Cardiac magnetic resonance imaging of a patient with an magnetic resonance imaging conditional permanent pacemaker

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Abstract

Cardiac magnetic resonance imaging (MRI) is increasingly used as the optimum modality for cardiac imaging. An aging population and rising numbers of patients with permanent pacemakers means many such individuals may require cardiac MRI scanning in the future. Whilst the presence of a permanent pacemaker is historically regarded as a contraindication to MRI scanning, pacemaker systems have been developed to limit any associated risks. No reports have been published regarding the use of such devices with cardiac MRI in a clinical setting. We present the safe, successful cardiac MRI scan of a patient with an MRI-conditional permanent pacing system.

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Introduction

Magnetic resonance imaging (MRI) gives superior imaging resolution and is increasingly the modality of choice for functional and anatomical imaging in cardiovascular disease.[1] In an aging population the prevalence of patients with implanted trans-venous pacing systems means that, increasingly, such patients will require a cardiac MRI study; however, the presence of a permanent pacemaker (PPM) has traditionally excluded MRI as a viable imaging modality.

The use of MRI as a viable and safe imaging modality for individuals with an implanted PPM has been an issue of debate for some time.[2] There is increasing evidence that MRI can be considered safe in certain circumstances.[3,4] However, there are reports of hazards both to the device and the patient, including fatalities.[2,5-10] Historically, the main concerns centered around the potential for the strong magnetic fields to move the device, cause inappropriate pacemaker stimulation, potential alterations to the device programming, and to create cardiac tissue damage through local heating with consequent alteration in lead thresholds.

Confidence has improved following the recent advent of MRI conditional systems, approved and CE marked for conditional use with MRI scanning, including cardiac MRI. Whilst MRI scanning of anatomy remote to the heart has been increasingly reported,[9] there remains a reluctance to use MRI fields to directly image the heart and thorax. Indeed, initial recommendations involved keeping the pacing device away from the isocenter of the magnet, hence precluding cardiac imaging. The concern was that the risk of damage to the device or the patient would be too high if the magnetic field was concentrated directly over the heart, as well as the increased potential for artefact attenuation of image quality. However, despite growing evidence to support the safety of these devices in MRI scanning of the heart under experimental conditions,[9] to our knowledge there are no published reports regarding their use with cardiac MRI in a clinical setting.

Case Report

A 64-year old man presented with a history of increasing exertional breathlessness, chest tightness and intermittent fatigue shortly after undergoing left atrial ablation for paroxysmal atrial fibrillation (AF). Following an initial diagnosis of AF in 2005, medical management with anti-arrhythmic drugs (including amiodarone) had been effective, but worsening symptoms necessitated left atrial ablation with pulmonary vein isolation in 2009. Subsequent to this, he reported increasing breathlessness and chest discomfort.

Due to persistent symptomatic sinus bradycardia, he underwent insertion of a permanent pacemaker system in February 2010. Given his ongoing symptoms and the uncer-

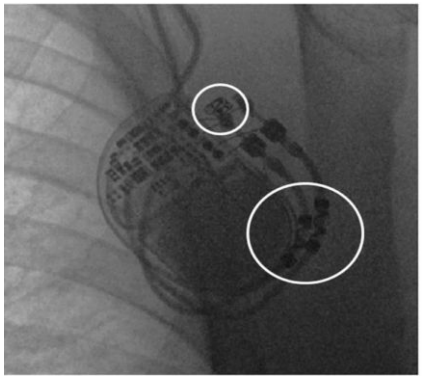

Figure 1. Chest X-ray, enlarged image of generator box. Radio-opaque labels are present on the lead (large circle) and device (smaller circle) to indicate that the device can be used with magnetic resonance imaging.

tainty of the underlying diagnosis, the pacing system selected for implant was a Medtronic EnRhythm MRI™ SureScan™ dual chamber device and CapSureFix MRI™ leads (Figure 1). This pacing system (generator box and leads) is the first to be designed to be compatible with MRI scanning under pre-defined conditions;[11] in general terms, these conditions include marginal limitation of the magnetic field and ensuring that the pacemaker is well established and functioning reliably.

The patient's past medical history included Wolf-Parkinson-White syndrome, with successful ablation of a right free wall accessory pathway in 1995, moderate aortic valve regurgitation, essential hypertension, benign prostatic hyperplasia, obesity (BMI=37) and mild psoriasis. Physical examination revealed a regular paced rhythm, quiet aortic stenotic and regurgitant murmurs, and clear lung fields. Trans-thoracic echocardiography provided non-diagnostic images as a consequence of body habitus. Coronary angiography four years previously had demonstrated no significant coronary disease.

In view of the wide differential diagnosis and the patient's previous exposure to high-dose ionising radiation, MRI scanning was considered the most appropriate imaging modality to gather information on coronary perfusion, left ventricular function, valvular status, pericardial constraint and pulmonary venous anatomy in a single imaging procedure, free of further ionising radiation.

Cardiac magnetic resonance imaging scan

The scan was performed according to a local protocol designed to closely follow the conditions of use published by the manufacturers of the device.[11] Close liaison with the manufacturers' technical representatives was maintained throughout. A 1.5 T magnetic field (Philips Intera, Philips Healthcare, the Netherlands) was employed and specific absorption rate (SAR) was kept to 1 watts/kg or less; well beneath below the 2 watts/kg advised. The device pocket had healed well over the previous five months and lead thresholds were stable, comfortably below the stipulated capture thresholds of 2.0 volts at 0.4 millisecond pulse width (Table 1). As the patient was not dependent on pacing, the device was programmed to the manufacturers' advised setting of ODO (i.e. sensing only, not pacing) during the scan, with continuous non-invasive hemodynamic monitoring. The patient experienced no abnormal sensations during the scan. The device sensing and pacing parameters pre- and immediately post-scan did not change to any significant degree (Table 1). Subsequent pacing checks also proved unremarkable, with no undue changes to battery longevity.

