Introduction to MRI

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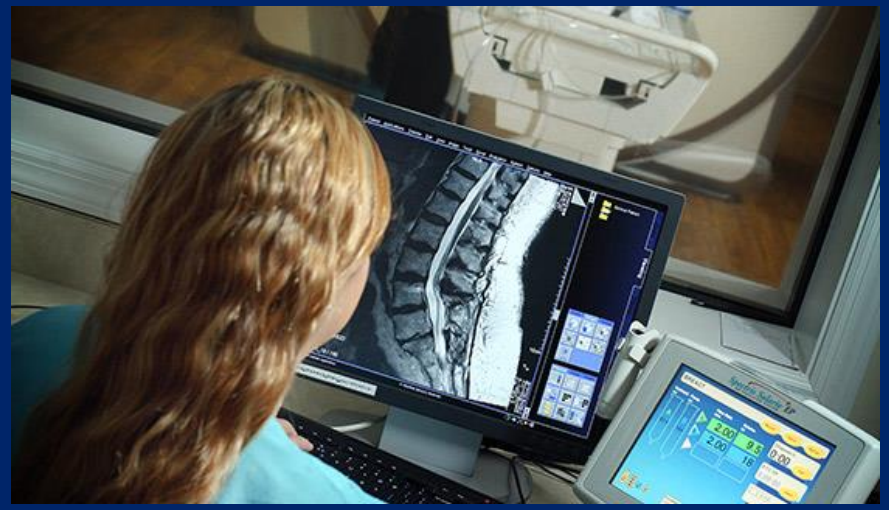
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What is MRI?

- Magnetic Resonance Imaging
- Preferred procedure for identifying and diagnosing conditions throughout the body
- Obtains detailed images of organs and tissue without the need for x rays or radiation delivery
- MRI uses a powerful magnetic field and radio waves to create images
- Patient is placed on the table and scanned inside the bore
- Bore is a large cylinder shape with an opening on both ends





Physics of MRI

- To obtain an MRI image, a patient is placed inside a large magnet and must remain very still during the imaging process in order not to blur the image
- MRI uses powerful magnets and radio signals that interact with protons inside the human body and as a result creates an image
- The radio waves knock the nuclei of the atoms in your body out of their natural position.
- As the nuclei realign into proper position, they send out radio signals. These signals are received by a computer that converts them into an image

https://www.youtube.com/watch?v=1CGzk-nV06g&t=11s

https://www.nibib.nih.gov/science-education/science-topics/magnetic-resonance-imaging-mri

MRI Screening Form

- Every patient must complete this form
- Establishes thorough screening of patients in prep of MRI scan
- Critical component in MRI safety
- Encourage patients to fill out with detail so we can determine they are a safe candidate for the exam
- Complete online or paper form prior to appointment

Question
Do you have a Continuous Glucose Monitor?
Do you have a sleep apnea implanted device?
Do you have any type of electronic, mechanical, or magnetic implant?
Do you have an artificial heart valve?
Do you have an aneurysm clip?
Do you have a neurostimulator, diaphragmatic stimulator, deep brain stimulator, vagus nerve stimulator, bone growth stimulator, spinal cord stimulator, or any biostimulator (in-place or removed)?
Do you have any type of internal electrodes or wires?
Do you have a cochlear implant?
Do you have an implanted drug pump (e.g., insulin, baclofen, chemotherapy, pain medicine)?
Do you have a spinal fixation device?
Do you have any type of coil, filter, or stent?
If yes, list type
Do you have a cardiac pacemaker, defibrillator or other cardiac implant (in place or removed)?
Do you have any type of surgically implanted ear implant?
Do you have a penile implant?
Do you have a surgically implanted artificial eye?
Do you have an eyelid spring and/or eyelid weight?
Do you have any type of implant held in place by a magnet?
Do you have any type of surgical clip or staple?
Do you have an IV access port (e.g., Broviac, Port-a-Cath, Hickman, PICC line)?
Do you have a shunt?
Do you have a surgically implanted artificial limb?
Do you have a tissue expander (e.g., breast)?
Do you have surgical mesh?
Do you have radiation seeds?
Do you have any implanted items (e.g., pins, rods, screws, nails, plates, wires)?
Do you wear a hearing aid?
Do you have a removable drug pump (e.g., insulin, Baclofen, Neulasta)?
Do you have any type of removable ear implant?
Do you have a removable artificial eye?
Do you have any type of removable implant held in place by a magnet?
Do you have any type of removable surgical clip or staple?
Do you wear a medication patch (e.g., nitroglycerine, nicotine)?
Do you have a removable artificial limb?
Do you have removable dentures, false teeth, or a partial plate?

