

SAFETY HAZARDS UNIVERSITY OF LOUISVILLE:

MRI units:

AND

NMR units:



University of Louisville

“SIX-YEAR-OLD PATIENT FATALLY INJURED FOLLOWING TRAGIC INCIDENT IN MEDICAL CENTER'S MRI SUITE”

ALBANY, September 28, 2001 – The New York State Health Department today announced that Westchester Medical Center (WMC) in Valhalla, New York will be fined \$22,000 for its failure to ensure patient safety during MRI procedures. The State Health Department cited WMC for eleven violations that occurred on July 27, 2001, leading to the tragic death of a sedated six-year-old patient. The child sustained fatal injuries after being struck in the head by a ferrous oxygen canister that was pulled into the magnetic resonance imaging (MRI) scanner.

New York State Dept of Health 2001 Press Release

“DEATH LINKED TO HOSPITAL SCAN”

MELBOURNE, AUSTRALIA — The Alfred Hospital has announced a review of its safety procedures after the death of a man whose pacemaker malfunctioned during a magnetic resonance imaging scan. Hospital spokesman David Faktor admitted safety procedures were not properly followed when an elderly man died during MRI treatment on April 1.

The Herald Sun

By Jeremy Calvert and Tanya Taylor

Thursday April 13 2000-04-13

News Corporation Melbourne Australia

“U.S. WARNS OF INJURIES FROM IMPLANTED STIMULATORS”

WASHINGTON (Reuters) - People with implanted nerve stimulators to treat brain, spinal or other disorders may risk comas, serious injury or death if they undergo magnetic resonance imaging scans, U.S. regulators warned on Tuesday. The Food and Drug Administration said it had received several reports of serious injuries, including comas and permanent neurological impairment, in patients with the stimulators who underwent MRIs.

Reuters Health, May 11, 2005

“MISHAP CAUSES \$200K IN DAMAGE TO MRI MACHINE”

- ▶ SEATTLE(AP) —An expensive MRI machine at Virginia Mason Medical Center in Seattle suffered hundreds of thousands of dollars in damage when a metal floor buffer was mistakenly placed nearby and was sucked in by the machine's powerful magnets, KIRO 7 Eyewitness News reported.....

POSTED: 6:09 am PST January 11, 2005

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IS MRI AND NMR ALWAYS DANGEROUS?

- ▶ They are not dangerous for patients or personnel if appropriate safety procedures are followed

Serious or fatal incidents can occur if safety procedures are **not** followed.

BE AWARE OF UNIQUE HAZARDS!

Unlike x-ray machines, the static magnetic field is ALWAYS “on”. It doesn’t turn off at night or after hours.

The magnetic field is invisible.

Normally safe objects are dangerous in an MRI room

WHAT IS MRI?

- ▶ Magnetic Resonance Imaging uses a fixed or “static” magnetic field, rapidly changing “gradient” magnetic fields and radiofrequency (RF) signals to visualize:

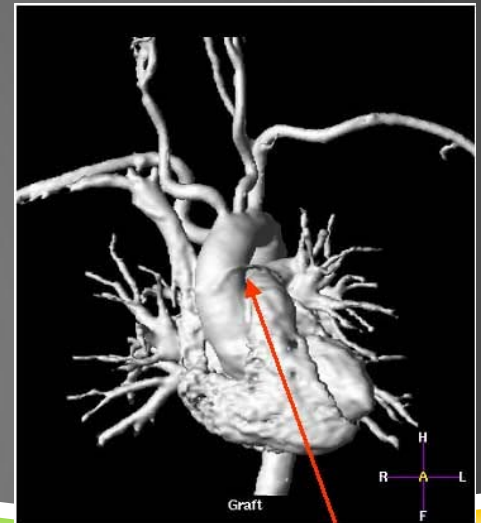
Anatomy

Tissue characteristics

Vascular flow

Perfusion and diffusion

Chemical composition of tissue



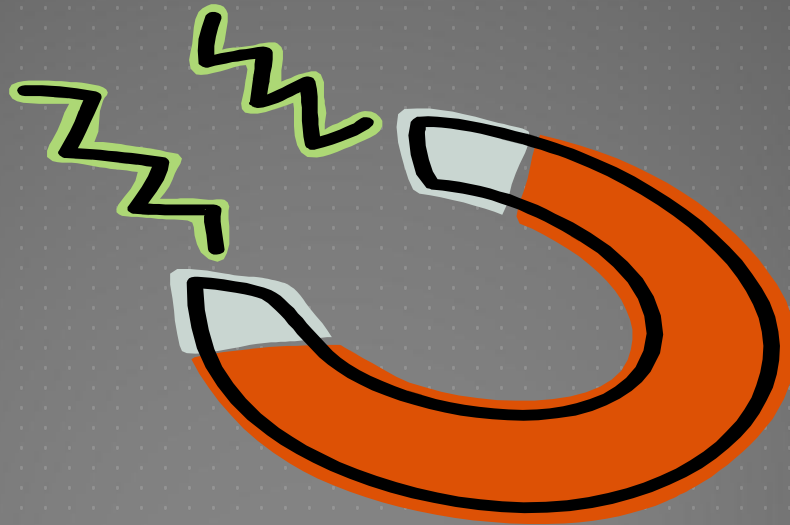
MRI HAZARDS

- ▶ Static Magnetic Field
- ▶ Gradient Fields
- ▶ Radiofrequency pulses
- ▶ Cryogenics (used to cool the superconducting magnet)



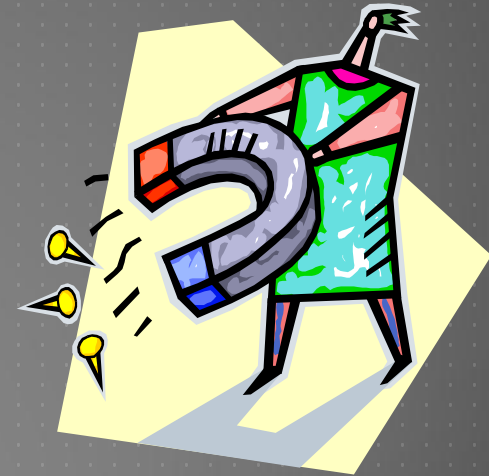
MAGNETIC FIELDS

- ▶ Magnetic fields are measured in Gauss (G) and Tesla (T).
 - ▶ $1 \text{ T} = 10,000 \text{ G}$
- ▶ The preferred unit to represent magnetic field is Tesla.



HOW MAGNETIC IS IT?

- ▶ The earth's magnetic field is approximately
0.0001 – 0.00005 Tesla
- ▶ The “safe” levels of magnetic field exposure for the
general public is considered anything below:
0.0005 Tesla



MRI ROOM

- ▶ Any of the magnetic field coming from the MRI unit that is above the safe level of 0.0005 T is **contained within the room** that houses the MRI unit.
- ▶ **ABSOLUTELY NO MAGNETIC OBJECTS ARE ALLOWED IN THE MRI ROOM.**

MRI ROOM, CONTINUED.

- ▶ There is a metal detector installed in the door frame of the entryway into the MRI room that is located in the basement of the B Building.
 - ▶ Walk **SLOWLY** to the door frame and stop to see if the lights flash red or green;
 - ▶ If the lights flash red, back out of the area
 - ▶ If the lights are green, you may enter the room.



55B MRI UNIT ENTRY

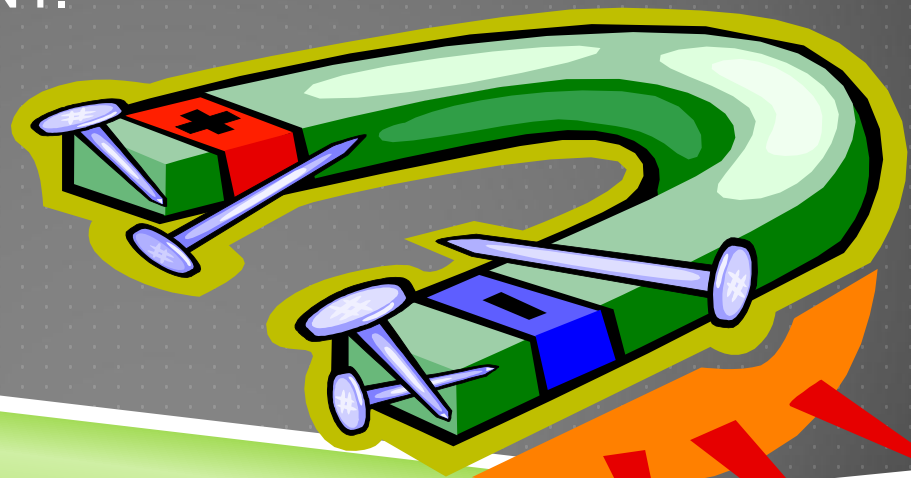
- ▶ The following link shows a video on using the metal detector.

