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Case Report

Magnetic resonance imaging in a patient with an implantable cardiac defibrillator

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ABSTRACT

A 58-year-old man, in whom an implantable cardiac defibrillator (ICD) had been implanted for Brugada syndrome, suffered rapidly progressive general paralysis. Various diagnostic imaging techniques were performed, but the cause could not be determined. Magnetic resonance imaging (MRI) scanning was performed. A 1.5-Tesla MRI system was used, and the ICD was programmed to ODO mode and all tachycardia detection was turned off. MRI was performed safely under electrocardiogram and pulse oximeter monitoring, and appropriate precautions were taken in preparation for an emergency. ICD parameters did not change in post-imaging investigations. MRI revealed an apparent tumor in the patient's medulla and upper cervical spinal cord, which was diagnosed as high-grade astrocytoma. When performing MRI procedures in patients with an ICD under urgent conditions, it is necessary to have complete knowledge of the procedure and to make careful preparations.

1. Introduction

Magnetic resonance imaging (MRI) is a diagnostic technique that has become the imaging modality of choice for many neurological and musculoskeletal disorders. However, a growing number of patients are being treated with cardiac implantable electric devices (CIEDs), such as pacemakers (PMs) and implantable cardiac defibrillators (ICDs), and cardiac resynchronization therapy. The use of MRI has been contraindicated in patients with implanted CIEDs. However, MRI is sometimes necessary in these patients for a variety of practical reasons. A number of cases of MRI scanning in patients with PMs, and some cases in patients with ICDs, have been reported in the United States and Europe [1,2]; however, in Japan there are few reports on MRI use in patients with PMs and, in particular, none on patients with ICDs.

2. Case report

A 58-year-old man, who had been treated for neurofibromatosis type 1 in the dermatology department and bronchial asthma in the respiratory department of our hospital, presented to the cardiology department with a Brugada-like electrocardiogram (ECG) in 2005. The patient's brother had died from sudden death at age 53. The baseline ECG was saddleback type, but intravenous pilsicainide injection at 1 mg/kg induced a typical coved-type ECG. Also in his electrophysiological assessment, ventricular fibrillation was induced by 2 extrastimuli from the right ventricular apex. Familial Brugada syndrome was highly suspected and an ICD was implanted. The device was exchanged in 2010 because the battery had become exhausted.

In September 2011, the patient suffered right-sided paralysis, which rapidly progressed to all 4 limbs, and was admitted to the neurology department. His ECG showed a saddleback pattern in the right precordial leads consistent with Brugada syndrome. An ICD with an atrial lead and a dual-coil ventricular defibrillation lead was apparent on his chest radiograph (Fig. 1). To identify the etiology of the paralysis, contrast-enhanced computed tomography (CT), CT myelography, cerebral blood flow scintigraphy, and whole-body gallium scintigraphy were performed, but no obvious abnormality was found. In the meantime, his condition worsened and he experienced aspiration with swallowing disturbance; steroid pulse therapy was administered to relieve the symptoms. At this point, fluorodeoxyglucose positron emission tomography (FDG-PET)/CT was performed, and it showed obvious uptake at the patient's medulla to his upper cervical spinal cord, suggesting the presence of a malignant tumor. To confirm this diagnosis and establish a treatment plan, we performed MRI. Written informed consent containing the risks of this procedure including ICD dysfunction or damage, fatal arrhythmia, and death was obtained from the patient and his family.

The patient had an implanted Medtronic SECURA DR device (atrial lead: Medtronic 6940/52 cm, ventricular lead: Medtronic

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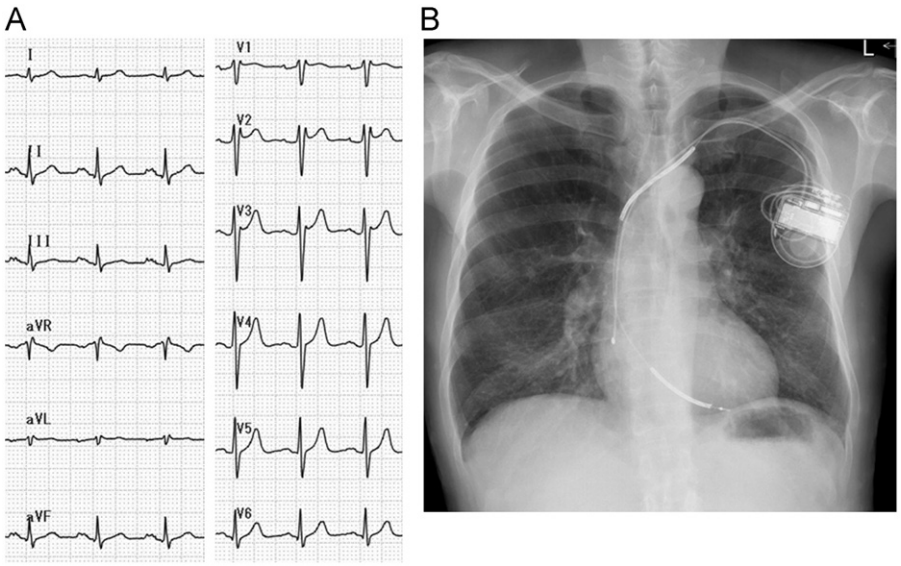

