Magnetic Resonance Imaging in Patients with Implanted Cardiac Devices

Site Applicability

PHC

Practice Level

Specialized:
Heart Rhythm Services Device Clinic Nurses, Device Technicians, Electrophysiology (EP) Physicians, Radiology Physicians, MRI Technologists

Need to Know

Clinical Indication: This guideline applies to the care of individuals with an implanted cardiac device requiring magnetic resonance imaging (MRI). This includes leadless, single- or dual-chamber pacemakers, cardiac resynchronization pacemakers, transvenous or subcutaneous cardioverter defibrillators and internal loop recorders.

- It is estimated that up to 75 % of patients with an implanted pacemaker will develop an indication for MRI in long-term follow up.
- Though rare, MRI scanning may cause potential adverse effects to individuals with implanted cardiac devices which include: radiofrequency induced heating of the leads, movement or dislocation of the device or leads, current induction, pacing dysfunction, asynchronous pacing with the possibility of induction of hemodynamically significant tachy-arrhythmias, reed switch activation, changes in capture threshold and loss or changes to programmed data.
- The 2021 Update on Safety of Magnetic Resonance Imaging defines a Non MR-conditional device as a failure to meet both of the following criteria:
    - Device components must all be MRI-conditional and of the same manufacturer. Any combination of products from different manufacturers have not been tested together and therefore cannot be classified as MRI-conditional.
    - Allowable MRI field strength (1.5 or 3.0 Tesla) set by the product specifications. No devices have been tested or approved at higher field strengths (greater than 3.0 Tesla).
- See Appendix A for the protocol and workflow guidelines of Non MR and MR-Conditional devices.
- Device nurse/technician present at the discretion of the heart rhythm team for MR-conditional devices.
- Health care providers with ACLS supervising for Non MR-conditional devices (except non-dependent pacemakers or MR-conditional defibrillators.
- For patients with Non MR-conditional devices, personnel with skills to program devices (physician or

nurse/technologist) should be available on the premises for troubleshooting.

- See Appendix B for recommendations for device scanning modes.
- Although infrequent, MRI referrals for in-patients require special considerations:
    - Referrals for inpatients at SPH should follow the routine process from the Radiology Department which includes provision of the MR requisition form, patient history and device information as well as reason for urgent/emergent status.
    - Inpatients deemed 'emergent or urgent' from other hospitals should be reviewed by the Radiology Department and discussed with the EP physician on call.
    - If coming from another hospital:
        - The most recent device interrogation and last PaceArt note will be requested by the SPH Device Clinic. A copy of the SPH MRI Checklist will be provided to the referring hospital to complete and be returned by fax to SPH at least one day prior to scan.
        - All transport and in-transit nursing considerations must be made by the Radiology Department and the originating hospital.

Follow-up after MRI:

- If no change in device performance noted upon post-MR interrogation, the device can be reprogrammed and the patient can continue with their usual scheduled appointments for device follow-up.
- If changes are noted in device performance, patients should be scheduled for device clinic follow-up urgently or as determined by the EP physician on-call.
- The location of device follow-up, either in-person or via remote monitoring will be at the SPH Device Clinic or their usual Device Clinic.
- If the follow-up is conducted at another Device Clinic, a copy of the interrogation report will be requested by the SPH Device Clinic.

Documentation

Documentation for the clinic assessment and device testing pre and post MRI to be completed on the 'Pacemaker or ICD Checklist for Magnetic Resonance Imaging' Form: PHC-HH126 (see Appendix D).

Patient and Family Education

Patients receive an education pamphlet which includes two appointment times (pre-MRI assessment and MRI scan date) from the EP physician's office upon receiving the referral from radiology (See Appendix C).

Additional information and further discussion of potential risks associated with the scan will occur with the EP physician at time of device clinic pre-MRI assessment and with the radiologist at the time of MRI.

Expected Outcomes

The patient will remain hemodynamically stable. The MRI will be completed safely with no complications. Potential complications include: inappropriate cardiac device pacing, heating of the leads, current induction, movement or dislocation of the device and transient reed switch activation. It is the physician's responsibility to monitor for potential complications and provide intervention as necessary.

