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# Clinical Medicine Insights: Cardiology

# Electromagnetic Interference with Implantable Cardioverter Defibrillators Causing Inadvertent Shock: Case Report and Review of Current Literature

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**ABSTRACT:** As the number of patients having implantable cardioverter defibrillator (ICD) devices is increasing, it is important for the physicians and patients to be aware of situations and conditions that can result in interference with normal functioning of these devices. There are multiple cases of malfunction of ICDs reported in literature and it may be of great significance to have an overview of these incidents for appropriate recognition and future prevention. Here we are reviewing the available literature as well as reporting an interesting case of electromagnetic interference (EMI) resulting from leak of current in pool water causing firing of ICD.

**KEWORDS:** defibrillator, electromagnetic interference, inadvertent shock

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### Introduction

Implantable cardioverter defibrillators (ICDs) are a proven therapy for secondary and primary prevention of sudden cardiac death.<sup>1,2</sup> Because of their effectiveness, the number of patients having these devices is increasing by the day.<sup>3</sup> So, it is important for the primary care physicians, cardiologists, and the patients alike to be aware of the common problems that can be encountered. Electromagnetic interference (EMI) is one of the inappropriate causes of firing of automatic ICDs (AICDs). We are reporting a case of AICD firing due to EMI resulting from leakage of electric current in the pool.

### **Case Report**

This is a case of a 76-year-old male with past medical history of gout, diabetes mellitus, coronary artery disease, and ischemic cardiomyopathy with ejection fraction of 30%. His past surgical history is significant for coronary artery bypass grafting.

Patient had an AICD which was implanted in July 2006. The device was EnTrust D154ATG made by Medtronic. The atrial lead was 5594 CapSure SP Novus, made by Medtronic and implanted in July 2006 while right ventricle/superior vena cava (RV/SVC) lead was 6947 Sprint Quattro Secure, made by Medtronic and implanted in March 2009. On his current presentation, he came to see his cardiologist after being shocked by his ICD three times.

The patient was swimming in his pool when he felt these shocks. He denied any chest pain, palpitations, headache, lightheadedness, or dizziness before being shocked. As soon as he felt shocks, he came out of the pool and did not get any further shocks after coming out of water. The patient was taking subcutaneous insulin, aspirin, clopidogrel, metoprolol, candesartan, simvastatin, furosemide, famotidine, allopurinol, and colchicine at home. The patient was allergic to penicillin and social history was significant for smoking half a pack of cigarettes per day for 40 years. The physical



examination was normal. From the ICD interrogation done in his cardiologist's office, the device was programmed to detect ventricular fibrillation (VF) at > 188 bpm and ventricular tachycardia (VT) between 162–188 bpm. Sensitivity was programmed to 0.3 mV. Pacing lead impedance was 272 ohms and defibrillator lead impedance was 39 ohms for RV and 52 ohms for SVC. Stored intra-cardiac electrograms recorded during this event showed high frequency undulating noise consistent with 60 Hz alternating current (Fig. 1). This was interpreted by ICD as VF and was shocked three times (Fig. 2). The pool was examined by a certified electrician who found a small leak into the pool from a lamp. The problem was fixed. Patient was counseled to be careful handling electrical equipment.



Figure 1. Intra-cardiac electrocardiograms recorded by the device during the event showing, high frequency electromagnetic interference in the background of normal QRS morphology (White Arrows), shocks delivers during this event (marked as stars), black arrow denotes the time when patient came out of pool and shows disappearance of EMI with no further shocks.