Fig. 1. (A) Electrocardiogram and (B) chest radiograph on admission. The electrocardiogram showed a saddleback-type Brugada ECG. A dual-chamber ICD was apparent in the left subclavian area, and an atrial lead and a dual-coil ventricular defibrillation lead were connected to the ICD.

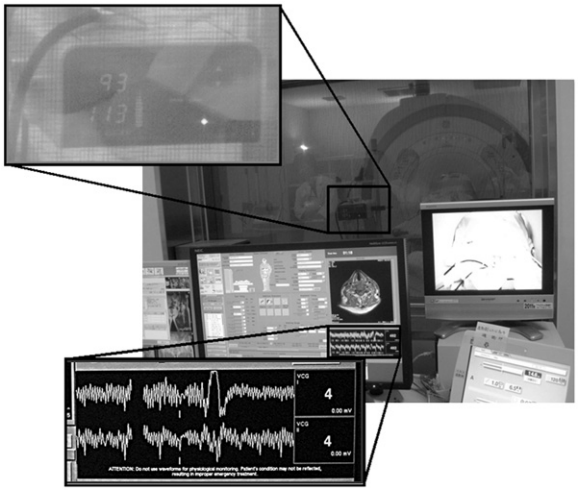

Fig. 2. Placement of monitors at the MRI console. The ECG monitor was displayed on the main control screen; however, heart rhythm was not determinable during scanning due to noise. The monitor of the pulse oximeter was placed so that it could be seen from outside the room. Thus, the patient's pulsatile rhythm was monitored continuously during the study. A television monitor showed the patient's appearance.

6945/65 cm). The MRI machine used was a GE Signa HDx 1.5-Tesla system. Before performing MRI, we referred to the European position statement on MRI in patients with CIEDs [3]. Because sinus rhythm was maintained and ventricular tachycardia was not experienced, we programmed the pacing mode of the ICD to ODO and turned off all tachycardia detection. A radiology technician, nurse, clinical engineer, radiologist, neurologist, and cardiologist were present in the control booth. A device programmer, an external defibrillator, and an emergency cart were set at the MRI console. An ECG monitor, usually used for ECG synchronization during MRI scanning, and a pulse oximeter were fixed to the patient. The pulse monitor was placed where it could be seen from the control room. Furthermore, a television camera was employed to monitor the patient's appearance (Fig. 2).

Diffusion-weighted imaging (DWI), T2-weighted (T2W), fluid-attenuated inversion-recovery (FLAIR), and gadolinium-enhanced T1-weighted (Gd-T1W) imaging protocols were performed during the examination. Because remote programming was available with the patient's ICD device, the intracardiac rhythm was monitored until the patient entered the room; however, after closing the door, remote monitoring was not possible. After closing the door, ECG monitoring began. However, during MRI scanning, the noise became loud enough to obscure the continuous determination of the heart rhythm by ECG. The pulse oximeter, however, showed the patient's pulse continuously during scanning. The patient showed no disturbance during the study, and no ICD parameter changed significantly just after or 1 week after the scan, when compared with the last pre-scan data. Atrial pacing threshold was 1.0 V at a 0.4 ms pulse width before MRI scanning, 1.0 V after scanning, and 0.75 V after 1 week. Ventricular threshold was 0.5 V at a 0.4 ms pulse width, 0.75, and 0.75 V before, just after, and 1 week after scanning, respectively. In the same way, intrinsic atrial amplitude was 3.6, 3.6, and 3.8 mV, respectively. Intrinsic ventricular amplitude was 15.0, 15.1, and 12.9 mV, respectively. Atrial lead impedance was 494, 494, and 475 Ω, respectively. Finally, ventricular lead impedance was 437, 475, and 418 Ω, respectively.

MRI revealed an apparent tumor in the patient's medulla and upper cervical spinal cord, with partial extension towards the fourth ventricle (Fig. 3). The post-MRI diagnosis made was that of a neurogliomatous tumor. Following these results, biopsy of the tumor at the fourth ventricle was performed, and the tumor was diagnosed as a grade III–IV astrocytoma. Subsequently, radiotherapy was started in this patient.

3. Discussion

We performed cranial to cervical MRI scanning safely in a patient with ICD implantation who showed signs of central neurological disease that could not be diagnosed by other imaging techniques.

