combination therapy in patients with non-insulin-dependent diabetes mellitus whose hyperglycemia is not controlled by diet or sulfonylurea therapy alone.

Metformin is thought to act by decreasing hepatic glucose production and enhancing peripheral glucose uptake as a result of increased sensitivity of peripheral tissues to insulin. Only rarely does it cause hypoglycemia.

The most significant adverse effect of metformin therapy is the potential for the development of metformin-associated lactic acidosis in the susceptible patient. This condition is estimated to occur at a rate of 0 to 0.084 cases per 1,000 patient years. Patient mortality in reported cases is about 50%. However, in almost all reported cases, lactic acidosis occurred because one or more patient-associated contraindications for the drug were overlooked. In one extensive 13-year retrospective study [4] of patients in Sweden, 16 cases were found and all patients had several comorbid factors, most often cardiovascular or renal disease. There are no documented cases of metformin-associated lactic acidosis in properly selected patients.

Metformin is excreted unchanged by the kidneys, probably by both glomerular filtration and tubular excretion. The renal route eliminates approximately 90% of the absorbed drug within the first 24 hours. Metformin seems to cause increased lactic acid production by the intestines. Any factors that decrease metformin excretion or increase blood lactate levels are important risk factors for lactic acidosis. Renal

8.50 x 11.00 in

202

Metformin and Gadolinium

It is not necessary to discontinue metformin prior to gadolinium-enhanced MR studies when the amount of gadolinium administered is in the usual dose range of 0.1 to 0.3 mmol per kg of body weight.

Table A: **Medications containing metformin***

Generic Ingredients	*Trade names*
Metformin	Glucophage
	Glucophage XR
	Fortamet
	Glumetza
	Riomet
Glyburide/metformin	Glucovance
Glipizide/metformin	Metaglip
Pioglitazone/metformin	ActoPlus Met
	ActoPlus Met XR
Repaglinide/metformin	Prandimet
Rosiglitazone/metformin	Avandamet
Saxagliptin/metformin	Kombiglyze XR
Sitagliptin/metformin	Janumet
	Janumet XR

(Metformin and several of the combination drugs also available in generic versions)

203

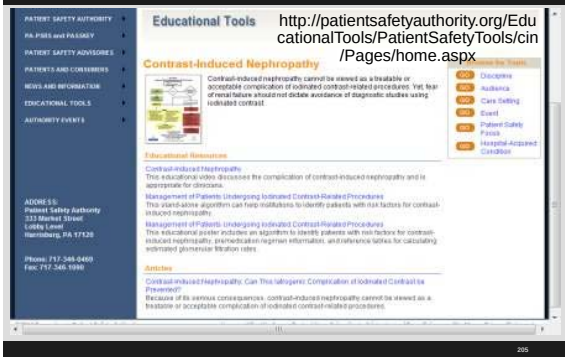
Contrast Induced Nephropathy CIN

- Kidney failure can occur from iodine dye used for x-rays (70 reports)
  - Hospitals should amend informed consent to include this information
  - 10-12 percent of all renal failure cases from CIN
  - Most common in patients with known history of renal failure or impairment
- Consider doing a FMEA
  - **Toolkit** available[1]

[1]http://www.patientsafetyauthority.org/EducationalTools/PatientSafetyTools/cin/Pages/home.aspx

204

Contrast Induced Nephropathy Toolkit



http://patientsafetyauthority.org/EducationalTools/PatientSafetyTools/cin/Pages/home.aspx

205

Toolkit

- Toolkit includes the following:
  - A copy of the advisory
  - Brief informational video on CIN
  - Stand alone algorithm to identify patients at risk for CIN
  - Poster
  - Reference tables for calculating estimated glomerular filtration rate

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Toolkit

- Discuss with patients the increased risk with:
  - Nephrotoxic drugs such as chemo
  - Certain antibiotics
  - NSAID
  - Acyclovir
  - Immunosuppressants
  - ACE inhibitors
  - Lasix
  - Lithium
  - Oral phosphate bowel cleansing products

