Performing Magnetic Resonance Imaging in Patients with Conditional Cardiac Devices: A Collaborative Protocol to Mitigate Risk

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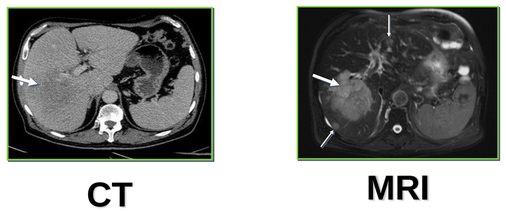
Background

Magnetic resonance imaging (MRI) is becoming a gold standard for soft tissue evaluation. However, the performance of MRI is contraindicated in patients with conventional cardiac devices. It is expected that 50 -75% of patients with implantable cardiac devices will require an MRI over the lifetime of their device and that MRI indications will double after age 65[1,2]. Given the increase in MRI indications and the growing number of cardiac devices, MRI conditional cardiac devices have been developed. **Safe performance of MRI in patients with these select devices requires careful verification of compatibility through screening protocols.** The lack of standardized screening protocols and knowledge regarding the existence of these conditional cardiac devices has led to MRI refusal in this patient population.

Differential Diagnostic Power



CT MRI

Image source: courtesy of Torsten Sommer, Director, Department of Radiology, German Red Cross Hospital Bonn, Academic Institution of the University of Bonn, Marktstr, Neuwied, Germany

Objective

To ensure patients are not denied access to MRI with conditional cardiac devices and to mitigate risk by developing a rigorous screening protocol to ensure the correct compatibility has been verified.

Safety Concerns

Hazards due to radiofrequency (RF), static and gradient magnetic fields can cause the following:

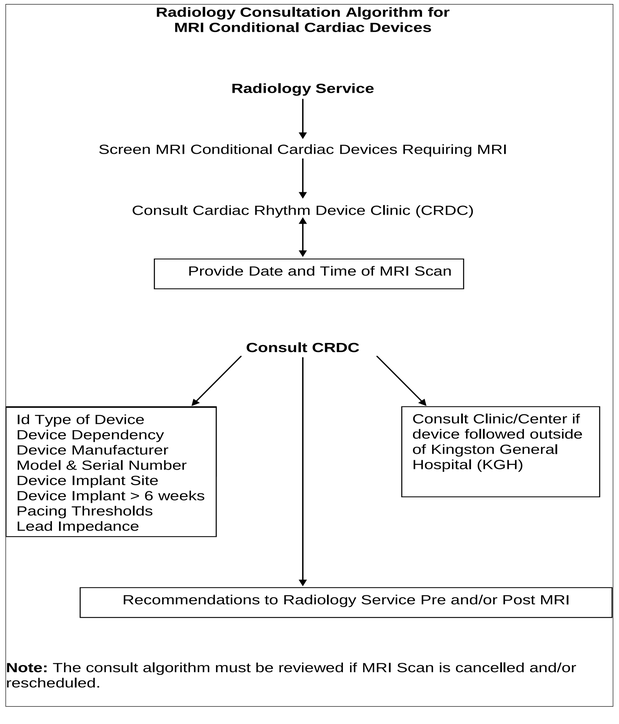
- Mechanical effects (device movement, dislodgement, or lead fracture)
- Lead tip heating
- Over and Under-sensing
- Current induction leading to rapid pacing
- Reed switch interference
- Electrical reset or permanent device damage
- Death

