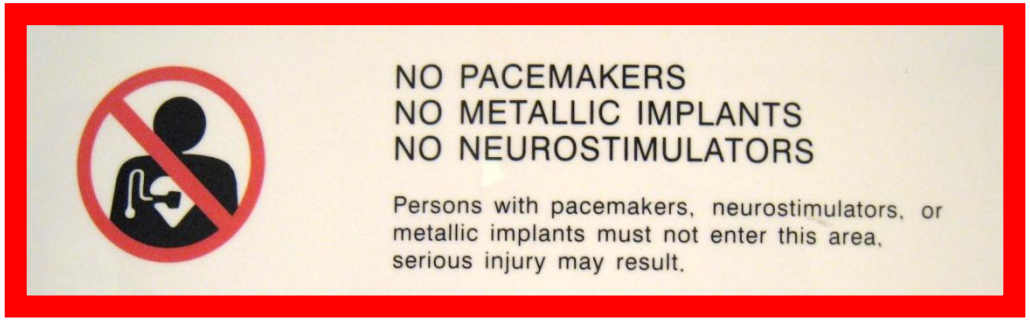
MRI for Patients with MRI-Conditional Pacing System: Radiographers' Role

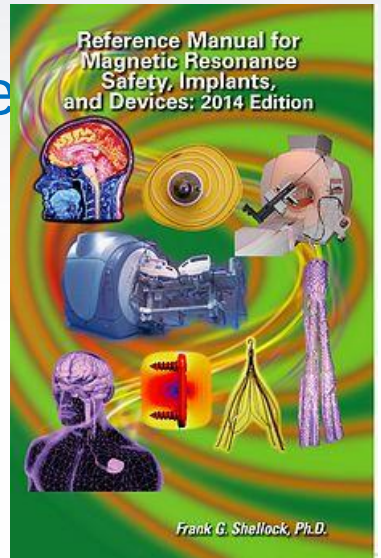
Lawrance Yip
DM, DR, QMH

醫院管理局
HOSPITAL AUTHORITY

MRI & Pacemaker

- MRI is a crucial and growing imaging modality
  - Plays an important role in clinical management
  - Essential for acute clinical conditions e.g. acute cord compression, acute ischemic stroke etc.
- Contra-indications for MRI
  - Conventional (MRI-unsafe) pacemaker
  - Intra-orbital metallic foreign bodies
  - Other MRI-unsafe cardiovascular implantable electronic device and bio-medical implants



