

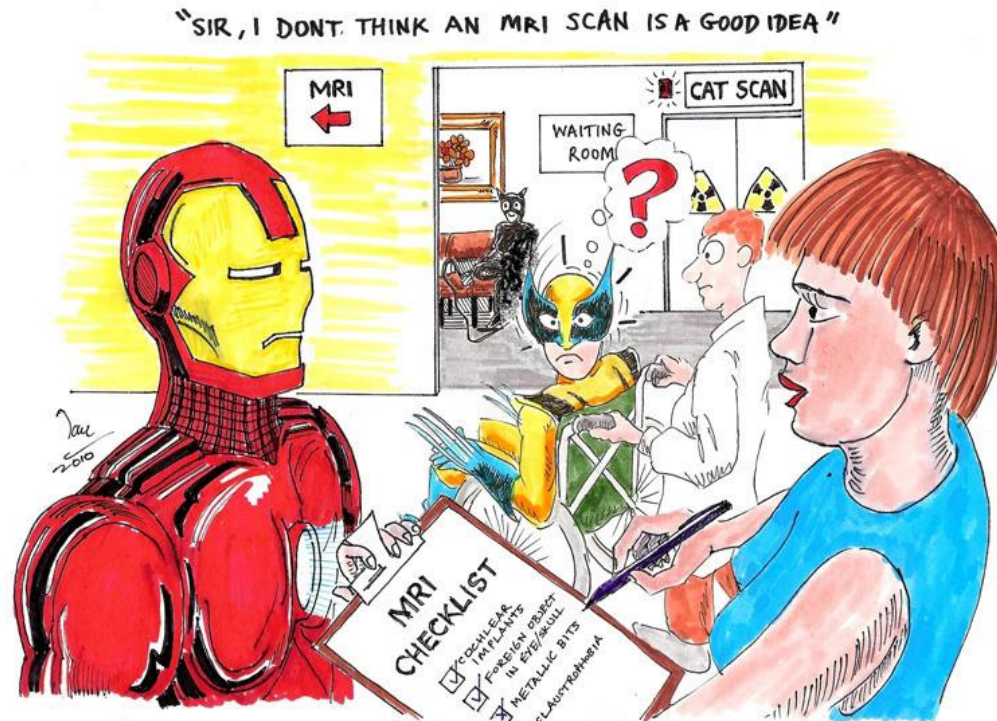
Scanning a superhero

An overview of the safety considerations

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Case Study

- Name: James Howlett
- 133 year old male
- Requires a hip scan

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 - Adamantium-infused skeleton
 - Superhuman senses
 - Accelerated healing
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- **SCAN?**