Related Documents

Lower Mainland Medical Imaging

References

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8. Paterson, D. I., White, J. A., Butler, C. R., Connelly, K. A., Guerra, P. G., Hill, M. D., ... & Windram, J. (2021). 2021 Update on Safety of Magnetic Resonance Imaging: Joint Statement From Canadian Cardiovascular Society/Canadian Society for Cardiovascular Magnetic Resonance/Canadian Heart Rhythm Society. Canadian Journal of Cardiology, 37(6), 835-847.

Appendix A

MR SCAN PROTOCOL

Non MR-Conditional and Conditional Devices

MRI procedure approved after consultation by Radiologist and referring physician

Absolute contraindications:
- Fractured leads, lead extenders, or adaptors, battery life less than 6 months to ERI mode, capped leads, lead plugs in non MR-Conditional devices

Relative contraindications:
- Leads implanted less than 6 weeks from MRI, epicardial lead, abandoned transvenous lead, device generator overlaps with scan region

YES

Contraindicated (discuss clinical need and possibility of alternate imaging or perform MRI with appropriate programming (see Appendix B)

NO

- X-ray ordered by Radiologist
- Referral package send to Device Clinic with notification of MRI date
- Patient receives MRI education sheet with Pre MRI and Post MRI appointment dates from the Device Clinic

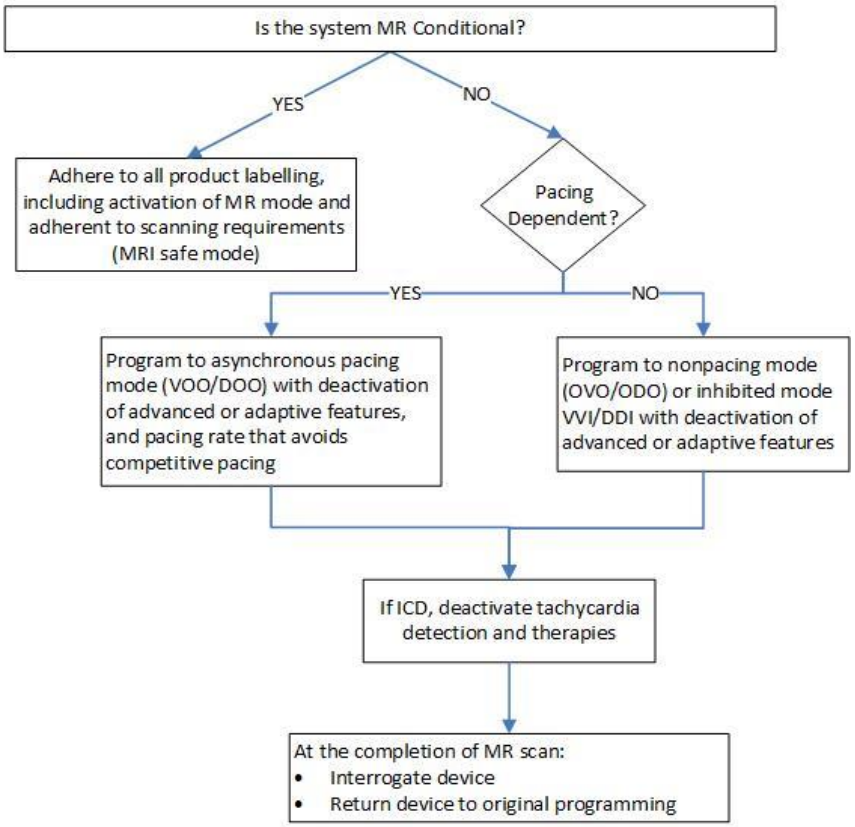
Device Clinic Appointment
- EP Or cardiologist assessment and device interrogation
- Assessment and interrogation report documented on form PHC-HH126
- See appendix B for appropriate device settings for MR scan