To watch the video, copy the link to your browser:

- <http://www.youtube.com/watch?v=TENr-3jjVFE&feature=youtu.be>

CHARACTERISTICS OF THE MAGNETIC FIELD

- ▶ The force of the field is greatest at the periphery of the magnet. This **FORCE INCREASES** as you move closer to the magnet.
- ▶ NOT ALL MAGNETS ARE THE SAME FIELD STRENGTH, THUS THEIR “ATTRACTIVE FORCES” WILL BE DIFFERENT.



PROJECTILE EFFECT

- ▶ The static magnetic field exerts a strong force on ferromagnetic or weakly magnetic objects.
- ▶ They are attracted at high speed to the MRI scanner, causing severe or fatal injury to a patient in the scanner or to anyone in their path



PROJECTILE EFFECT

- ▶ Objects that have been drawn as projectiles into the bores (centers) of MRI scanners include:

- ▶ IV Poles
- ▶ Chairs
- ▶ Screwdrivers
- ▶ Pens
- ▶ Fork lift tine
- ▶ Hairpins
- ▶ Floor buffers
- ▶ Mops
- ▶ Forceps
- ▶ Scissors
- ▶ Guns
- ▶ Hammers
- ▶ Fire Axes
- ▶ Oxygen cylinders
- ▶ Fire Extinguishers
- ▶ Vacuum Cleaners
- ▶ Ladders
- ▶ Earrings
- ▶ Wheelchairs
- ▶ Radios
- ▶ Paperclips

PROJECTILE EFFECT

From Simply Physics, Moriel NessAiver, Ph.D. originally from Rolland Bammer



CHAIR



INJECTOR

IF IT'S METAL, KEEP IT OUT!

- ▶ All ferromagnetic metal objects are prohibited from the MRI scan rooms.
- ▶ If you don't know if an object is safe, **NEVER GUESS.** Ask an MRI technologist to check it for you.

Remember that a scissors, a wheelchair, an oxygen tank, and many other familiar objects can be deadly in an MRI suite.

MAGNETIC FORCE

- ▶ The following link is a YouTube video of the strength of a magnet. This is a 4 Tesla MRI unit. At the University, we have a 3 Tesla and a 9 tesla unit. (you must copy and paste the link on your internet browser)

<http://www.youtube.com/watch?v=6BBx8BwLhqg&feature=related>

DEVICE MALFUNCTION

- ▶ Induced voltages from gradient magnetic fields can cause malfunction of patient monitoring equipment such as EKG monitors, pumps, and ventilators.
- ▶ **Only MRI safe or MRI conditional patient monitoring equipment can be used.**

METAL IMPLANTS

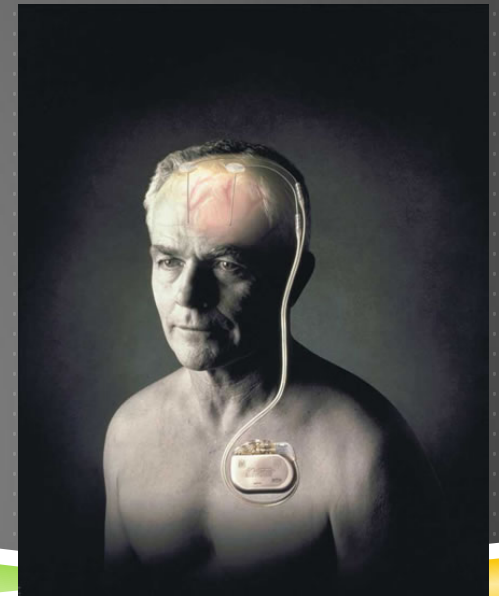
- ▶ Ferromagnetic metal implants in **patients or staff working in the MRI room** may twist or move in the static magnetic field, resulting in torn or ruptured tissue.
- ▶ Only implants identified by the manufacturer as MRI safe or MRI conditional are safe to scan.

METAL IMPLANTS

- ▶ Bullets and pellets in the body are prohibited.
- ▶ Metal shavings/fragments near the orbits are prohibited. If they move during the MRI scan they can damage the optic nerve, causing in one well known case permanent blindness to a patient.

RF HAZARDS – INTERNAL THERMAL EFFECTS

- ▶ Radiofrequency (RF) pulse sequences are transmitted to the patient's body during imaging . RF energy is absorbed in the form of heat.
- ▶ Heat from RF energy can be absorbed by implanted magnetic devices such as neurostimulators, causing internal burns and tissue destruction.



RF HAZARDS – SURFACE BURNS

- ▶ Metal objects such as monitoring leads and electrodes and medication patches can absorb RF energy as heat and burn the patient's skin.