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Patient Protection: Hearing



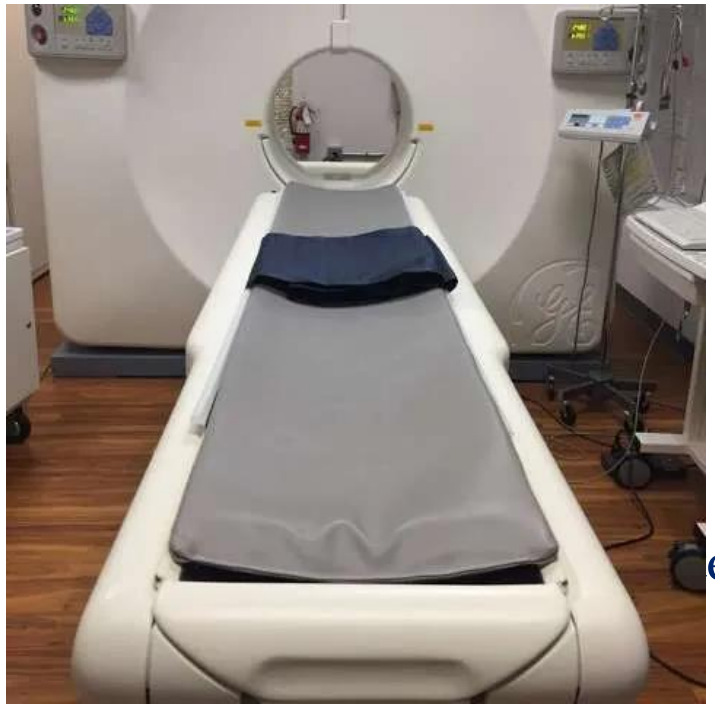


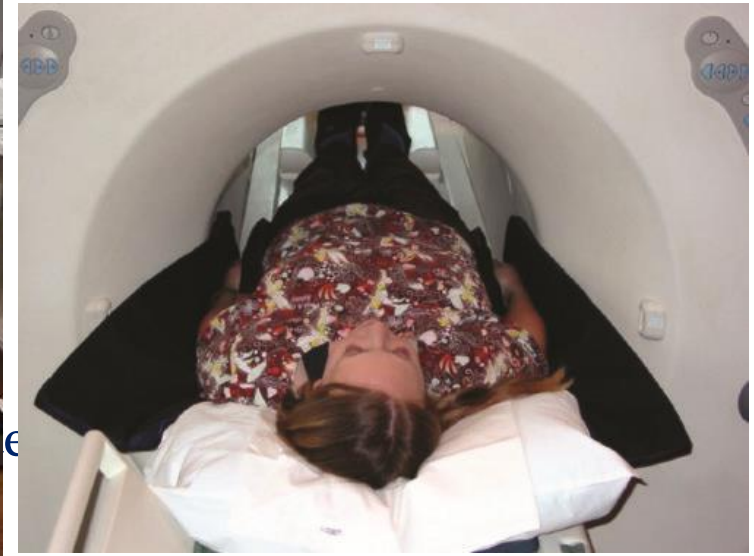
- 2 Forms: Ear plugs and headphones
- Provide to the patient upon entering zone 4
- The gradients is the main source of noise
- Occurs during the rapid alterations of electric currents within the gradient coils
- Sound is similar to a loud tapping or knocking
- Problems associated: hearing loss, heightened anxiety, tinnitus and discomfort

https://www.mrisafety.com/SafetyInformation_view.php?editid1=252

Patient Protection:
Padding

- Pads are used to:
  -provide patient comfort
  -prevent thermal injuries
  -minimize patient movement





