Reprinted with permission from
JOURNAL OF PACING AND CLINICAL ELECTROPHYSIOLOGY, Volume 25, No. 9, September 2002

Implantable Cardioverter Defibrillator Dysfunction During and After Magnetic Resonance Imaging

OLE-GUNNAR ANFINSEN, ROLF FRANCK BERNTSEN, HALFDAN AASS, ERIK KONGSGAARD, and JAN PEDER AMLIE

From the Department of Cardiology, Rikshospitalet, University Hospital of Oslo, Oslo, Norway

ANFINSEN, O.-G., ET AL.: Implantable Cardioverter Defibrillator Dysfunction During and After Magnetic Resonance Imaging. *This report describes a patient in whom a MRI of the brain was performed without realizing that an ICD had been implanted 8 days previously. Electromagnetic noise induced during the MRI was detected as ventricular fibrillation and nearly caused inappropriate shocks. Charge time during MRI was prolonged. The battery indicator switched to "end of life," but this was reversed by capacitor reformation. These problems could have been avoided by inactivating the ICD prior to MRI. Three months later, the pacing threshold increased from 0.4 V per 0.5 ms at implantation to 2.8 V per 0.5. It is still uncertain whether radiofrequency current heating at the electrode tip caused the increased pacing threshold or if this would have occurred independently of the MRI. MRI of patients with an active ICD may cause life-threatening complications, and it is unknown if MRI may be safely performed if the ICD is inactivated. Therefore, MRI of patients with an ICD remains contraindicated. (PACE 2002; 25: 1400–1402)*

implantable cardioverter defibrillator, magnetic resonance imaging, electromagnetic noise, ventricular tachycardia

Introduction

An implanted cardioverter defibrillator (ICD) or pacemaker usually contraindicates magnetic resonance imaging (MRI). There are potential hazardous effects related to magnetic force and displacement of the generator, electromagnetic interference resulting in asynchronous pacing, inhibition of a demand pacemaker, reprogramming, or thermal myocardial injury.

However, over the years some reports have emerged about patients with pacemakers subjected to MRI.[1–3] With modern pacemaker generators, it may be safe to perform MRI provided certain precautions are taken.[3]

Experience with ICDs and MRI is still limited, and decisions are largely based on phantom studies and theoretical consideration.[4] This report describes a patient in whom MRI of the brain was performed without the knowledge that an ICD had been implanted, which resulted in malfunction of the defibrillator.

Case Report

A 45-year-old man experienced ventricular fibrillation (VF) 6 months after a myocardial infarction. Despite early resuscitation and defibrillation, hypoxic brain injury with severely reduced short-term memory persisted. After 7 weeks of partial rehabilitation, a Ventak Prizm VR single chamber ICD (Guidant Inc., St. Paul, MN, USA) with an Endotak Reliance S (Guidant) (steroid-eluting tip) endocardial lead was implanted. The ICD was programmed to detect heart rates > 190 as VF and deliver shocks of 31 J with backup VVI pacing at a rate of 40.

Eight days after the operation, a MRI of the brain was requested at another hospital without realizing that an ICD had been implanted. Sagittal T2, axial T1- and T2-weighted series, and a "FLAIR-sequence" (Fluid Attenuated Inversion Recovery) (i.e., a T2-weighted sequence that suppresses signals from the cerebrospinal fluid) were performed with a magnetic field strength of 0.5 Tesla.

The ICD was interrogated the next day. Two "episodes" with an 11-minute interval had been detected during MRI. Stored electrograms showed electromagnetic noise superimposed on normal sinus rhythm that was detected as VF (Fig. 1). Charging of the capacitors occurred, but both therapies were diverted due to a noise-free interval at the time of reconfirmation. Charge times were 16 and 45 seconds, respectively.

Battery voltage at interrogation was 3.25 V (similar to implantation), but the battery indicator had switched to "end of life" due to the prolonged second charge time. After the capacitors had been

Address for reprints: Ole-Gunnar Anfinsen, M.D., Dept. of Cardiology, Rikshospitalet, University Hospital of Oslo, N-0027 Oslo, Norway. Fax: +47-23073917; e-mail: ole-gunnar.anfinsen@rikshospitalet.no

Received October 8, 2001; revised November 15, 2001; accepted January 30, 2002.

