

## RAPID COMMUNICATION

# Feasibility of cardiac magnetic resonance imaging in temporary permanent pacemaker implants in pediatric myocarditis and complete atrioventricular block

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**Abstract**

**Background:** Diagnosing myocarditis in children presenting with complete AV block (CAVB) is challenging. Temporary permanent pacing support using standard transvenous active fixation lead can be inserted percutaneously until recovery. However, access to cardiac magnetic resonance (CMR) imaging may be limited due to safety concerns.

**Cases:** We report three cases where CMR was performed using temporary permanent pacemaker in situ. We evaluated the effect of device artefacts on image quality and examined any instances of device malfunction.

**Conclusion:** In children with CAVB and myocarditis, a temporary permanent pacemaker can provide reliable pacing until recovery, and CMR can be safely performed with the implanted pacemaker without compromising image quality.

**KEYWORDS**

cardiac MRI, complete AV block, myocarditis, temporary permanent pacing

## 1 | INTRODUCTION

Myocarditis presenting as complete atrioventricular block (CAVB) is uncommon. Earlier studies showed that 15% of the biopsy-proven myocarditis had high-grade AV block or CAVB.<sup>1</sup> It can be reversed if diagnosed and treated early, abating the need for permanent pacemaker insertion.<sup>2</sup> Cardiac MRI is the gold standard for diagnosing children with a sensitivity of 86%–91% and specificity of 74%–89%.<sup>3</sup> We prioritize cardiac MRI for stable patients with CAVB and possible myocarditis. For those rapidly deteriorating, like in fulminant myocarditis, we stabilize them first, possibly with mechanical circulatory support, before considering MRI.

## 2 | CASE DETAILS

### 2.1 | Case 1

A 5-year-old boy with fever and seizures had bradycardia and CAVB during a seizure. He had lymphocytic leukocytosis, troponinaemia, mild LV dysfunction, and minimal pericardial effusion. Tests for myocarditis were negative. Given recurrent episodes of asystole and Stokes-Adams seizure-like episodes, he underwent emergent temporary permanent pacing (TPP) with active fixation lead (Medtronic CapSureFix Novus MRI-conditional 4076-52 cm; Medtronic, Minneapolis, MN, USA) from right internal jugular venous (IJV) access and was connected to refurbished SJM

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Endurity PM2160 DDDR pulse generator (PG) with plugged atrial port. After implantation on the second day of presentation, CMR was performed with 36 cardiac channel 1.5T scanner (Siemens, Avanto, Erlanger, Germany) with a parallel acquisition method. Spoiled gradient echo sequences were preferred for cine imaging, with shimming done before each sequence. Late gadolinium enhancement (LGE) sequences were obtained with a higher receiver bandwidth, and T1 map values with a R2 map  $>0.95$  were considered for evaluation to nullify the artefact. As per the protocol described (Figure 2), he underwent CMR, which showed evidence of myocarditis in the form of sub-epicardial LGE, elevated T2 and T1 values and mild pericardial effusion (Figures 1 and 3). After CMR, his pacing lead parameters, battery capacity were normal. The patient received IV immunoglobulin (IVIg) treatment at 1g/kg/day for 2 days. LV function and CAVB normalized. After a 3-day Holter, TPP was removed on Day 10. Child remained in sinus rhythm at the 12-month follow-up.

## 2.2 | Case 2

An 8-year-old girl with fever, sore throat and syncope had an ECG showing CAVB with ventricular rate of 35bpm. She underwent emergency TPP from right IJV with Medtronic CapSureFix Novus MRI-conditional 4076-52cm lead and was connected to refurbished Medtronic Vitatron G20A2 SSIR PG followed by CMR as per protocol (Figure 2) on Day 5 of illness, which was normal. After CMR, the device had normal impedance, thresholds, and unchanged battery capacity. Myocarditis workup was negative. After 10 days