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Gadolinium Based Contrast

- Gadolinium is a clear, non-radioactive liquid, approved by the FDA as an injectible contrast agent used during MRI
  - Provides better contrast between healthy and unhealthy tissue
  - Can cause nephrogenic systemic fibrosis
- Screen all patients for renal dysfunction
- Gadolinium is a clear, non-radioactive liquid, approved by the FDA as an injectible contrast agent used during MRI

208

Gadolinium Based Contrast

- Be aware of BUN and creatinine when ordering Magnetic resonance angiography (MRA) that requires IV contrast
  - Use MRI to take pictures of blood vessels
  - Dose for MRA may be 3x higher than dose for MRI
- If patient being dialyzed, do immediately after test
  - Patients with severe renal impairment at risk for NSF
  - Do not exceed recommended dose of GBCA
  - Risk is 4 percent in this population

209

Gadolinium Based Contrast

- Consider adding to Informed Consent
- FDA says risk for mild to moderate renal insufficiency is unknown but no reported cases
- New box warning now
- Affects mostly middle aged patients

210

FDA Gadolinium Bases Contrast

www.fda.gov/Drugs/DrugSafety/PostmarketDrugSafetyInformationforPatientsandProviders/ucm142882.htm

211

Gadolinium Based Contrast

- NSF (nephrogenic systemic fibrosis) is a debilitating and sometimes fatal disease affecting skin, muscles, and internal organs
- Diagnosis is confirmed by skin biopsy (thickened collagen bundles with surrounding clefts, mucin deposition, and proliferation of fibroblasts and elastic fibers)
- Linked to patients with moderate or end-stage kidney disease
- Note picture characterized by thickening, indurations, and hardening of the skin and distinct nodules can also be seen

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Gadolinium Based Contrast

- Symptoms can include hardening of skin, discoloration, burning, itching, joint pain and stiffness, hip pain, scarring of body organs, muscle weakness, difficult to bend joints, and death
  - Usually develops two to four weeks, but can develop two to three months after MRI
  - No known cure
- Multiple sites for law firms advertising that patients may be entitled to compensation and offering free case review

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International Center

The International Center for Nephrogenic Systemic Fibrosis Research (ICNSFR)

Last Updated June 27, 2011

Recent updates are indicated in red.

This site can be accessed at the following URL: http://www.icnfdr.org

By Sharon E. Cowper, MD
Associate Professor of Dermatology and Pathology
Yale University

Newly available:

Dr. Cowper's NSF Blog

What is NSF? | Links | Timeline | The "Center" | The NSF Registry at Yale | The NSF Support Group | Gifts of Support for NSF Research | Contact Information | References | Article Summaries | Citing this webpage | Images | Message from Dr. Cowper | FAQ

Original Case Definition

Patients who have developed large areas of hardened skin with slightly raised plaques, papules, or confluent papules, with or without pigmentary alteration and/or with biopsies showing increased numbers of fibroblasts, alteration of the normal pattern of collagen bundles seen in the dermis, and often increased dermal deposits of mucin.

Updated Case Definition

A multidisciplinary team of clinicians and dermatopathologists highly experienced in nephrogenic systemic fibrosis has recently completed a clinicopathological definition of NSF. This definition relies upon a combination of clinical and pathological findings derived from the study of numerous patients, the relevant medical literature, and histological slides and data contained within the Yale NSF Registry to create a reproducible diagnostic and work-up scheme for putative cases of NSF. The definition is currently under peer review, and once published, will be reproduced in some form on this website for the use of clinicians and pathologists.

http://www.icnfdr.org/

214

Summary

- Make sure you have a copy of the ACR MR Guidance Document
- Make sure your P&P is consistent with this document
- Keep door to Magnet room closed and limit and monitor access to MRI suite
- Test all items for ferromagnetic properties before taking them into the MRI room
- **Label** ferrous items that remain in the hospital so everyone knows they cannot be taken into the room
  - Such as sandbags