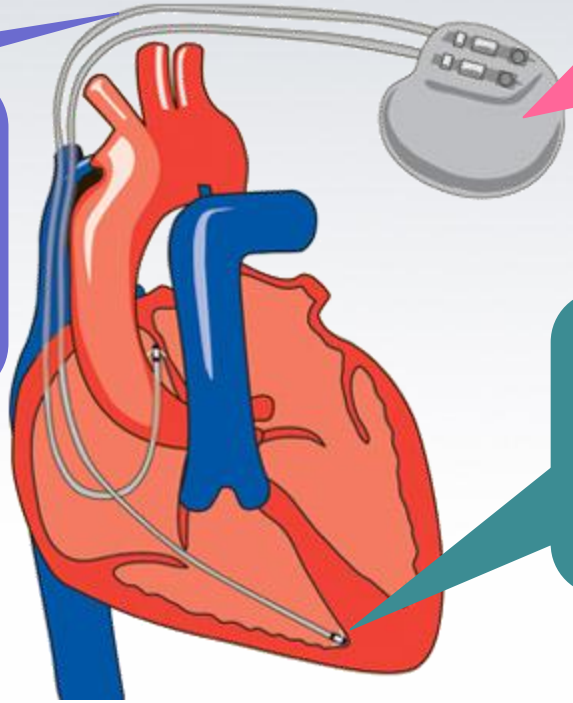


MRI & Pacemaker

- Potential interactions between pacemaker and MRI environment

Pulse generator
- **Unpredictable pacing mode**
- **Premature battery failure**

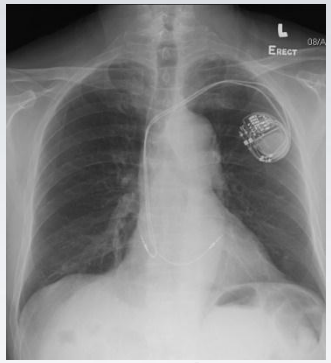
Pacing wire
- **Ventricular fibrillation**
- **Pacing inhibition**
- **Deliver inappropriate shocks**



Myocardium / pacing wire interface
- **Lead tip heating**
- **↑ pacing threshold**

MRI & Pacemaker

- Some centres in Europe & North America develop protocols of performing MRI for patients with conventional cardiac pacemaker
- Clinical, experimental & pacemaker expertise on site
- Certain risk remains
  - Increase in pacing threshold
  - MRI-related ectopy
  - Temporary communication failure with pacemaker



- FDA and American Heart Association do not support MRI for patients with conventional cardiac pacemaker

MRI-Conditional Pacing System

- MRI safety terminology by American Society for Testing and Materials (ASTM)

MRI Safe

- **Pose no hazard in all MRI environments**
- **Non-ferromagnetic items**

MRI Conditional

- **Pose no hazard in specified MRI environment with specified conditions of use**

MRI Unsafe

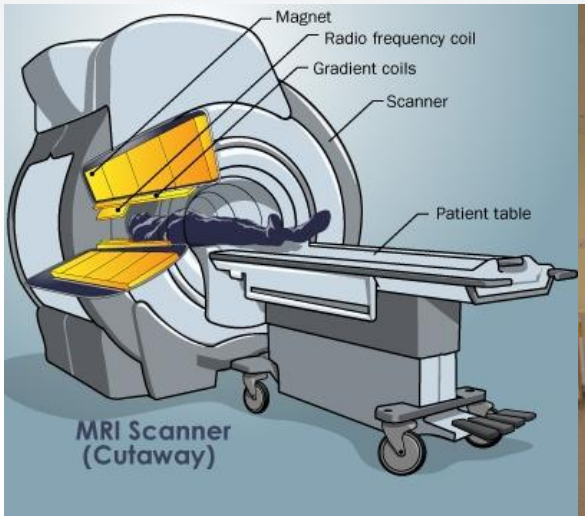
- **Pose hazard in all MRI environments**

MRI-Conditional Pacing system

- Specific features of MRI-conditional pacing system
  - Reduction in ferromagnetic content of pulse generator
  - Use of a Hall switch instead of reed switch
  - Modification of pacing leads to reduce lead tip heating
  - Shielding of the circuitry to minimize electro-magnetic interference
  - Protection of internal power supply

MRI-Conditional Pacing System

- Adjustment of MRI protocol and procedure to minimize the chances of interaction
  - Limited static magnetic field strength (1.5T)
  - Limited gradient slew rate (≤ 200T/m/s)
  - Limited radiofrequency power deposition (Whole body SAR ≤ 2W/kg)



MRI-Conditional Pacing System

Manufacturers	M	B	J
MRI Scanner	1.5T cylindrical bore MRI system	1.5T cylindrical bore MRI system	1.5T cylindrical bore MRI system
Average SAR (head)	≤3.2W/kg	≤3.2W/kg	≤3.2W/kg
Average SAR (whole body)	≤2W/kg	≤2W/kg	≤4W/kg
Maximum Slew Rate	≤200T/m/s	≤200T/m/s	≤200T/m/s
Scanner mode	Normal operating mode	Accumulated imaging time < 30mins	Normal or first level operating mode
Patient position	Supine	Supine	Supine
Iso-center of RF coil	No restriction	Yes (for some models)	No restriction
Implant site	R/L pectoral > 6 weeks	Chest area > 6 weeks	R/L pectoral >6 weeks

Guidelines on MRI for Patients with MRI-conditional Pacing System

MRI request for patients with MRI-conditional pacing system

Consult duty Radiologist for
- Indication of MRI Exam
- Risk / benefit analysis

MRI exam indicated for the patient?