- Among all types of injuries- burn injuries are most common
- Coils in the magnet produce an RF pulse that is applied to the patient's body and creates images
- Pads act as a thermal barrier and protect against burns the patient may acquire
- It is very important for patients to remain still during imaging
- Adding pads along the area of interest helps ensure little to no movement

https://pmc.ncbi.nlm.nih.gov/articles/PMC9849420/

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Forms of Communication

Call Bell

- Every patient is handed a call bell
- #1 form of communication
- Alerts us to stop the scan and check in on the patient



Sounds

- Variations of knocking, banging, and buzzing
- Hearing protection is mandatory
- Can experience hearing loss, and difficulty communicating

Sensation

- Painless
- Peripheral nerve stimulation may occur
- May feel mild sensation if patient has implants (pacemaker, hip replacement)

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Allergic Reactions

- Can be caused due to contrast administration
- Happens on rare occasion – less than 1%
- Iodine or gadolinium based
- **MRI contrast types:** Gadavist- prostate, pancreas
  Elucerim- brain
  Eovist- liver

- **Benefits For Use of Contrast:**
  - helps identify diseased areas
  - helps identify margin of disease

- **Preventing Allergic Reactions:**
  - doctor will prescribe medication
  - prednisone: take 3 doses before your scan a few hours prior
  - methylprednisolone- take 2 doses before your scan

Symptoms:

Range from mild- sever
- Feeling warmth
- Redness on the skin
- Nausea
- Itchiness
- Hives
- Difficulty breathing
- Convulsions
- Loss of consciousness

Risk Factors:
- Heart disease
- Kidney disease
- Diabetes
- Asthma
- Past reactions to contrast

https://www.mskcc.org/cancer-care/patient-education/preventing-allergic-reaction-contrast-dye
https://www.verywellhealth.com/iodine-contrast-allergy-83066

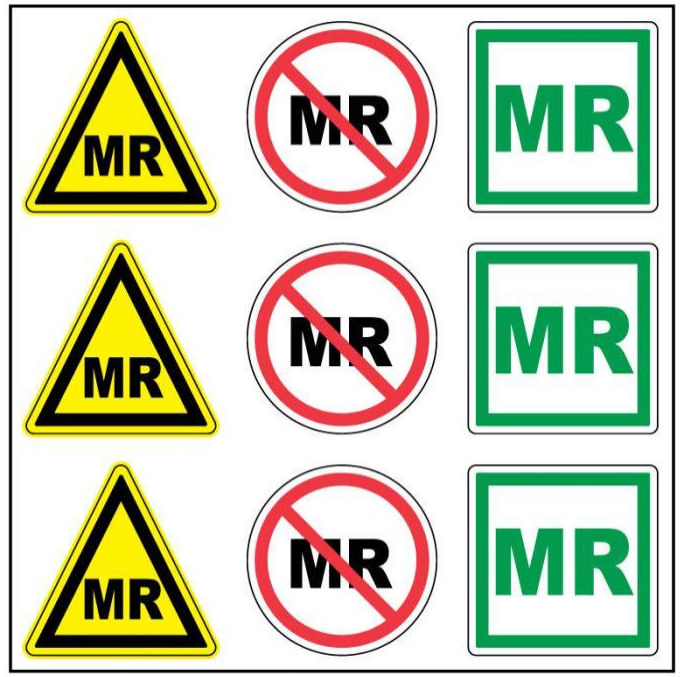
MRI Metals: Ferromagnetic vs Non- Ferromagnetic

Non- Ferromagnetic: NOT attracted to the magnet (safe)

- Titanium
- Aluminum
- Copper

Ferromagnetic: strongly attracted to the magnet

- Can become a projectile
- MRI safety concern for patients, MRI staff, and equipment
- Steel
- Iron
- Nickel
- Cobalt