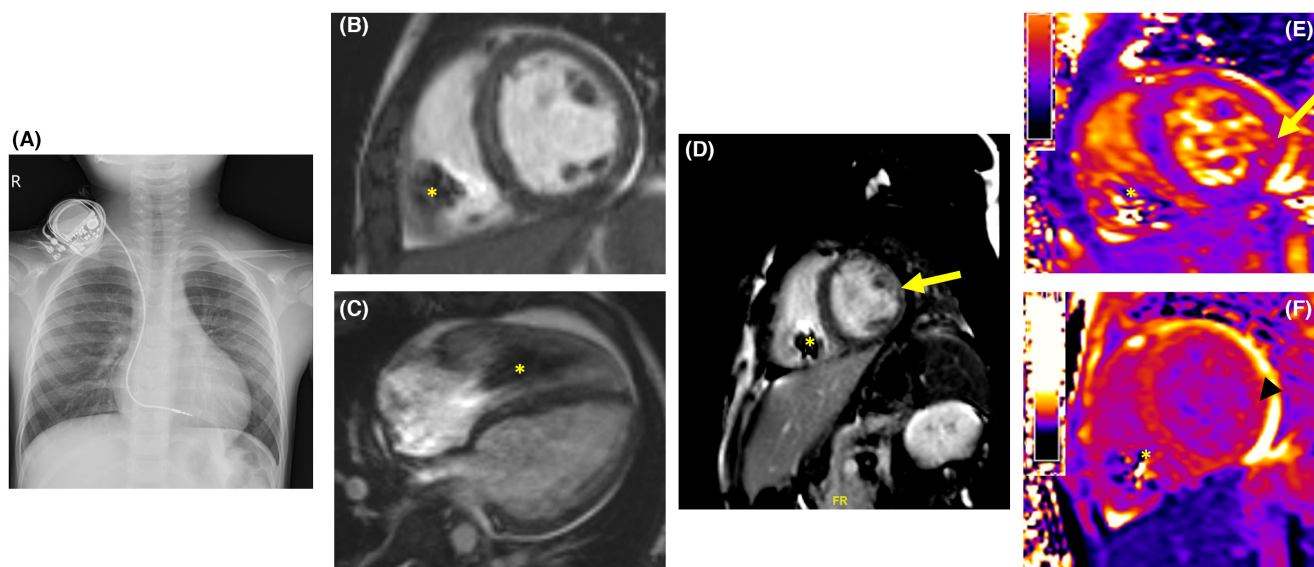
of observation with extended Holter monitoring, the TPP was removed, and the child was discharged. At 3-year follow-up, the child was asymptomatic and in sinus rhythm.

## 2.3 | Case 3

A 3-year-old boy with fever and cough for 2 weeks presented to an outside facility with loss of consciousness. Evaluation revealed CAVB with a rate of 30 bpm. He received emergent TPP from right IJV access with Medtronic CapSureFix Novus MRI-conditional 4076-52 cm lead and connected to a refurbished Biotronik Enticos 4S SSI PG. The patient had mild troponinaemia and moderate LV dysfunction. CMR done as per protocol (Figure 2) showed evidence of subacute myocarditis. IVIG treatment failed and led to a permanent pacemaker implantation after 16 days. During discharge, the LV function returned to normalcy. The child had normal pacing thresholds during follow-up for 4 years (Table 1).

## 3 | DISCUSSION

We report three cases of children with myocarditis and CAVB, where CMR was safely performed despite a TPP insitu. Pacemaker artefacts did not affect image quality. The safety and efficacy of such an approach in children with myocarditis has not been described so far. Our observations have significant diagnostic and therapeutic implications in children presenting with suspected myocarditis, a potential cause of reversible CAVB.



**FIGURE 1** (A) The chest radiograph shows a temporary permanent pacemaker with active transvenous fixing lead in situ. Cardiovascular magnetic resonance imaging of Case 1 where no significant artefacts affecting the diagnostic quality of the image from the lead (asterisk \*) in standard short axis spoiled turbo field echo (TFE) cine sequence (B) and standard long axis TFE cine image (C). (D) Delayed gadolinium enhancement seen over the sub-epicardial region of the anterolateral wall of LV (arrow). (E) shortened MOLLI (ShMOLLI) T1 map demonstrating increased T1 (1148) value in the lateral wall (arrow). (F) T2 mapping showed elevated native T2 relaxation time (69 ms) over the lateral wall of the LV (arrowhead), suggesting myocardial edema.