First, second, and third degree burns have resulted

A few patients with tattoos or tattooed eye-liner containing ferromagnetic material have suffered minor burns



PACEMAKERS

- ▶ **The magnetic field of the MRI scanner can shut off the magnetic switches in a pacemaker, causing the patient to go into cardiac arrest.**
- ▶ **Patients and staff with pacemakers cannot enter the MRI scan room or have an MRI scan.**
- ▶ **If a patient codes in the MRI room, do NOT take the crash cart into the room. Begin resuscitation efforts while bringing the patient outside of the room where full resuscitation can proceed.**

CONTRAINDICATIONS TO MRI SCANS

Patients with any of the following 3 devices are prohibited from having an MRI scan:

Pacemaker

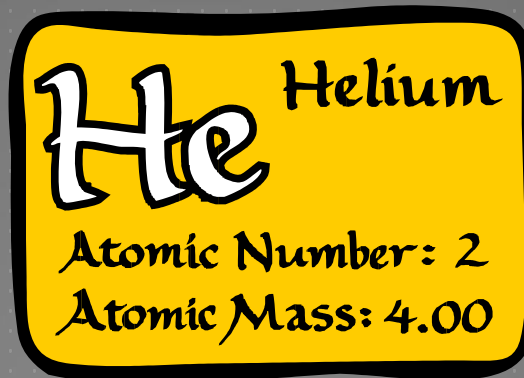
Implantable Cardioverter Defibrillator (ICD)

Neurostimulator

Other implanted devices or objects as previously mentioned, require further evaluation by MRI personnel to determine if they are safe for scanning.

CRYOGENS

- ▶ Cryogenics are chemicals used to cool the magnets on the MRI scanner and allow it to remain in a superconducting state.
- ▶ Liquid Helium is the most common cryogen used in MRI units.



CRYOGEN HAZARDS

- ▶ Cryogenics are cold enough to freeze human tissue within seconds and pose serious cold burn and frostbite hazards. As cryogenics are released to keep the magnet cool, they evaporate into odorless, colorless and tasteless gases.
- ▶ Most gas is recaptured, but some escape; normally any gas is vented safely out of the building.