For patients with CIEDs such as PMs or ICDs, MRI could induce adverse effects including tissue heating, failure of capture, runaway PM function, unpredictable reed switch behavior, asynchronous pacing, or damage to PM circuitry [4]. Consequently, MRI is contraindicated in such patients. However, in medical situations such as the case described here, MRI has an

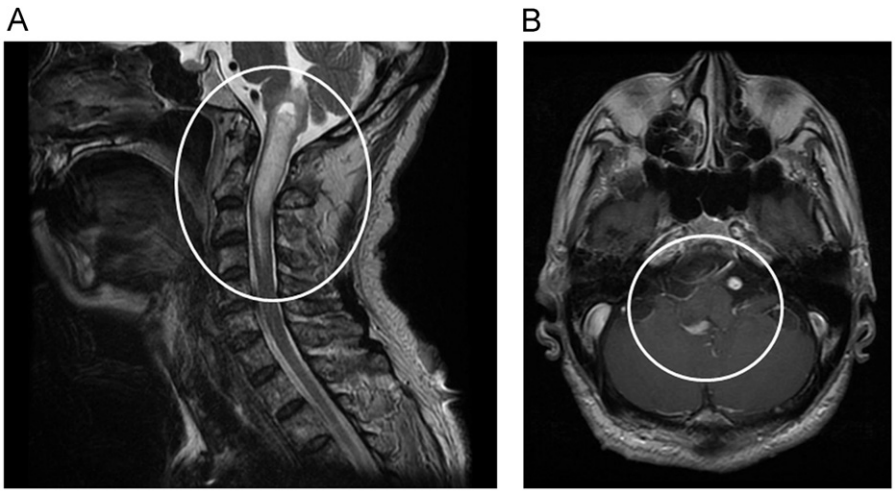

Fig. 3. Cranial to cervical MRI. (A) A sagittal section of the T2-weighted image shows an apparent high-intensity region at the medulla to upper cervical spinal cord, indicating a brainstem tumor. (B) A transverse section at the level of medulla shows partial extension of the tumor towards the fourth ventricle.

indispensable role in diagnosis, especially for brain and cerebrospinal diseases, and is occasionally necessary.

In North America and Europe, the use of MRI in patients with PMs and ICDs has been reported in some cases. Two position statements, one from the European Society of Cardiology and the other from the American Heart Association, guide clinicians who are conducting MRI in patients with CIEDs [3,5]. We performed the MRI described in the current study according to both of these statements. We built enough consensuses among the clinicians involved to perform MRI for this patient. We used a 1.5-Tesla MRI machine with a maximum specific absorption rate of 2.13 W/Kg, without taking special measures. A pulse oximeter proved very effective in monitoring the patient's status during MRI scanning. We used the ODO setting for programming of the ICD device, and no adverse events were observed. Although MRI is thought not to induce severe adverse events when used appropriately in non-PM-dependent patients, great care must be taken with pacing-dependent patients. Furthermore, because rapid stimulation events in a phantom study [3] and device resetting in a human case [2] have been reported, patients at high risk for life-threatening arrhythmia should be subject to particularly vigilant supervision.

A United States Food and Drug Administration (FDA) approved MRI-conditional PM, and some PMs and ICDs that are MRI-conditional in the European Union, although they are not domestically approved, will be available in Japan in the near future. However, when using these devices, interrogation and reprogramming before and after MRI will be important; furthermore, some characteristics of both the patient and the machinery will continue to restrict the use of MRI in CIED patients. Moreover, to be fully MRI-conditional, both CIED generators and leads must be suitable for use in MRI machines; therefore, it will take some time before CIEDs are truly compatible with MRI use.

4. Conclusions

We performed cranial to cervical MRI in a patient with an ICD who needed urgent diagnosis. As similar situations will continue to occur in the near future, it is important to have accurate knowledge of, and to prepare appropriate systems for, the use of MRI in CIED-implanted patients.

A summary concerning the use of MRI in such situations follows. (1) Absolute safety of MRI in patients with an ICD of a previous or current version cannot be guaranteed, and each case requires a careful risk–benefit evaluation. (2) Potential adverse effects of MRI must be explained to the patient, and informed consent must be obtained. (3) Specific absorption rate and total active scan time, such as the length of radiofrequency exposure, is limited according to the appropriate recommendation or scientific statement, and high-risk anatomic regions with full coverage of the lead loop must be excluded. (4) Reprogramming of the ICD should be carried out as appropriate, including setting the pacing mode to ODO and turning off all tachycardia detection, and a physician with electrophysiological expertise should perform post-scan device reprogramming. (5) Continuous monitoring of ECG and pulse oximetry is needed. (6) MRI should be performed under well-controlled circumstances, for example, resuscitation facilities should be available at the MRI site.

Conflict of interest

None.

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