We must screen for patient metals and implants due to determine if patient is safe to enter zone 4 and be scanned

Most surgeries that involve metal implants are done using titanium

MRI-Compatible Devices and Implants



- **Safe:**
- No known hazard
- Safe to enter MRI zone 4



- **Unsafe:**
- Hazardous
- Do not enter MRI environment
- Do not scan



- **Conditional:**
- No known hazards
- Safe to enter MRI environment
- Has specific conditions of use

MRI compatible devices are safe to be scanned under specific conditions

Patient must present an implant card that allows us to confirm the information provided

Once determined the device is MRI compatible

We place the machine into “safe mode” by entering the specific conditions

Conditions Refer To:

Specific Absorption Rate (SAR)

Spatial gradient

Gradient Slew Rate

Source: Citation







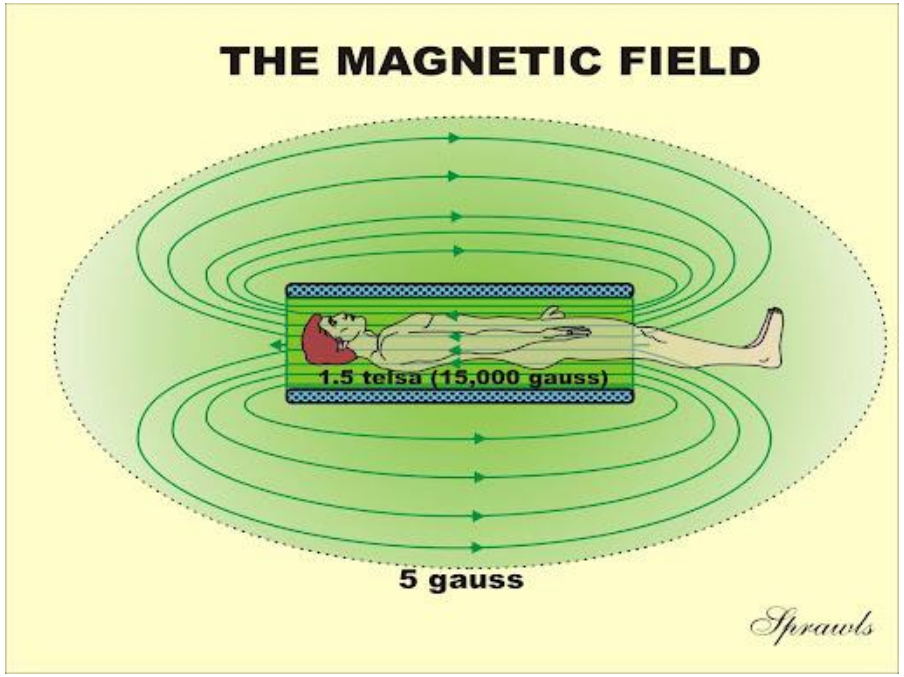
https://www.google.com/search?sca_esv=5e42f7fa02a5a005&rlz=1C1GCEA_enUS1105US1105&q=mri+metals&udm=7&fbs=ABzOT_CWdhQLP1FcmU5B0fn3xuWpA-dk4wpBWOGsoR7DG5zJBtmuEdhfywyzhendkLDnhcoz2MlB1dVLatL09WpR-ccv5lsI0EqzmXSeJlYCI5JKx-ochTRaelQNEyeeleDP-Dp3CmHLdh19LKdWNC4idk0N1Yt9NcyihhKSCG17-4xZaTtnviR3_BcrSzGSGwWyaDJXuEoFHHCgSeOXrzUPRd3ttD36PA&sa=X&ved=2ahUKEwirnIic5s2LAxVgrYkEHeSqA2MQtKgLegQIKBAB&biw=1920&bih=919&dpr=1#fpstate=ive&vld=cid:07432e3e,vid:6BBx8BwLhqg,st:0