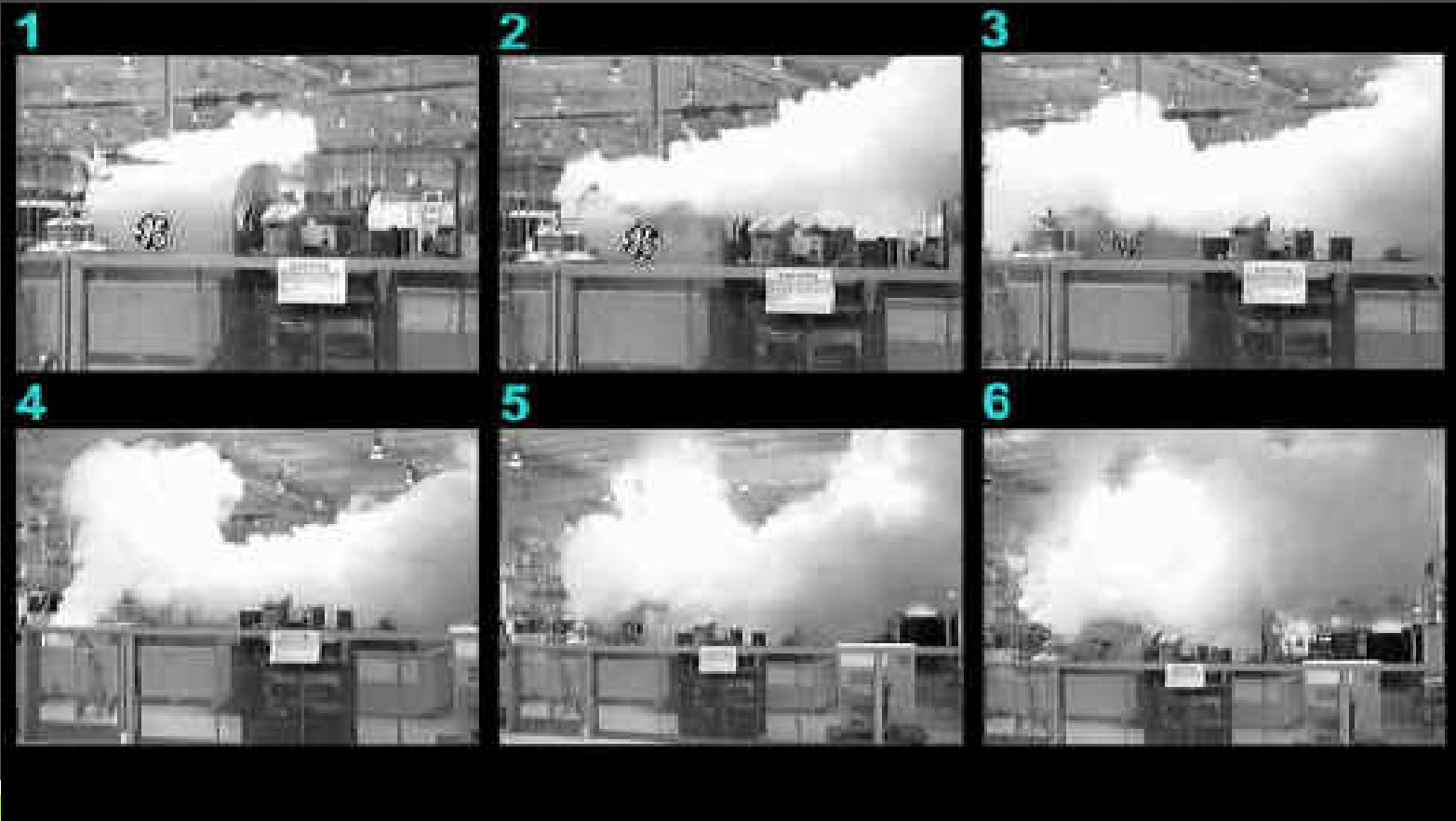
QUENCH

- ▶ An emergency shutdown of the magnet is called a system Quench.
- ▶ During a quench, all of the cryogen evaporates quickly and emergency venting systems direct the escaping cryogen through a vent to the outside of the building.
- ▶ If there is a problem with the venting and the cryogen is released in the room, **this could cause an asphyxiation hazard or even damage the equipment in the room.**

IN THE EVENT OF A QUENCH

- ▶ Evacuate all patients quickly and safely.
- ▶ The entire MRI suite should be evacuated and everyone should be moved outside of the room.
- ▶ The MRI technologist must confirm the magnetic field has dissipated prior to the safe entry of response teams.

QUENCH



QUENCH HAZARDS - ASPHYXIATION

“New York Times Article: Worker at Hospital Dies; Gas Leak Suspected, September 21, 2000. A worker was asphyxiated by liquid nitrogen while installing an MRI. Six other people were injured.”

Individuals in the room can be asphyxiated if a quench occurs. Remove patients and personnel as quickly and safely as possible.

QUENCH HAZARDS – MAGNETIC FIELD

- ▶ If a quench occurs, do not assume the magnetic field will be instantly gone. It may be several hours until it dissipates.
- ▶ If a fire or other disaster occurs and the magnet is quenched, safety precautions are still necessary for hospital and emergency personnel until the MRI service engineer determines the magnetic field is gone.

WHAT IS NMR?

- ▶ Nuclear Magnetic Resonance is a research technique that can provide detailed information about molecules.
- ▶ NMR units are self-contained, with the high magnetic field confined to within the unit itself.
- ▶ NMR units are subject to the same risk hazards as MRI units.



Bruker 700 MHz. Nuclear
Magnetic Resonance (NMR)
spectrometer

NMR UNIT

- ▶ On the NMR research units, the safe levels of 0.0005 T are at the legs of the unit.
- ▶ The interior of this unit is extremely well shielded so the magnetic levels above the safe limit are contained within a couple of feet from the unit itself.

NMR SAFETY

- ▶ Safety precautions for the NMR unit are the same as the MRI unit.
- ▶ REMEMBER: The magnetic field is ALWAYS on.
- ▶ Don't enter the NMR room if you have a pacemaker.
- ▶ Assume that all metal objects are ferromagnetic and will be attracted to the magnet unless otherwise verified
- ▶ The NMR unit also uses cryogenics for superconduction and cooling; quenches can occur.
 - ▶ In the event of a quench, notify others and leave the room immediately.
 - ▶ Notify a facility manager immediately.

SIGNAGE

- ▶ Signs for Magnetic Risk are informational and will be placed on the door entering the room with the MRI or NMR unit.



SIGNAGE

- ▶ The Zone signs may be placed in the MRI suite
 - ▶ Zone I – All areas accessible to the general public
 - ▶ Zone II – area between the publicly-accessible Zone I and the restricted areas of Zones III and IV.
 - ▶ Zone III – area where free access by unscreened non-MR personnel or ferromagnetic objects or equipment can result in serious injury or death.
 - ▶ Zone IV – the actually area with the MRI scanner.



QUESTIONS?

- ▶ If you have questions contact:
- ▶ Radiation Safety Office:
 - ▶ 852-5231
 - ▶ sarah.hughes@louisville.edu