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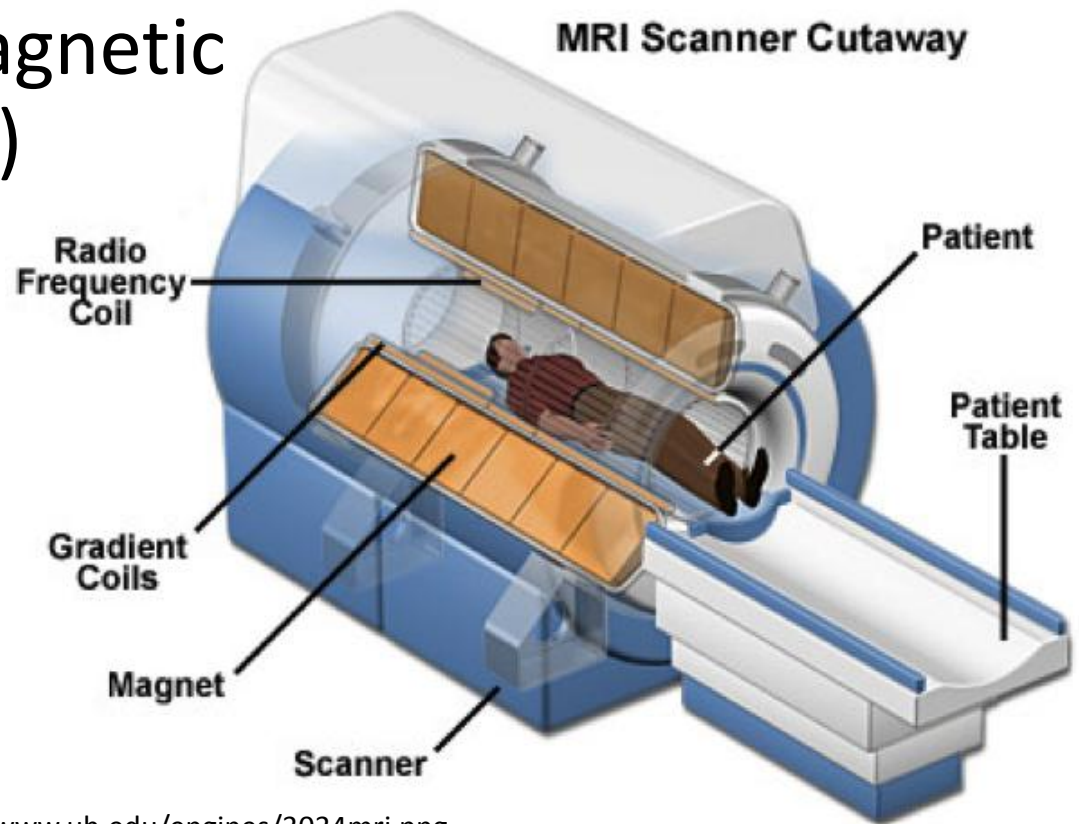
• **SCAN?**



Overview

3 main hazards in MRI:

- Static magnetic field
- Radio Frequency (RF) fields
- Time varying magnetic fields (gradients)



Hazards in MRI – Static Magnetic Field

- In clinical scanners, field strength is typically 1.5T
 - ~30,000 times the strength of the Earth's magnetic field
- Effects to consider:
 - Translational (attractive) force
 - Rotational force (torque)
 - Physiological effects
 - Interactions with implantable devices



Credit: GENSCO Equipment

Hazards in MRI – Static Magnetic Field

- **Translational and Rotational Forces**

- Both depend on:
 - the magnetic susceptibility of the object
 - the magnetic field strength, B
- Only translational depends on:
 - how rapidly the magnetic field strength changes with distance, dB/dz (“spatial gradient”)



Hazards in MRI – Static Magnetic Field

- **Translational and Rotational Forces**

- There have been multiple deaths and injuries due to the translational and rotational forces acting on equipment and implants
- The “projectile effect” has resulted in fatalities
- Two deaths caused by rotation of aneurysm clips
- Blindness caused by rotation of metal shards within the eye

Hazards in MRI – Static Magnetic Field

- **Physiological effects**

- Some people experience vertigo, nausea and phosphenes (“seeing lights”) when moving through a static magnetic field.



Hazards in MRI – Static Magnetic Field

Interaction with medical implants

- Some medical implants are ferromagnetic, conducting and/or have active components
- Possible issues:
 - Movement, rotation and/or vibration of implant
 - Inappropriate sensing, triggering or activation of active device
 - Damage to implant
- Following the MRI Conditions minimises these risks



Case Study

Hazards:

- Static magnetic field



- **SCAN?**

Hazards in MRI – Radiofrequency Fields

Radiofrequency (RF) Fields

- Main considerations:
 - Burns
 - Heating



Credit: "Woo-Hoo Durnnit?" *The Simpsons*.