# Discussion

EMI, also called radio frequency interference (RFI) when in high frequency or radio frequency, is a disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source. The disturbance may interrupt, obstruct, or otherwise degrade or limit the effective performance of the circuit. For the normal functioning of an ICD, appropriate detection of myocardial action potentials is needed. EMI resulting in ICD malfunction is a well-known phenomenon.<sup>4</sup> Source of EMI may be a normally functioning device including electronic article surveillance systems, hand-held radiofrequency remote controls, slot machines, abdominal muscle stimulators, etc. EMI may also be due to leakage of alternating electrical



Figure 2. Intra-cardiac electrocardiograms recorded by the device during the event showing, high frequency electromagnetic interference in the background of normal QRS morphology (White Arrows), shocks delivers during this event (marked as stars), black arrow denotes the time when patient came out of pool and shows disappearance of EMI with no further shocks.

#### Table 1. Reported cases of EMI related ICD malfunction.

NO.	AUTHORS	CAUSE OF EMI LEADING TO ICD FIRING
1	Stelios P. et al. <sup>7</sup>	Electrical current leakage from the electrical switch that was not grounded in the bathroom
2	Ali M et al. <sup>5</sup>	Accidental contact with AC power line during work
3	Ashok G. et al.4	Shower with minimal electrical leak
4	Sung L. et al. <sup>8</sup>	Swimming in a pool with minimal electrical leak
5	Ayman A et al.9	Refrigerator with unearth power supply
6	Ngai C. et al. <sup>10</sup>	<ul> <li>Outdoor use of power drill in rain</li> <li>Washing machine</li> </ul>

current from different devices such as a washing machine, refrigerator, swimming pool, and shower, among many others.

If the radiofrequency signal is strong enough, it can be detected by the ICD. The detection of these signals depend on various factors including the strength of signal, distance of the device from the source of EMI, path of the current through the body, and the size of receiver.<sup>5</sup>

ICDs have built-in algorithms for detection of ventricular dysrhythmias. It is difficult for these algorithms to differentiate EMI from true ventricular arrhythmia; thus EMI may be detected and interpreted by an ICD as a shockable rhythm leading to inappropriate shock delivery. Inappropriate shock delivery from ICD in an awake patient is not only painful and frightening but also pro-arrhythmic.<sup>6</sup> Currently, there are few cases reported in the literature where EMI resulted in an inappropriate ICD shock (Table 1).

Our case, along with the other cases reported, illustrate some potential environmental hazards in patients with an ICD. Diagnosis of an inappropriate ICD shock depends on history and device interrogation. These patients typically deny any symptoms such as dizziness, lightheadedness, or syncope before the shock delivery. Interrogation of ICD reveals high frequency background noise (resulting from EMI) superimposed on patient's baseline rhythm.

Management of such inappropriate shock includes educating the patients about potential sources of EMI and their avoidance (Table 2). At the same time, efforts should be made to improve the ICDs, which includes better shielding of the devices and improving the software algorithms in order for EMIs to be differentiated from real cardiac dysrhythmias.

## **Author Contributions**

Wrote the first draft of the manuscript: MA, TB, MT. Contributed to the writing of the manuscript: CL, SF, ST. Agree with manuscript results and conclusions: SB, TB. Jointly developed the structure and arguments for the paper: 
 Table 2. Following can be used as example to educate patients about safety of ICDs.

- · Patients should Stay away from:
  - High-voltage power lines
  - Large Magnets
- · Cell phones should be used with caution
- Following devices at least 12 in. (30.5 cm) away from the pacemaker or ICD:
  - Radio transmitters
  - Magnets
  - Arc welders
  - Battery-powered cordless power tools
  - · Industrial power generators

HB, MR, MK. Made critical revisions and approved final version: TB, MA, SB. All authors reviewed and approved of the final manuscript.

#### DISCLOSURES AND ETHICS

As a requirement of publication the authors have provided signed confirmation of their compliance with ethical and legal obligations including but not limited to compliance with ICMJE authorship and competing interests guidelines, that the article is neither under consideration for publication nor published elsewhere, of their compliance with legal and ethical guidelines concerning human and animal research participants (if applicable), and that permission has been obtained for reproduction of any copyrighted material. This article was subject to blind, independent, expert peer review. The reviewers reported no competing interests.

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