MRI
- Informed consent completed with Radiologist (Use form 2745/PHC-MR002,Consent to Treatment)
- X-ray completed (if not already done) and viewed by Radiologist
- Cardiac device testing completed prior to scanning and settings programmed as per guideline (Appendix D) or EP physician orders.
- Patient scanned in MRI room # 1 and attached to continuous ECG monitor, NIBP and pulse oximetry
- Radiologist or designated fellow to be present at all times during procedure to monitor patient's hemodynamic function for non MR-conditional devices (except PM no dependency) or MR-conditional defibrillators.
- Cardiac arrest cart with defibrillator readily available
- Patient's chest, including any other areas the pacing device is implanted in, must be wrapped in RF blankets. RF blankets must fully encompass the patient's chest and be in continuous contact all the way around
- Use a Transmit-Receive coil where possible, use 'Normal' mode, 'Whole' gradients, not 'Zoom'
- Monitor and document Average (whole body) SAR for all sequences. SAR must be less than 2.0 W/kg for all sequences
- Avoid extending FOV or slices to encompass the areas where the device is implanted
- Radiologist should limit the protocol to a minimum number of sequences required for the exam

Post MRI
- Cardiac device testing completed by Device Clinic nurse or technologist.
- Cardiac device settings re-programmed to original settings
- Any changes with cardiac device testing discussed with EP physician on-call
- Follow-up plan for assessment of cardiac device discussed with patient

Appendix B

Recommendations for Device Scanning Mode



Subcutaneous ICD (S-ICD)
- Recommend scanning at 1.5 T in a monitored setting, supervised by health care providers with ACLS
- Tachycardia therapies off for scan

Leadless Pacemakers
- Recommend scanning at an MRI field strength not exceeding manufacturers specification
- Scan in a monitored setting with access to device clinic team for troubleshooting

Implantable/Injectable Loop Recorder
- Recommend scanning at an MRI field strength no exceeding manufacturers specification
- No special requirements necessary for monitoring and access to device clinic team
- Recommend downloading stored data prior to scanning and clearing unwanted data post MRI scan

Appendix C Patient Education

Appointment Information

How you want to be treated.

Magnetic Resonance Imaging with a Cardiac Implantable Electronic Device

Patients with implanted cardiac devices (pacemakers, implantable cardioverter defibrillator, or implantable cardiac monitor) must have a screening exam before having magnetic resonance imaging (MRI).

An MRI is a non-invasive medical test that uses a magnetic field and radio waves to produce images of the body's organs and soft tissues. The magnetic field can affect metal or metallic devices in the body.

There are some potential, but small risks to having an MRI with a cardiac device.

These risks include:

- Malfunction or changes in the programming of the cardiac device.
- Unintended stimulation or alert deactivation.
- Premature battery depletion.

You have 2 appointments booked for your MRI scan.

Appointment	Date and Time	Location
1. Screening Exam St. Paul's Heart Rhythm Device Clinic		St. Paul's Hospital Heart Rhythm Device Clinic 211-1033 Davie Street Vancouver, BC * Note this clinic is not located inside St. Paul's Hospital
2. MRI St. Paul's Hospital Radiology Department		St. Paul's Hospital Providence Building 2nd floor, Radiology Department

1. **Screening Exam Appointment:**

   You will be seen by an electrophysiologist (heart doctor who specializes in the heart's electrical system) at the SPH Heart Rhythm Device Clinic before your MRI to check your cardiac device and talk about the risks associated with the MRI.

2. **MRI Appointment:**

   At the time of your MRI, a member of the SPH Heart Rhythm Device Clinic will check your cardiac device before and after the scan. Your heart will be monitored during the MRI exam. Additional precautions will be taken for your safety during the MRI. If you feel any discomfort during the exam, please let the MRI technologist know immediately.

After your MRI is complete, it is important for you to follow the instructions below.

Follow-up Appointment

- Continue to have your cardiac device checked on your usual follow-up schedule. This may be at the St. Paul's Hospital Device Clinic or your regular Device Clinic or doctor where you have your device checked.
- If you are not a patient of the St. Paul's Hospital Device Clinic, call your usual Device Clinic and let them know you had an MRI.
- We recommend you make an appointment to have your device checked in the next 6-12 months following your MRI. This is to make sure that the MRI has not affected your device. Some effects are not seen immediately after the scan.

When to Get Help

Call your regular Device Clinic if you have either of the following:

- A warm or burning sensation at the site of your cardiac device following the MRI.
- Beeping from your cardiac device.