Methods

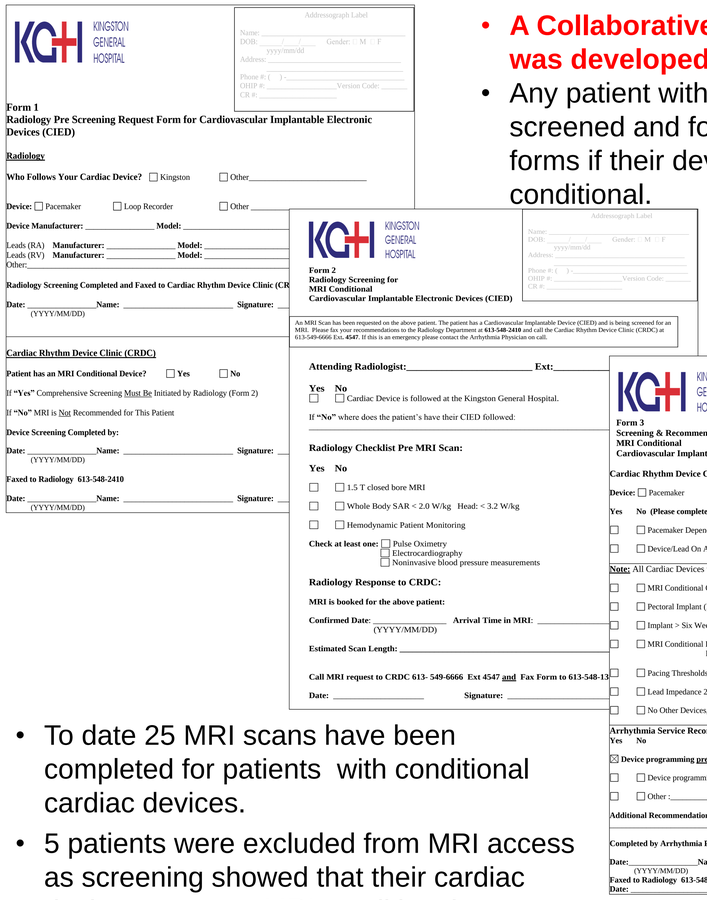
1. Established an Interprofessional working group from the Radiology and Arrhythmia Service.
2. Literature review.
3. Interprofessional working group education provided by device industry Clinical Specialist.
4. Teleconference with MRI clinical expert with experience performing MRI on conditional cardiac device patients.
5. Review of industry safety recommendations for Radiology and the Arrhythmia service.
6. Reviewed checklists, and workflow documents from hospitals performing MRI on conditional cardiac devices in Canada.
7. Received Health Canada approval documentation for MRI conditional status of device.
8. Reviewed our institutions collaborative consultation process and screening protocols for cardiac device patients undergoing surgery and/or radiation oncology.

Results

A comprehensive workflow document was developed outlining each department's responsibilities:



Note: The consult algorithm must be reviewed if MRI Scan is cancelled and/or rescheduled.



KINGSTON GENERAL HOSPITAL

Form 1
Radiology Pre Screening Request Form for Cardiovascular Implantable Electronic Devices (CIED)

Addressograph Label

Name: _____ DOB: _____ Gender: ☐ M ☐ F
yyyy/mm/dd
Address: _____
Phone #: ( ) - _____
OHIP #: _____ Version Code: _____
CR #: _____

Radiology

Who Follows Your Cardiac Device? ☐ Kingston ☐ Other_____

Device: ☐ Pacemaker ☐ Loop Recorder ☐ Other _____

Device Manufacturer: _____ **Model:** _____

Leads (RA) **Manufacturer:** _____ **Model:** _____
Leads (RV) **Manufacturer:** _____ **Model:** _____
Other:_____

Radiology Screening Completed and Faxed to Cardiac Rhythm Device Clinic (CR

Date: _____ **Name:** _____ **Signature:** _____
(YYYY/MM/DD)

Cardiac Rhythm Device Clinic (CRDC)

Patient has an MRI Conditional Device? ☐ Yes ☐ No

If **"Yes"** Comprehensive Screening Must Be Initiated by Radiology (Form 2)

If **"No"** MRI is Not Recommended for This Patient

Device Screening Completed by:

Date: _____ **Name:** _____ **Signature:** _____
(YYYY/MM/DD)

Faxed to Radiology 613-548-2410

Date: _____ **Name:** _____ **Signature:** _____
(YYYY/MM/DD)

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Form 2
Radiology Screening for MRI Conditional Cardiovascular Implantable Electronic Devices (CIED)

Addressograph Label

Name: _____ DOB: _____ Gender: ☐ M ☐ F
yyyy/mm/dd
Address: _____
Phone #: ( ) - _____
OHIP #: _____ Version Code: _____
CR #: _____

As MRI Scan has been requested on the above patient. The patient has a Cardiovascular Implantable Device (CIED) and is being screened for an MRI. Please fax your recommendations to the Radiology Department at **613-548-2410** and call the Cardiac Rhythm Device Clinic (CRDC) at 613-549-6666 Ext. **4547**. If this is an emergency please contact the Arrhythmia Physician on call.

Attending Radiologist:_____ **Ext:**_____

Yes No
☐ ☐ Cardiac Device is followed at the Kingston General Hospital.