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Summary

- Do pocket check before entering, especially for scissors, hemostats, and pens
- Need to review policy and procedure annually
- Consider education on MRI safety in orientation and during annual skills lab
- Provide formal training for all who enter, including nursing, transport, security, environmental services, maintenance, etc.
- Any nurses or physicians or other staff who enter MRI must be screened

216

Summary

- Routinely access compliance with these policies and procedures, especially housekeeping and maintenance and security
- Have special MRI safe equipment for use in MR room such as **IV pole,** oxygen canister, fire extinguishers, monitors, wheelchair, etc. and have them marked for use in MRI room
- Provide all patients with hearing protection

217

Summary

- Don't make assumptions about equipment such as sand bags and pillows being safe
  - Check them out
- Report all incidents to the FDA MedWatch program
- Never code a patient in the MRI suite
- If you buy a new MRI or upgrade the system make sure the label of "MR Conditional" still applies

218

Summary

- Always assume MR system's static magnetic field is on
- Identify 4 zones in the MRI suite and surrounding floors
  - Include adjacent floors where magnetic field exceeds 5 gauss
- Consider doing a FMEA or RCA if event occurs
- Check sedated patients periodically for heating at sensor site

219

Summary

- Don't allow equipment and other devices past the 5 G lines unless tested by the device manufactures
- Make sure these devices are labeled "MR safe" (see book at end and website with list of more than objects and implants tested at 3-Tesla or higher)[1]
- Audit compliance with policy

[1] http://www.mrisafety.com/list.asp

220

Summary

- Provide patient information booklet on MRI[1]
  - Explain it is vital to remove all metallic objects in advance of the MRI exam
  - Explain that scanner can dislodge clip from blood vessel, cause heart pacemaker to malfunction, or damage their external hearing aid

[1] http://www.mrisafety.com/safety_article.asp?subject=170

221

Summary

- Use a MRI screening form to ask about things that might cause a health risk or interfere with imaging
  - Refer MRI screening form on an annual basis for anything that needs to be added or amended
- Remove patches that contain metal before the MRI and if unsure remove patch

222

Summary

- Make sure MRI procedure is pre-certified if patient has insurance
  - Document information in medical record
- Remember to use an ABN if no medical necessity
  - Check with physician for acceptable ICD code or necessity first
- Patients should wear hospital gown without metallic snaps

223

Summary

- Have piped medical gases in MR room
  - Will help prevent oxygen tanks from being brought in
- Don't loop cables or allow cables to cross one another and use MR compatible cables when conducting an MRI
- Don't let patients touch the wall of the magnetic bore

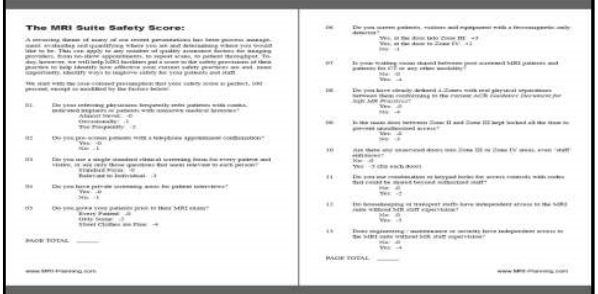
224

Summary

- Assign a MR safety officer
  - Review the P&P yearly
  - Ensure staff are trained
- Empower MR technicians to have control over access to MR environment
- Screen all personnel coming into MR environment

225

MRI Safety Calculator


The MRI Suite Safety Score:

www.mri-planning.com/jcr/MRI_Suite_Safety_Calculator_booklet.pdf

226

The End! Questions??