No

Yes

Reconfirm the preconditions of pacing system is fulfilled before MRI exam

Preconditions of pacing system fulfilled?

Yes

No

Arrange Cardiologist / technical personnel of MRI-conditional pacing system on site during MRI exam for programming of pacing system

Ensure operating mode and technical parameters of MRI system are complied with the related safety recommendations of MRI-conditional pacing system

Exam completed

Alternative imaging exam

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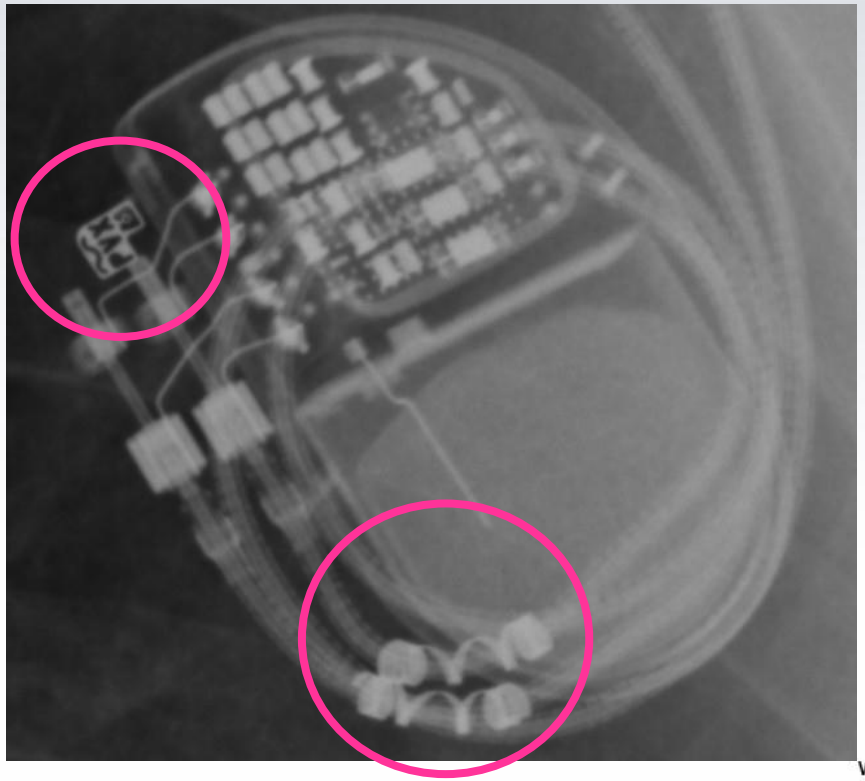
Pre-Scan Checklist

- Ensure the MRI examination is clinically indicated
- Consult patient records to verify the model of the pacing system is MRI-conditional

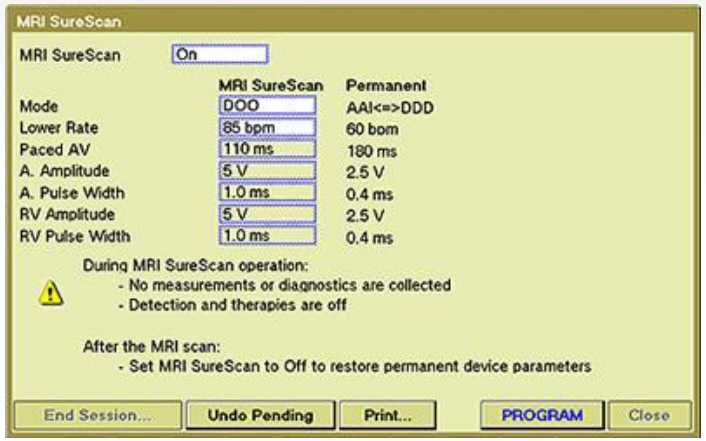


Pre-Scan Checklist

- Ensure all pre-conditions required for MRI examination are fulfilled
- Patient without other MRI contra-indications
  - e.g. other biomedical implants, abandoned leads etc.
- Obtain written informed consent from the patient