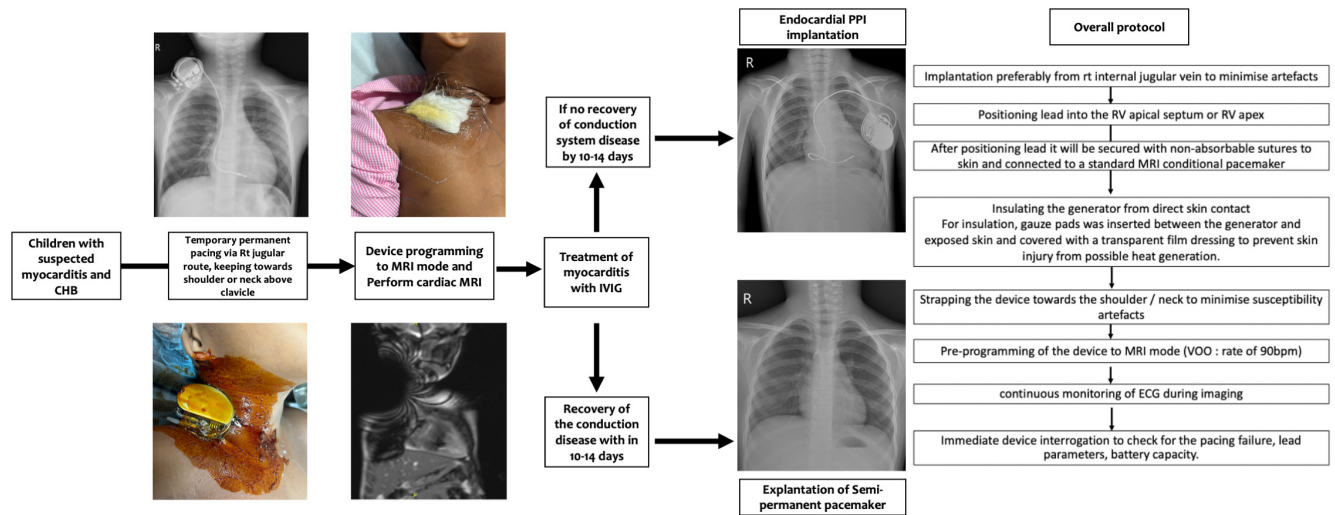


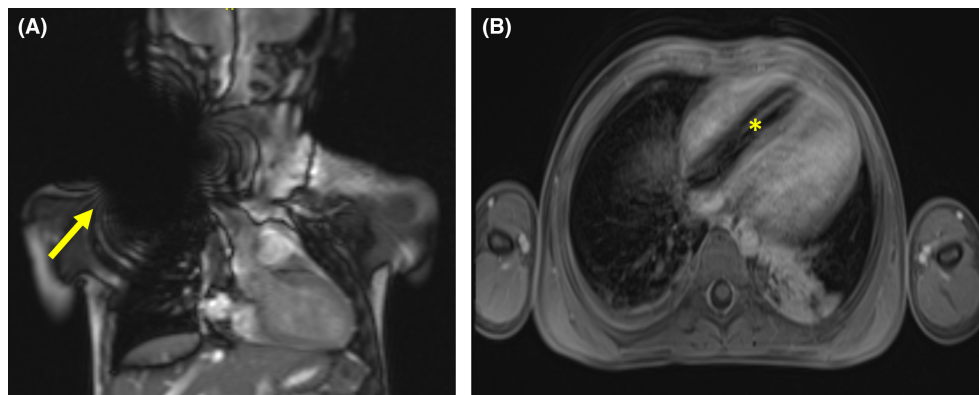
FIGURE 2 Protocol followed in the management of children presenting with complete AV block (CAVB) and suspected myocarditis.

TABLE 1 Clinical, imaging and follow-up characteristics of patients.