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President Patient Safety and Healthcare Education

Board Member
Emergency Medicine Patient Safety Officer

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NQF 34 Safe Practices

- Updated list in 2010 and 2011 on 34 Safe Practices for Better Healthcare
- Audit with changes 2014
- Should be followed in all health care facilities to reduce risk of harm to patients
- Organized into seven sections
- Includes list of **29 never events** that many states require to be reported (2011 NQF changed and updated the list)

228

Resources on 34 Safe Practices

- NQF has an electronic copy of the book that can be purchased for $29.99[1]
  - NQF, publication unit, 601 Thirteenth Street, NW, Suite 500 North, Washington, DC, 2005[2]
- **TMIT** has a website and you can listen to past presentations[3]

[1] http://www.nqfstore.org/store/

[2] www.qualityforum.org

[3] http://www.safetyleaders.org or http://www.tmit1.org/pages/workshopsWebinars.jsp

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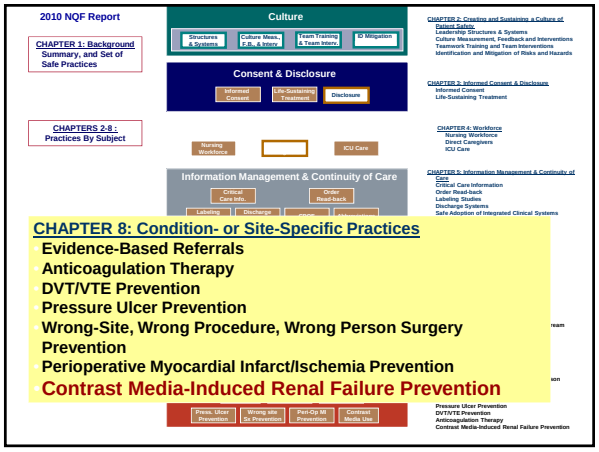

What Does MR Safe Mean?

- New classification system in 2006 was developed by ASTM International and supported by FDA
- Terminology from ASTM International
  - Old name was the American Society for Testing and Materials
  - Easy to remember because they are like colors of street light, green is go, red is stop
- New MR safe and old MR safe terms have very different meanings

231

What Does MR Safe Mean?

- MR safe refers to an item that poses no known hazards in all MRI environments
- MR Safe means the device or implant is completely non-magnetic, non-conducting, and non-RF reactive, eliminating all primary potential threats during MRI procedure
- Categories include MR safe, MR-Conditional, and MR-Unsafe
- This is the MR safe sign

232

MR Conditional

- MR Conditional refers to a device or implant that may contain magnetic, electrically conductive, or RF-reactive components that are safe for operations in proximity to the MRI
  - Provided that conditions for safe operation are defined and observed
  - Tested safe to 1.5 teslas, or safe in magnetic below 500 gauss in strength
  - RF is radio frequency–can heat the body
- Yellow sign in the MR conditional sign

233

MR Conditional

- Safety of the device is conditioned on a specific MR environment
- Device may not be MR conditional with more powerful or upgraded MR systems
- Object may or may not be safe for the patient undergoing an MR procedure, levels 1-7
  - Depending on the specific condition present
- Information is in subcategories to indicate the specific recommendation

234

MR Conditional

- Conditional 1–Object is acceptable for patient in MR environment, despite fact it showed positive findings for magnetic field interaction
  - Object is considered to be weakly ferromagnetic
- Conditional 7–Device is not intended for use during MR procedure

235

Unsafe

- **Unsafe–**Reserved for objects that are significantly ferromagnetic and pose threat to person and equipment in room
  - Unsafe in any MR environment
- **Unsafe 1–**The object is considered to pose a potential or realistic risk or hazard to a patient or individual in the MR environment, primarily as the result of movement or dislodgement of the object
  - Contraindicated for MRI
  - Note that the "default" static magnetic field strength for an unsafe implant or device is 1.5-Tesla

236

Unsafe 2

- Object displays only minor magnetic field interactions which, in consideration of the in vivo application of this object, is unlikely to pose a hazard or risk in association with movement or dislodgment
  - Presence of this object is considered to be a contraindication for an MR procedure
  - Represents potential risks such as excessive heating or other potentially hazardous conditions
    - Example: Swan-Ganz catheter melted in patient during MRI