Five Gauss line

- Gauss = measurement unit of a magnetic field
- Imaginary line around the perimeter of the magnet
- Represents the distance from the magnet to where the magnetic strength is equal to 5 Gauss
- Typically, these lines are outlined om the floor of the room
- As you enter the gauss line perimeter, the strength of the magnet will feel stronger
- Any ferromagnetic objects is strictly prohibited past this line- can turn into a projectile event
- The 5-gauss line affects implanted devices (pacemakers, defibrillators, breast tissue expanders)
- We place the patient onto the MRI safe stretcher and remind them to not sit up right while in the magnet room
- We send the patient into the bore SLOWLY so that it does not displace the device
- It's important to check in on the patient during the scan to ensure they don't feel any heating around the implanted device

https://www.urmc.rochester.edu/MediaLibraries/URMCMedia/rcbi/UR-CABIN-MRI-Safety-Issues-EmergencyProcedures.pdf





Potential Hazards

- Screening patients thoroughly is an important step in preventing potential hazards from entering the MRI room
- Involved asking patients about their medical history, major surgeries, implanted devices, all other metals inside the body
- 1st Step: complete MRI paper screening form
- 2nd Step: Interview the patient
- 3rd Step: wand the patient with an MRI safe handheld metal detector
- Be sure to wand from the top of the patient's hand to the bottom of their legs, as well as front to back of the body
- Projectiles are one of the biggest dangers associated with MRI
- It is crucial to discover any risks ahead of the scan





Environment

- RF shielding is installed all around the MRI room.
- It is found in the walls, floors, and ceilings
- Prevents outside RF noise from interfering with the accuracy of the MRI images

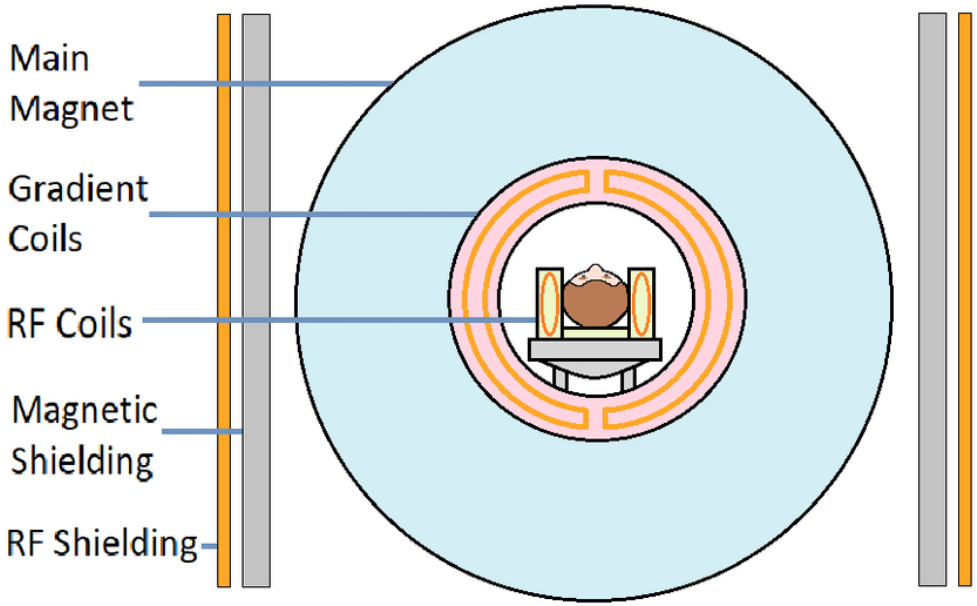
There are 2 types of RF shielding:

1. Passive:

- Permanent
- Done by the engineers during construction
- Found in the perimeter of the room
- Controls the environment as is

2. **Active:**

- A set of coils used to reduce the static fringe field generated by the main magnet
- Improves main magnet homogeneity and quality of the MRI images
- Located in the MRI machine itself
- Controls the environment as it's changing and QA by the service engineer



https://mriquestions.com/active-shield-confusion.html