Pre-Scan Checklist

- Cardiologist shall be on site to check the parameters of cardiac pacing system
  - Battery level
  - Pacing threshold
  - Lead impedance
- Cardiologist programs the pacemaker to “MRI mode” or “Scanning mode” immediate before MRI examination
- Patient ready for MRI examination

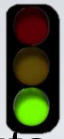


Checklist During MRI Exam.

- Maintain voice & visual contact with patient
  - Emergency call bell / In-bore intercom system / CCTV
- Patient may feel warmth and gentle tugging sensation near the pacemaker
- Monitor the patient's hemodynamic functions
  - Pulse oximetry
  - Non-invasive blood pressure
  - ECG
- Keep an external defibrillator and the emergency trolley available during MRI examination

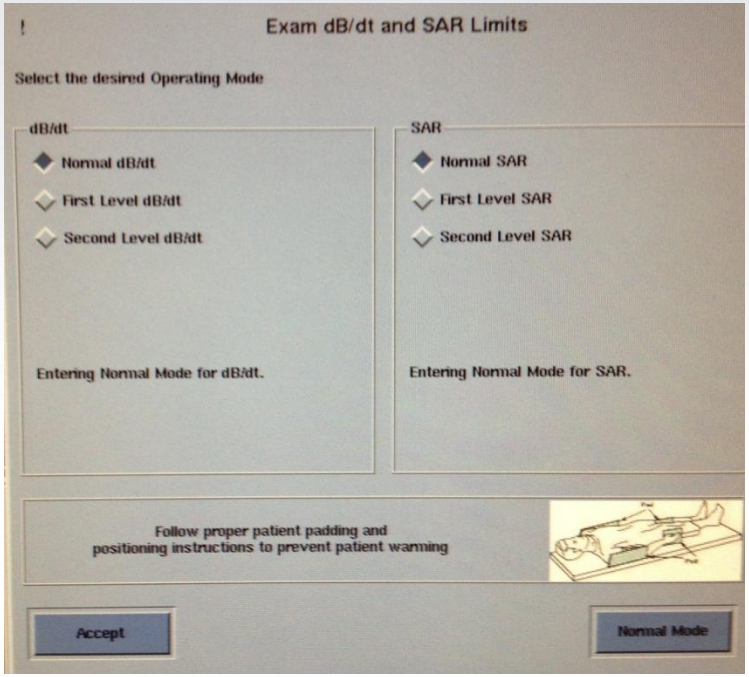
Checklist During MRI Exam.

Checklist During MRI Exam.

- Ensure operating conditions of the MRI system are fully complied with safety recommendations
- Appropriate operating mode of the system
  - Normal operating mode 
    - None of the system outputs may cause physiological stress to patients
  - First level controlled operating mode 
    - One or more system outputs may cause physiological stress to patients and needs to be controlled by medical supervision
  - Second level controlled operating mode 
    - One or more system outputs may produce significant risk for patient and explicit ethical approval is required

Checklist During MRI Exam.