Hazards in MRI – RF Fields

Burns

- Most common cause of injury in MRI
- Burns can be avoided by:
 - Using appropriate devices e.g. MR-conditional and following the conditions
 - Placing insulating padding between coils, wires, bore of scanner etc. and the patient's body
 - Ensuring that no loops are formed by the tissues of the body
 - Removing items of clothing and accessories as required
 - Ensuring that there are no loops in wires and cables

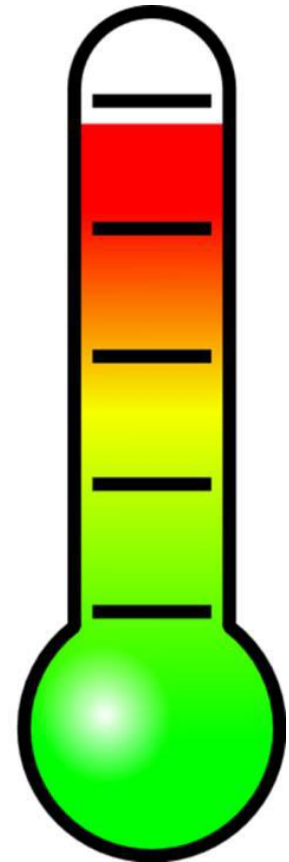


Credit: Knopp et al, *Radiology* (1996)

Hazards in MRI – RF Fields

Heating

- RF energy is transmitted into the body during MR imaging
- Most of this energy is re-emitted and is used to form images
- Some energy is absorbed by the tissues, and is then dissipated in the form of heat
 - increase in body temperature



Hazards in MRI – RF Fields

- **Heating**

- Measured by *Specific Absorption Rate (SAR)* and *B1+RMS*
– covered later
- SAR/B1+RMS limits are in place to ensure patient safety:
 - **NORMAL MODE** –a whole body temperature rise of $> 0.5^{\circ}\text{C}$ will be prevented
 - **CONTROLLED MODE** (1st Level) –a whole body temperature rise of $> 1^{\circ}\text{C}$ will be prevented
- Care must be taken when dealing with patients who have compromised thermoregulatory responses
 - pregnancy, hypertension, fever, use of vasodilators etc.

Case Study

Hazards:

- Radio Frequency (RF) fields

• **SCAN?**



Credit: New X-Men #148, *Marvel*.

Hazards in MRI – Time Varying Magnetic Fields

- “Magnetic Field Gradients”
- Two main considerations:
 - Acoustic noise
 - Peripheral nerve stimulation

Hazards in MRI – Gradients

Acoustic Noise

- Gradients are switched on and off rapidly during scanning
- This causes the coils to vibrate against their mountings and generates acoustic noise
- Sound pressure of MRI scanner is > 90 dB
- Staff and patients must wear ear protection if in the scanner room during scanning



Hazards in MRI – Gradients

- **Peripheral nerve stimulation (PNS)**

- This stimulation can be sufficient to cause discomfort and limb movement, and in extreme cases can cause severe pain
- Pulse sequences which involve fast gradient switching e.g. EPI are most likely to cause PNS
- Likelihood of PNS reduced by scanning in Normal Mode

Case Study

Hazards:

- Time varying magnetic fields (gradients)

• **SCAN?**



Case Study

Risks:

- Ferromagnetic skeleton in static magnetic field
- Possible heating /burns
- Acoustic noise
- Image quality

• **SCAN?**



Case Study

Risks:

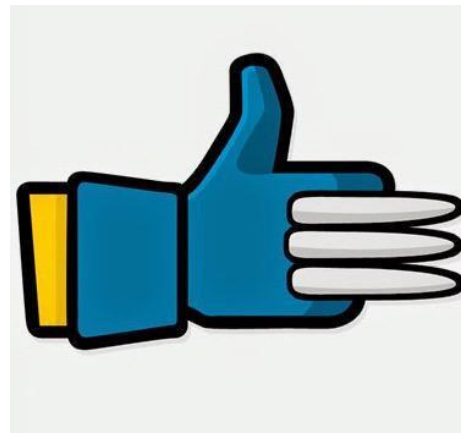
- Ferromagnetic objects in static magnetic field
- Possible burns
- Acoustic noise
- Image quality

• **SCAN?**



Finally

- MRI incidents are rare, but can be fatal
- The majority of incidents are avoidable
- Risks can be minimised by appropriate training and following local rules and SOPs:
 - Restrict access to CAA
 - Staff and patient checklist
 - Correct use of MR Safe and MR Conditional equipment
 - Careful patient positioning
 - Use of hearing protection



Questions?

WOLVERINE?....



OR 2 BAT MEN?