Diagnostic quality images were acquired, including first pass adenosine stress perfusion imaging, and early and late gadolinium enhanced imaging. A minor degree of artefact was reported due to dephasing (Figures 2 and 3) which did not compromise the quality of data interpretation.

The scan comprehensively evaluated both anatomy and function without the need for ionising radiation and without compromising the image quality. The LV dimensions and contractility were normal, as was the stress perfusion scan. Flow velocity imaging showed mild aortic stenosis with moderate regurgitation. The pulmonary veins were shown to be free of stenosis.

Table 1. Characteristics of the pacing leads before and immediately after the scan.

	Pre-scan		Post-scan	
	Atrium	Ventricle	Atrium	Ventricle
Threshold @ 0.4 ms (V)	0.5	1	1	1
Sensing (mV)	3.3	7.8	3.9	7.6
Impedance (nms)	416	480	440	528

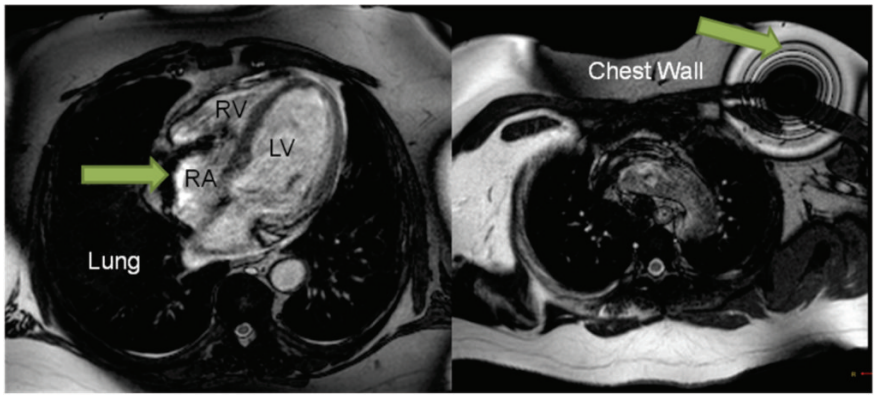

Figure 2. Still images taken from balanced steady state free precession (bSSFP) cine image acquisition. Trans-axial view of the heart (left hand panel) showing lead artefact (arrow) in the right atrium (RA) and right ventricle (RV). Trans-axial view of the pre-pectoral pocket (right hand panel) showing artefact from the pacemaker generator box (arrow): artefact did not compromise the quality of data interpretation.

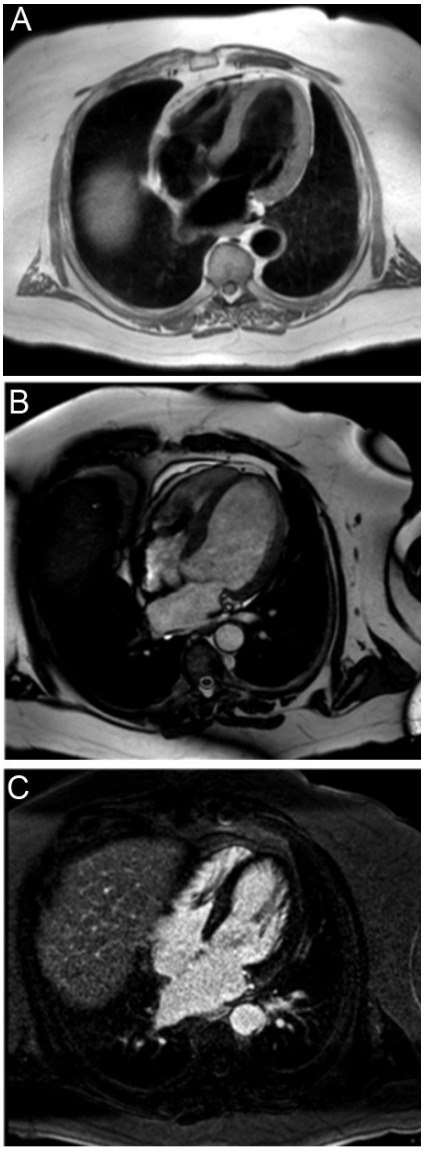

Figure 3. (A) Four chamber orientation of the heart using black blood imaging showing a small amount of artefact in the right atrium. (B) Still image from a bSSFP cine clip showing excellent resolution with only minimal artefact. (C) Late gadolinium enhanced imaging showing absence of left ventricular scarring, again with minimal interference from the pacing leads.

Conclusions

To our knowledge, this is the first report in a clinical setting of the safe use of cardiac MRI to investigate a patient previously implanted with an MRI conditional pacemaker. Only minor adjustments were required to the usual scanning protocol and high quality diagnostic images were readily obtained. Importantly, the patient experienced no ill effects and there was no change in pacemaker function. Whilst there have been reports of MRI scans undertaken on various parts of the anatomy, including the heart, of individuals with pacing devices,[3,4] there have been justifiable concerns about risks of MRI imaging with conventional pacemaker devices.[5-10] We demonstrate that safe high quality cardiac MRI scanning with a dedicated MRI conditional pacemaker device can be performed safely and successfully in a clinical setting.

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