

Cardiac magnetic resonance imaging in a patient with temporary external pacemaker: a case report

Uzma Chaudhry ^{1*}, Jonas Svensson ^{2,3}, Henrik Mosén ⁴, and David Mörtzell ¹

¹Department of Cardiology, Clinical Sciences, Lund University, Arrhythmia Clinic, Skåne University Hospital, Getingevägen, Lund S-221 85, Sweden; ²Medical Radiation Physics, Department of Translational Medicine, Lund University, J Waldenströms gata 35, Malmö S-205 02, Sweden; ³Department of Medical Imaging and Physiology, Skåne University Hospital, Getingevägen, Lund S-221 85, Sweden; and ⁴Department of Clinical Physiology, Clinical Sciences, Lund University, Skåne University Hospital, Getingevägen, Lund S-221 85, Sweden

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Background

Magnetic resonance imaging (MRI) is increasingly becoming the imaging modality of choice for many clinical disorders due to superior image quality and absence of radiation. However, access to MRI remains limited for most patients with cardiac implantable electronic devices due to potential safety concerns. In line with guidelines, there is no absolute contraindication to perform MRI, but warrants careful risk-benefit assessment.

Case summary

A 59-year-old man was admitted with a 5-day history of central chest pain and few week's history of general malaise, dry cough, and breathlessness. Electrocardiogram confirmed complete atrioventricular block (CAVB). A slight increase in cardiac enzyme was noted. Coronary angiogram revealed atheromatous changes, but no obstructive coronary lesion. A temporary transvenous pacemaker was inserted. Transthoracic echocardiogram confirmed a dilated left ventricle with severely reduced left ventricular function. To facilitate diagnosis (hence prognosis), management and mobilization, investigation with cardiovascular magnetic resonance (CMR) was warranted but contraindicated by the temporary transvenous pacemaker. An active fixation pacemaker lead was therefore placed in the right ventricle via percutaneous puncture of the right subclavian vein and connected to a pulse generator, both secured to the skin with sutures and adhesive medical dressing. Appropriate device programming and close patient monitoring ensured that CMR could be performed without any adverse effects. A diagnosis of acute myocarditis was confirmed. Regular device interrogation during an extended 3-week period with temporary pacing ruled out any device failure. As there was no resolution of CAVB, the patient received a dual-chamber pacemaker.

Discussion

Cardiovascular magnetic resonance was feasible and safely performed on a patient with a temporary permanent external pacemaker system using a standard screw-in pacing lead and a regular pulse generator fixed to the skin. Although more studies are needed for generalizability, CMR may be used in highly selected patients with a temporary pacemaker.

Keywords

Cardiovascular magnetic resonance • Temporary pacemaker • External pulse generator • Case report

Learning points

- Pre-magnetic resonance imaging, appropriate device programming is essential in addition to continuous monitoring of patient with electrocardiography and pulse oximetry.
- For diagnostic purposes, balancing a risk-benefit assessment, cardiovascular magnetic resonance may be safely performed on selected patients with a temporary permanent external pacemaker system.

* Corresponding author. Tel: +46 46 171209, Email: uzma.chaudhry@med.lu.se

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Introduction

Worldwide, 1.2–1.4 million cardiac implantable electronic devices (CIEDs) are implanted annually.¹ Magnetic resonance imaging (MRI) is increasingly becoming the imaging modality of choice for many clinical disorders due to superior image quality and absence of radiation.² It has been estimated that up to 50–75% of patients with CIED will need an MRI at some point after implantation.^{3,4} However, access to MRI remains limited for most of these patients due to potential safety concerns.^{4,5} Extensive literature and clinical experience is available today which supports MRI examination of patients with conventional pacemaker and implantable cardiac defibrillator systems with low risk for patients, provided a safety protocol is adhered to.⁶

We present a case where cardiovascular magnetic resonance (CMR) was performed on a patient with an external MRI-conditional pacemaker generator with a right ventricular lead, which led to a diagnosis of myocarditis.

Timeline

Time	Events
23 April 2019	Presented to Accident and Emergency department Complete atrioventricular block (CAVB) confirmed Coronary angiography revealed atheromatous changes Temporary transvenous pacemaker inserted via right femoral vein Transthoracic echocardiogram revealed a moderately dilated left ventricle with an ejection fraction (EF) of 30%
24 April 2019	Temporary permanent external pacemaker implanted
25 April 2019	Cardiovascular magnetic resonance was performed at a 1.5 T MR scanner Acute myocarditis diagnosed Ejection fraction 28%
26 April 2019	Pacemaker interrogation; normal sensing, impedance, and thresholds. Continued CAVB
29 April 2019	Pacemaker interrogation; normal sensing, impedance, and thresholds. Intermittent CAVB
30 April 2019	Endomyocardial biopsy with normal findings
6 May 2019	Repeat transthoracic echocardiogram with EF 29%
9 May 2019	Pacemaker interrogation; normal sensing, impedance, and thresholds. Intermittent CAVB.
13 May 2019	Permanent dual-chamber pacemaker implanted
16 May 2019	Discharged home. New York Heart Association Class III.