237

Resources

- MRI safety website at www.mrisafety.com
- Cost of MRI accidents at http://www.mri-planning.com/accidents.html
- Reference Manual for Magnetic Resonance Safety, Implants and Devices, 2008 edition at above website
- The Joint Commission Sentinel Event Alert 38, Issued February 14, 2008, Preventing Accidents and injuries in the MRI Suite, at www.jointcommission.org

238

Resources

- Emanuel Kanal MD, Magnetic Resonance Safe Practice Guidelines of the University of Pittsburgh Medical Center, 2001, at http://www.jointcommission.org/NR/rdonlyres/8EFBFDA8-81A4-4F8C-9A14-07D1CBD55674/0/UPMC_Guidelines.pdf
- Safety Concerns in the MR Environment, Healthcare Risk Control Analysis, March 2006, ECRI Institute, Vol. 4, Radiology 5, 20 pages
- Wikipedia, MRI at http://en.wikipedia.org/wiki/MRI

239

Resources (continued)

- "Fatal MRI Accident is First of Its Kind," www.webmd.com/content/Article/34/1728_85340.htm
- ACR Guidance Document for Safe MR Practices: 2007, AJR:188, June 2007, http://www.acr.org/SecondaryMainMenuCategories/quality_safety/MRSafety/safe_mr07.aspx
- "Ensuring Safety for Infants Undergoing Magnetic Resonance Imaging," *Medscape*, http://www.medscape.com/viewarticle/499273

240

Resources (continued)

- "Projectile Cylinder Accidents Resulting from the Presence of Ferromagnetic Nitrous Oxide or Oxygen Tanks in the MR Suite," AJR:177, July 2001
- Radiographic Imaging CEU Source, LLC, Part 6, MRI Safety For Health Care Personnel

241

Resources (continued)

- "What's New in MR Safety," *Health Devices*, Vol. 34, No. 10, October 2005, ECRI. Includes a "Starter List of Devices and Equipment for Use in the MR Environment." www.ecri.org
- CDRH Draft Document: "A Primer on Medical Device Interactions with Magnetic Resonance Imaging Systems" http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm107721.htm

242

Resources (continued)

- "CDRH Guidance for Testing MR Interaction with Aneurysm Clips, Draft Document" http://www.fda.gov/
- ASTM F2052-00 Standard Test Method for Measurement of Magnetically Induced Displacement Force on Passive Implants in the Magnetic Resonance Environment
- ASTM F2119-01 Standard Test Method for Evaluation of MR Image Artifacts From Passive Implants at www.astm.org (standards can be purchased)

243

Resources (continued)

- MR-Technology information portal at http://www.mr-tip.com/serv1.php?type=welcome and this has links to more than 2100 publications
- Thomas, S. and Kanal, E., "Ferromagnetic Detector to Screen Patients for Metallic Foreign Bodies Prior to MR Imaging," Abstract presented at the American Society of Neuroradiology annual meeting in Toronto, May 2005, http://www.koppdevelopment.com/articels/abstract.htm

244

Resources (continued)

- American Society of Testing and Materials F 2503-05, *Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment*
- VA National Centers for Patient Safety MR Hazard Summary and MR Hazard Summary—August 2001 Update, www.patientsafety.gov/SafetyTopics/mrihazardsummary.html

245

Resources (continued)

- "Burns in MRI Patients Wearing Transdermal Patches," *ISMP Medication Safety Alert!*®, April 8, 2004, www.ismp.org/Newsletters/acutecare/articles/20040408.asp?ptr=y
- MRI screening form at MRIsafety.com or at www.imrser.org and www.acr.org
- MRI screening tool in ACR 2007 document above
- MRI safety checklist at http://mnrad.com/DOCS/MNRMRISafetyForm.pdf

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Resources (continued)