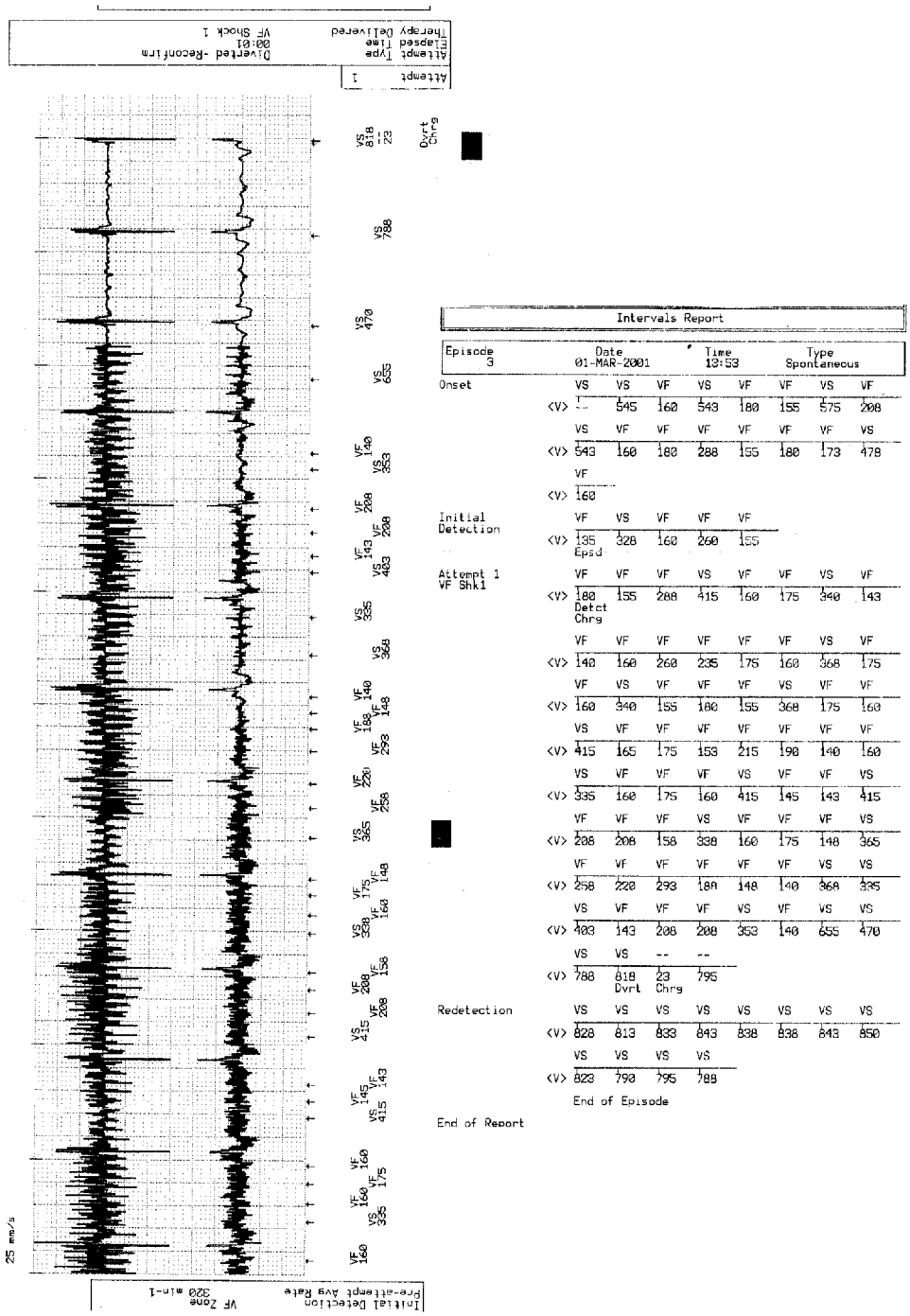

Figure 1. *Stored electrograms and intervals report from the first "episode" during magnetic resonance imaging of the brain, showing electromagnetic noise superimposed on normal sinus rhythm (HR 70) detected as ventricular fibrillation. Charging of the capacitors occurred, but therapy was diverted due to a noise-free interval at the time of reconfirmation. Charge time for this episode was 16 seconds.*

reformed twice, the battery indicator returned to "beginning of life."