Case presentation

In April 2019, a 59-year-old man with history of chronic back pains presented to the Accident and Emergency department with a 5-day history of central chest pain and few weeks history of general malaise, dry cough, and breathlessness. On examination, he was pale and clammy. Initial blood pressure was 147/76 and heart rate 59 b.p.m. He was afebrile and had an oxygen saturation of 99% on room air. On physical examination, he had a regular cardiac rhythm with normal heart sounds and vesicular breath sounds. Electrocardiogram showed complete atrioventricular block (CAVB), heart rate 58 b.p.m., and inferior Q-waves. He exhibited transient loss of consciousness and hypotension and telemetry confirmed CAVB with intermittent long pauses. The patient was immediately transferred to the onsite cardiac catheterization laboratory. Coronary angiography revealed atheromatous changes, but no obstructive coronary lesion. A temporary transvenous pacemaker was placed via right femoral vein and programmed to VVI 60. Prophylactic antibiotics with Cloxacillin 2 g t.d.s. was initiated. He was transferred to the Coronary Care Unit for further care.

Troponin-T was 17 ng/L at admission (upper normal limit < 15 ng/L) and peaked at 49 ng/L. Creatine kinase-MB and myoglobin were normal. His brain natriuretic peptide concentration was elevated to a maximum of 1078 ng/L (upper normal limit < 100 ng/L). He had normal renal function and inflammatory markers. Transthoracic echocardiogram revealed a moderately dilated left ventricle with an ejection fraction (EF) of 30% and a mildly reduced right ventricular function. He subsequently decompensated with left heart failure which was treated with intravenous loop diuretics. Forty-eight hours of levosimendan was also given and due to drug-induced hypotension, the patient received noradrenaline.

The patient's underlying rhythm revealed continued CAVB with variable heart rate, necessitating pacing. With differential diagnosis of myocardial infarction, systemic inflammatory disease and myocarditis in mind, potential reversible causes of CAVB, further investigation with CMR-imaging was warranted, however, contraindicated by the temporary transvenous system. Delayed CMR imaging either with or without potential implantation of a permanent pacemaker was not recommendable due to unknown cardiac diagnosis (hence prognosis), and possible need for targeted drug therapy. On Day 1, an active fixation pacemaker lead (PML; Medtronic CapSureFix Novus MRI-conditional 4076-58 cm; Medtronic, Minneapolis, MN, USA) was placed in the right ventricle via percutaneous puncture of the right subclavian vein and connected to a Biotronik pulse generator (Enitra 8 SR-T MRI-conditional; Biotronik, Berlin, Germany). Lead and pulse generator were secured to the skin with sutures and adhesive dressing (Figure 1). Adequate sensing, impedance, and thresholds were achieved.

On Day 2, CMR including late gadolinium enhancement (LGE) was performed at a 1.5 T MR scanner (Magnetom Aera, Siemens Healthcare, Erlangen, Germany) equipped with a body matrix coil. Pre-MRI sensing, impedance, and threshold values were in range. The pacemaker MRI mode was activated; VOO 90 b.p.m. with output 4.8 V at 1.0 ms. Prior to scanning, it was ensured by visual inspection and manual palpation that the pulse generator did not move due to the surrounding magnetic field of the MRI system. The patient was monitored with continuous electrocardiography and pulse oximetry during the 45 min of scanning. The CMR-LGE was done uneventfully.



Figure 1 Temporary pacemaker using standard screw-in lead and pulse generator. Pacemaker lead and pulse generator sutured to skin and dressed. The picture was taken after 3 weeks of temporary pacing, just before contralateral implant of a permanent pacemaker system. There were no signs of infection at removal.

Post-MRI, initial threshold tests revealed elevated values of 3.2–3.4 V at 0.4 ms; however, subsequently, quickly normalized to pre-MRI values within a few minutes. The impedance and sensing values remained within range and battery capacity was unchanged.

The CMR showed mildly dilated left ventricle, 223 mL (normal range 109–191 mL) and the left ventricular EF was 28%. Regional wall motion abnormality was seen; severe hypokinesia/akinesia midventricular/inferior basal with hypokinesia septal midventricular and basal and inferolateral. Myocardial oedema was observed and with LGE seen in the septal, inferior, and lateral wall (*Figure 2*), acute myocarditis was confirmed. The images did not exhibit any artefacts of importance for the assessment of pathology, as a result of MR sequence optimization, but artefacts caused by the PML can, for example, be seen in the right ventricle (*Figure 2*, marked as PML in the left image). The right ventricle had normal size and function.