- Normal operating mode is recommended for MRI examination of patient with MRI-conditional pacing system
- Restrict maximum gradient slew rate and Specific Absorption Rate (SAR) of the MRI system below the safety limits

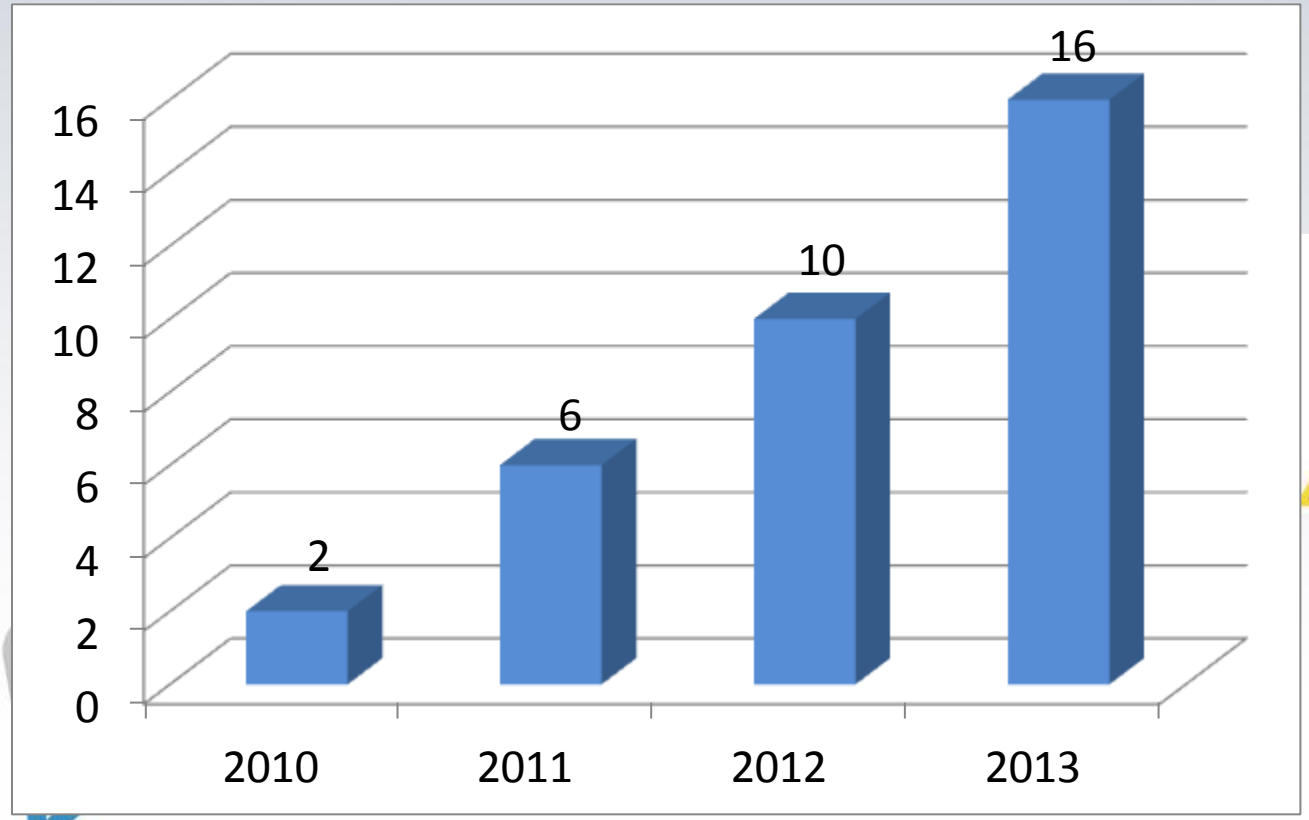


After Care

- Cardiologist resumes the normal settings of pacemaker immediate after MRI examination
- Report of pacemaker programming shall be documented

Statistics of MRI of Patients with MRI-conditional Pacing System

- 2010 – 2013 (Total 34 MRI examinations)
- No adverse effect was reported in all patients