Call 911 or have someone take you to the nearest emergency department if you have any of the following:

- A shock from the defibrillator (if you have an ICD) and you do not feel well afterwards.
- You experience 2 or more shocks (if you have an ICD) within a 24-hour period.
- If you pass out/faint/lose consciousness.
- Pain in your chest and/or shoulder.
- Dizziness or confusion.
- Your heart feels like it is beating quickly or racing.

Appendix D MRI Pacemaker/ICD Assessment and Checklist

Providence HEALTH CARE

MAGNETIC RESONANCE IMAGING ASSESSMENT AND CHECKLIST FOR PATIENTS WITH PACEMAKER OR ICD

Interdisciplinary Assessment

Place Patient Form Label Here

CLINIC ASSESSMENT (to be completed by physician at time of consultation)

Date of assessment: _____

MRI site: _____

☐ X-ray complete or ☐ X-ray to be done on day of MRI ☐ 12 lead ECG

☐ No documented epicardial leads, lead extender or adaptors present, other devices or abandoned/retained leads

Cardiac device: ☐ Pacemaker ☐ ICD ☐ CRT

MRI conditional generator: ☐ Yes ☐ No All leads MRI conditional: ☐ Yes ☐ No

MRI compatible system: ☐ Yes ☐ No

Model: _____ Date of implant: _____ Site of implant: _____

Lead Model: _____ Date of implant: _____ ☐ Atrial

Lead Model: _____ Date of implant: _____ ☐ Right Ventricular

Lead Model: _____ Date of implant: _____ ☐ Left Ventricular

DEVICE TESTING (to be completed by Device Clinic nurse/technologist during clinic assessment)

P wave	
Atrial threshold	
Atrial impedance	
R wave	
Ventricular threshold	
Ventricular impedance	
Battery longevity	
AP%	
VP%	

Presenting rhythm: _____

Pacemaker dependent: ☐ Yes ☐ No

Underlying heart rate: _____

Current pacing parameters: _____

☐ Pacing capture threshold values stable and below 2V at a pulse width of 0.4 ms

☐ Lead impedances must be 400 to 1500 ohms without change in trend

☐ No pacing related diaphragmatic stimulation

EP Physician orders for device settings during MRI/Comments: _____

EP Physician: _____ (Signature) _____ (Printed name) _____ (College ID)

Device Clinic Nurse/Technologist: _____ (Signature) _____ (Printed name)

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MAGNETIC RESONANCE IMAGING ASSESSMENT AND CHECKLIST FOR PATIENTS WITH PACEMAKER OR ICD

Interdisciplinary Assessment

Place Patient Form Label Here

DAY OF MRI (to be completed by Device Clinic nurse/technologist prior to scan)

Date: _____

DEVICE TESTING (prior to scan)

P wave		Presenting rhythm today: _____
Atrial threshold		Underlying rhythm today: _____
Atrial impedance		☐ Pacing capture threshold values stable and below 2V at a pulse width
R wave		☐ Lead impedances 400 to 1500 ohms without any change in trend
Ventricular threshold		☐ Both leads functioning normally (as evaluated during device check-up)
Ventricular impedance		☐ No pacing related diaphragmatic stimulation
Battery longevity		Device settings: (programmed as per EP physician orders)

Device Clinic Nurse/Technologist: _____ _____
Signature Printed name

POST MRI (to be completed by Device Clinic nurse/technologist upon completion of MRI)

DEVICE TESTING (Post MRI)

P wave		☐ Pacing capture threshold values stable and below 2V at a pulse width
Atrial threshold		☐ Lead impedances 400 to 1500 ohms without any change in trend
Atrial impedance		☐ Both leads functioning normally (as evaluated during device check-up)
R wave		Device settings post MRI: _____
Ventricular threshold		
Ventricular impedance		
Battery longevity		

Notes: _____

_____

_____

Follow-up: _____

_____

_____

Device Clinic Nurse/Technologist: _____ _____
Signature Printed name

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Persons/Groups Consulted:
SPH Device Clinic Registered Nurses and Device Technologists
SPH Heart Rhythm Electrophysiologist Physicians
SPH Magnetic Resonance Imaging Physician team and Technologists

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