- MRI safety at GE website at http://www.gehealthcare.com/usen/mr/mrsafety/index.html
- ECRI Hazard Report, Patient Death Illustrates the Importance of Adhering to Safety Precautions in Magnetic Resonance Environments
- Sawyer-Glover A, Shellock FG. Pre-MRI procedure screening: recommendations and safety considerations for biomedical implants and devices. J Magn Reson Imaging 2000;12: 92-106

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Resources (continued)

- International Society for Magnetic Resonance in Medicine (ISMRM) at www.ismrm.org
- American College of Radiology at www.acr.org
- FDA Public Health Advisory on Nephrogenic Systemic Fibrosis (NSF) or Nephrogenic Fibrosing Dermopathy (NFD) at http://www.ismrm.org/
- Shellock FG, Crues JV. MR procedures: biologic effects, safety, and patient care. Radiology, 2004;232:635-652

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Resources (continued)

- Shellock FG, Kanal E. SMRI Report. Policies, guidelines and recommendations for MR imaging safety and patient management. Questionnaire for screening patients before MR procedures. J Magn Reson Imaging 1994;4:749-751, 1994
- Strokowski, Laura, Undergoing Magnetic Resonance Testing, Advances in Neonatal Care, Vol. 5, No. 1 (February), 2005; pp 14-27

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Resources (continued)

- Okada S et al. Safety of gadolinium contrast agent in hemodialysis patients. Acta Radiol 2001; 42(3): 399-341
- FDA Public Health advisory on NSF at http://google2.fda.gov/search?q=Gadolinium+based+contrast&client=FDAgov&site=FDAgov&lr=&proxystylesheet=FDAgov&output=xml_no_dtd&getfields=*&x=21&y=14
- FDA information for healthcare professionals at http://www.ismrm.org/special/FDA%20gadolinium1206.pdf

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Resources (continued)

- American Society for Healthcare Engineering's monograph *Designing and Engineering MRI Safety*, the Department of Veterans Affairs *MRI Design Guide* (see http://www.Mednovus.com/downloads/Who_recommends_FMD.pdf
- MR Hazard Summary, MR Primer,VA National Center for Patient Safety at http://www.patientsafety.gov/SafetyTopics/mrihazardsummary.html

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Lenz's Forces

- Heinrich Lenz formulated this law in 1834
- Lenz's law was a physical interpretation of Faraday's law of induction
- Lenz's law states that the induced current in a loop is in the direction that creates a magnetic field that is parallel to the change in magnetic flux through the area enclosed by the loop. That is, the induced current tends to keep the original magnetic flux through the field from changing
- It is principle of the conservation of energy

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Lenz's Forces (continued)

- To see why, move a magnet toward the face of a closed loop of wire
- And electric current is induced in the wire because the electrons within it are subject to an increasing magnetic field as the magnet approaches
- This produces an electromagnetic field that acts upon them
- Direction of current depends on whether north or south pole of magnet is approaching (north pole is anti clockwise and south pole is clockwise)

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Lenz's Forces (continued)

- If you take a coil and connect it to make a loop to the permanent magnet like short circuiting the coil
- Basically the coil affects the magnetic field
- For an easy to see video on this go to http://msdaif.googlepages.com/demo_lenz
- The second object basically generated its own magnetic force

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Lenz's Forces (continued)

- Thus, moving a large metallic but non-ferromagnetic electrical conductor toward the magnet bore will result in the induction of a voltage and associated magnetic field
- If, for example, one tries to move a nonferrous oxygen tank into the bore of an MR scanner, as the scanner bore is approached, Lenz's forces will be sufficiently strong to virtually stop forward progress of the tank

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Lenz's Forces (continued)

- Further, the faster one moves the tank into the bore, the greater the opposing force that is created to stop this motion, implications for patients with large implants
- If you move a patient /implant too fast, can result in forces on the implant, slowly move into and out of bore, some light erroneously cancel the procedure

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Thank you for attending!

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