With confirmed myocarditis of unknown cause, the patient was commenced on heart failure treatment with Ramipril, titrated to 5 mg b.i.d., Furosemide 40 mg o.d., and Epleronone 25 mg o.d. Pacemaker interrogation showed continued CAVB on Days 3 and 6. Endomyocardial biopsy done on Day 7 had normal yield and as white cell count remained normal, including eosinophils and lymphocytes, it was decided against immunosuppressive treatment. Investigations for *Borrelia* and sarcoidosis were subsequently negative. Day 13 echocardiogram showed an EF of 29%. Day 16 pacemaker interrogation

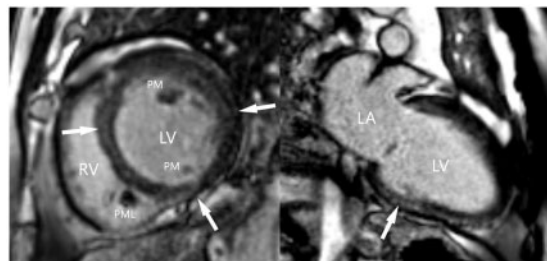


Figure 2 Cardiovascular magnetic resonance showing left ventricular pathology. Images showing late gadolinium enhancement in the septal, inferior, and lateral wall of the left ventricle (arrows). To the left, the heart is shown in short-axis view and to the right in a two-chamber view. The pattern of late gadolinium enhancement, when seen with signs of oedema, can be seen in inflammatory myocardial pathologies like myocarditis and is not typical for ischaemic pathology. LA, left atrium; LV, left ventricle; PM, papillary muscle; PML, pacemaker lead; RV, right ventricle.

revealed intermittent sinus rhythm and CAVB. As there was no resolution of CAVB, a permanent dual-chamber pacemaker was implanted via left subclavian vein on Day 20. A brief attempt was made to implant a left ventricular electrode, but the coronary sinus venogram showed absence of lateral and posterior veins, and a prolonged procedure including interventional techniques was not recommendable due to concurrent risk of device infection. The temporary external pacemaker was explanted without complications and overt signs of infection. Cultures from lead tip did not reveal any growth.

The patient continued to have effort breathlessness, New York Heart Association Class III but was subsequently discharged by Day 23 with planned follow-up in clinic.

Discussion

To our knowledge, this is the first case of successful cardiovascular MRI on a patient with a temporary pacemaker. The investigation was deemed necessary to facilitate prompt diagnosis and targeted management. Computed tomography–positron emission tomography was considered; however, imaging with CMR was chosen due to its cardiovascular diagnostic superiority bearing in mind differential diagnosis of myocarditis and myocardial infarction. In line with guidelines, there is no absolute contraindication to MRI, but warrants careful risk-benefit assessment.⁴ Previously, brain MRI has been performed uneventfully,⁷ however, in a clinical setting where the risk of interaction with the PML may be lower and the diagnostic yield of the examination not affected by the intracardial lead. Three safety concerns arises due to interaction between CIED and MRI.⁵ Firstly, the strong static magnetic field of the MR scanner may activate the reed switch, displace the leads or the device. Secondly, gradient magnetic fields can induce electrical currents in leads, causing over- and undersensing and induction of malignant ventricular tachyarrhythmias. Lastly, the radiofrequency energy generated may cause damage to pulse generator circuitry and battery, induce heat at the lead tip with resultant local tissue damage and risk of

malignant ventricular tachyarrhythmias. Adverse changes in sensing, thresholds, and impedance have also been reported.⁸ The MRI-conditional devices which eliminates the traditional major safety concerns were first introduced in 2008. The clinical experience gathered so far supports the use of MRI provided manufacturer's instructions are followed in regards to programming, timing, and MRI scanner settings. MRI is recommended to be performed at least 6 weeks after implantation due to risk of lead dislodgment.^{4,6}

The use of regular PMLs connected to a standard pacemaker for patients with prolonged need for temporary pacing has been previously described.⁹ In our patient where CMR was indicated, transient change in threshold was noted but quickly normalized, and there was no evidence of device failure.

Conclusion

Cardiovascular magnetic resonance was feasible and safely performed on a patient with a temporary permanent external pacemaker system using a standard screw-in pacing lead and a regular pulse generator fixed to the skin. There were no adverse events during MRI or during the 3 weeks of extended temporary pacing. Although more studies are needed for generalizability, CMR may be used in highly selected patients with a temporary pacemaker.

Lead author biography



Uzma Chaudhry is currently working as a consultant Cardiologist at the department of Cardiology, Arrhythmia clinic at Skåne University Hospital in Lund, Sweden. She has a special interest in cardiac devices and complex arrhythmia. She completed her medical degree in 2006 from University of Newcastle upon Tyne (UK) and did her initial specialist training in London. She completed her PhD from Lund University, Sweden, in 2019.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

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Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

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