No dislocation of the generator or injury to the pocket was observed. No imaging artifacts due to the ICD could be detected on the MRI brain scan.

Pacing threshold at 0.5-ms pulse duration increased from 0.4 V at implantation to 1.6 V 2 weeks after the MRI, and 2.8 V 3 months after the implantation. No further increase was found at 6 months. R wave morphology, amplitude, pacing, and high voltage impedances were unchanged.

VF was reinduced during deep sedation to secure proper ICD sensing, detection, and defibrillation. Later, the patient experienced one appropriate shock from the ICD: a fast ventricular tachycardia (VT) (HR 270) occurring during walking was converted by 31 J. Charge time for this event was 10 seconds and the shock impedance was 49 Ω.

Discussion

The presence of an implanted ICD still represents an absolute contraindication to MRI. Whenever MRI is requested at the University Hospital of Oslo, a written checklist has to be filled in and signed by the referring physician and a radiographer. It is explicitly asked whether the patient has a pacemaker electrode or other metal implant, and if he is able to communicate adequately. At the other hospital where the patient was treated, a written checklist was not mandatory, but radiographers were instructed to ask about metal implants. This routine proved to be insufficient for a patient with severely impaired short-term memory. However, it is the referring physician's responsibility to check contraindications before any examination.

This case describes what actually may happen if an active ICD is subjected to MRI. By inactivating arrhythmia detection prior to MRI, the problem of electromagnetic noise being detected as VF would have been avoided. This patient was close to receiving two inappropriate shocks during MRI. The reason for the prolonged charge time is unknown and warrants further study. It appears that the "end of life" indicator was set as a result of the MRI exposure. Whether this was due to suppression of battery voltage or due to interference with the monitoring circuit is unclear.

The increased pacing threshold may be caused by radiofrequency energy heating at the electrode tip during MRI.[3,5] The R wave amplitude and morphology were unchanged, but it is difficult to exclude micro-dislocation of the electrode tip as an alternative explanation. Such an increase of pacing threshold may also be seen occasionally during the first months after implantation without any obvious reason; currently there is only a 6-month follow-up on the patient. One might argue that the electrode should have been changed immediately. The authors have been reluctant with a new operation due to the patient's general condition with severe hypoxic brain injury. Of note, the ICD functioned correctly at induced VF and at a spontaneous fast VT.

Conclusion

Electromagnetic noise induced during MRI may be detected as VF and cause inappropriate shocks. Charge time may be prolonged during MRI. The battery indicator may switch to "end of life," but this is reversible by capacitor reformation. These problems could have been avoided by inactivating the ICD prior to MRI. It is still uncertain whether RF current heating at the electrode tip caused the increased pacing threshold, or if this would have occurred independently of the MRI. The presence of an ICD still represents an absolute contraindication to MRI. It is highly recommended to use signed checklists before referring patients to MRI.

References

1. Alagona P Jr, Toole JC, Maniscalco BS, et al. Nuclear magnetic resonance imaging in a patient with a DDD Pacemaker. PACE 1989; 12:619.
2. Gimbel JR, Johnson D, Levine PA, et al. Safe performance of magnetic resonance imaging on five patients with permanent cardiac pacemakers. PACE 1996; 19:913–919.
3. Vahlhaus C, Sommer T, Lewalter T, et al. Interference with cardiac pacemakers by magnetic resonance imaging: Are there irreversible changes at 0.5 Tesla? PACE 2001; 24: 489–495.
4. Luechinger R, Duru F, Scheidegger MB, et al. Force and torque effects of a 1.5-Tesla MRI scanner on cardiac pacemakers and ICDs. PACE 2001; 24:199–205.
5. Duru F, Luechinger R, Scheidegger MB, et al. Pacing in magnetic resonance imaging environment: Clinical and technical considerations on compatibility. Eur Heart J 2001; 22:113–124.