Characteristics	Patient 1	Patient 2	Patient 3
Age (years)/gender	5/male	8/female	3/male
Weight (kg)/height (cm)	16 kg/102 cm	20 kg/115 cm	14 kg/98 cm
Day of CMR performed after onset of illness/ After temporary permanent pacing (TPP) insertion	2nd day/same day of admission	5th day/same day of admission	6th day/same day of admission
Presenting complaint	Seizures	Syncope	Loss of consciousness
Serology for myocarditis (virology and PCR)	Negative	Negative	Negative
Troponin-T (ng/mL) (normal reference range: <0.017ng/mL)	0.23	0.19	0.33
Lead and device details	Medtronic Capsure Fix Novus MRI-conditional 4076-52 cm; SJM Endurity PM2160 DDDR pulse generator (PG) with plugged atrial port	Medtronic Capsure Novus 4076 MRI-conditional-52 cm; Medtronic Vitatron G20A2 SSIR	Medtronic CapSureFix Novus MRI-conditional 4076-52 cm; Biotronik Enticos 4S SSI
CMR findings	Sub epicardial LGE in anterolateral wall of left ventricle Elevated T1 and T2 values Pericardial effusion Acute myocarditis EF: 48%, mild LV dysfunction	Normal, EF: 58%, good LV function	Sub epicardial and patchy mid myocardial LGE over anterior and lateral left ventricle Elevated T1 values with normal T2 Subacute myocarditis EF: 37%, moderate LV dysfunction
Follow-up duration and rhythm	1 year, sinus rhythm	3 years, sinus rhythm	4 years, V paced rhythm

After initial safety concerns with MRI in patients with CIEDs, manufacturers developed MRI-conditional pacemakers to reduce device-related MRI interaction. However, proposed safety concerns with acute implantation of active fixation leads were (i) Displacement of device or pacing leads due to activation of reed switch from strong magnetic field of the MRI scanner. (ii) Gradient magnetic currents during MRI can induce electricity,

leading to over or under-sensing. (iii) Radiofrequency energy generated can damage the PG circuitry and may induce heat at the lead tip, resulting in local tissue damage and malignant ventricular arrhythmias.<sup>4-6</sup> With the leap in pacing technology, some of these issues were addressed. Still, most CIED manufacturers specify an exemption period of 6 weeks between implantation and MRI to avoid the risk of dislodgement.<sup>7</sup> Studies showed that with proper



**FIGURE 3** Balanced steady-state free precession (b-SSFP) cine images of Case 1 showing susceptibility artefacts from the pulse generator (arrow) at the right shoulder in coronal view (A) and from the right ventricular lead (asterisk \*) axial sections placed at right ventricular (RV) apex (B). These artefacts do not usually hinder diagnostic interpretation, except when the region of interest is near the pacemaker pulse generator or lead.

programming and adherence to dedicated safety protocols, MRI can be done safely in CIED patients.<sup>8</sup> However, recent guidelines suggest that performing an MRI earlier, if clinically warranted, is reasonable.<sup>9</sup> Existing data showed the feasibility of cardiac or non-cardiac MRI in patients with TPP within a median of 6 days of implantation.<sup>4,10,11</sup> However, feasibility and safety in pediatric patients is unknown.

For myocarditis patients, reliable pacing can be achieved using a simple protocol (Figure 2) until inflammation subsides. AV conduction recovery is seen in 67%–81% of patients within the first week of illness.<sup>12,13</sup>

According to the protocol, patients underwent CMR, and artefacts did not hinder the diagnostic interpretation, allowing the exclusion of myocarditis. (Figures 2 and 3). Artefact reduction was achieved with lowering field strength (1.5T), using spoiled gradient sequences, wideband LGE sequence, higher bandwidth and PG strapping.

## 4 | CONCLUSION

MRI conditional CIED as a TPP system illustrated in these cases with CAVB and myocarditis can assuage the concerns about the performance of CMR in children with suspected myocarditis with TPP and accordingly facilitate the diagnosis and treatment.

### CONFLICT OF INTEREST STATEMENT

Authors declare no conflict of interests for this article.

### PATIENT CONSENT STATEMENT

Written and informed consent has been obtained from all three involved patients, and they have approved this information to be published in this case series/brief communication.

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