If **"No"** where does the patient's have their CIED followed:

Radiology Checklist Pre MRI Scan:

Yes No
☐ ☐ 1.5 T closed bore MRI
☐ ☐ Whole Body SAR < 2.0 W/kg Head: < 3.2 W/kg
☐ ☐ Hemodynamic Patient Monitoring

Check at least one: ☐ Pulse Oximetry ☐ Electrocardiography ☐ Noninvasive blood pressure measurements

Radiology Response to CRDC:

MRI is booked for the above patient:

Confirmed Date: _____ **Arrival Time in MRI:** _____
(YYYY/MM/DD)

Estimated Scan Length: _____

Call MRI request to CRDC 613- 549-6666 Ext 4547 and Fax Form to 613-548-13

Date: _____ **Signature:** _____

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Form 3
Screening & Recommendation for MRI Conditional Cardiovascular Implantable Electronic Devices (CIED)

Addressograph Label

Name: _____ DOB: _____ Gender: ☐ M ☐ F
yyyy/mm/dd
Address: _____
Phone #: ( ) - _____
OHIP #: _____ Version Code: _____
CR #: _____

Cardiac Rhythm Device Clinic (CRDC)

Device: ☐ Pacemaker ☐ Loop Recorder ☐ Other _____

Yes No (Please complete the following questions)

☐ ☐ Pacemaker Dependant
☐ ☐ Device/Lead On Advisory _____

Note: All Cardiac Devices with Leads **(Must Be Yes in this Section)**

☐ ☐ MRI Conditional Cardiac Device **Manufacturer:** _____ **Model:** _____
☐ ☐ Pectoral Implant (Rt/Lt)
☐ ☐ Implant > Six Weeks
☐ ☐ MRI Conditional Leads (RA) **Manufacturer:** _____ **Model:** _____
Leads (RV) **Manufacturer:** _____ **Model:** _____
☐ ☐ Pacing Thresholds < 2.0 V @ 0/4 ms **(Not Applicable for Loop Recorders)**
☐ ☐ Lead Impedance 200-1,500 ohms **(Not Applicable for Loop Recorders)**
☐ ☐ No Other Devices, Leads (Including Abandoned), Adaptors or Extenders Present

Arrhythmia Service Recommendations to Radiology:
Yes No
☒ **Device programming pre MRI by CRDC is required for all CIEDs that are successfully screened**
☐ ☐ Device programming post MRI by CRDC
☐ ☐ Other :_____

Additional Recommendations:

Completed by Arrhythmia Physician

Date:_____ **Name:** _____ **Signature:** _____
(YYYY/MM/DD)

Faxed to Radiology 613-548-2410
Date: _____ **Signature:** _____

- **A Collaborative Screening Protocol was developed.**
- Any patient with a cardiac device is screened and follows through these 3 forms if their device is found to be MRI conditional.

- To date 25 MRI scans have been completed for patients with conditional cardiac devices.
- 5 patients were excluded from MRI access as screening showed that their cardiac devices were not MRI conditional.

Conclusions

- Rigorous screening protocols are required by Radiology and Arrhythmia services to mitigate patient risk and ensure patients with conditional cardiac devices are not excluded from MRI access.
- MRI scanning in this patient population should be completed in institutions that can provide cardiac device screening and programming.
- Future education sessions planned for nursing staff working in Radiology in order to transfer monitoring responsibilities during MRIs from Cardiac Rhythm Device Clinic (CRDC) nurses to Radiology nurses.
- Future revisions of screening protocols will be required based on advancement of MRI technologies and the introduction of more MRI conditional cardiac devices.
- Experience performing MRI on patients with conditional cardiac devices is limited, therefore a prospective evaluation, and analysis of our current screening protocol is required to ensure it remains evidence based.

References:
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3.Gimbel JR. The safety of MRI scanning of pacemakers and ICDs: what are the critical elements of safe scanning? Ask me again at 10,000. Europace 2010; 12(7): 915-917
4.Cronin EM, Mahon N, Wilkoff BL. MRI in patients with cardiac implantable electronic devices. Expert Rev Med Devices 2012; 9(2): 139-146
5.Lobodzinski SS. Recent innovations in the development of magnetic resonance imaging conditional pacemakers and ICDs. Cardiol J 2012; 19(1): 98-104
6.Sorrentino RA. A novel MRI-safe dual-chamber pacemaker system: Its time has come. Heart Rhythm 2011; 8(1): 74-75
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