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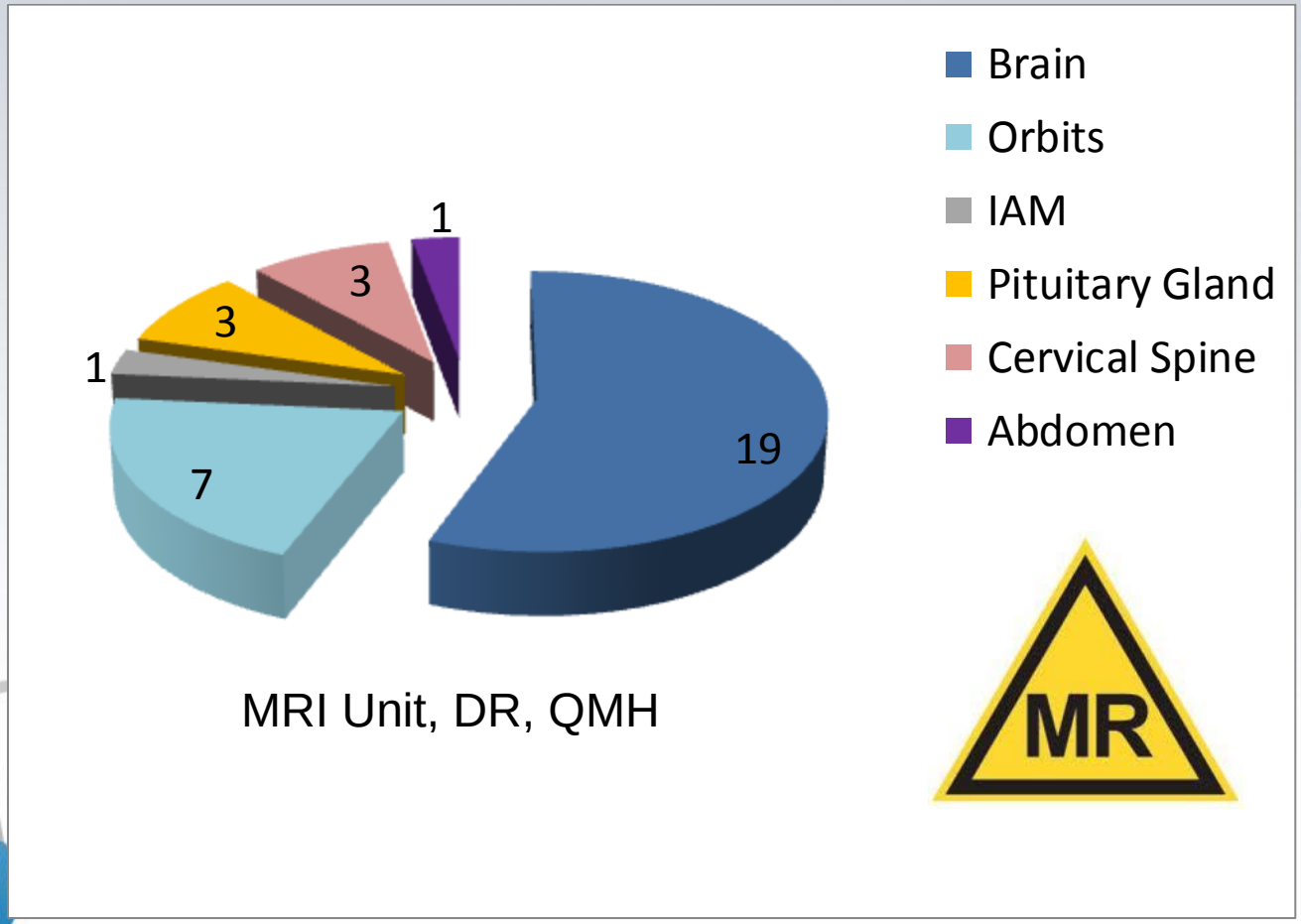

Conclusion

- MRI-conditional pacing system is developed to allow MRI examination to be performed under specific pre-requisites and technical conditions
- Radiographer is the most important gate-keeper of MRI safety to ensure strict adherence of the related safety guidelines so that the MRI procedures can be applied to the corresponding patients without adverse effect and benefit clinical management