ScieniQ Publishers

Japan Journal of Medical Science

Case report

Implanted Cardioverter Defibrillator interactions with Electromagnetic fields in the daily life environment: Case- report

Maurizio Santomauro[1]*, Carla Riganti[2], Gianluigi Iovino[1], Andrea Santomauro[3], Francesco Cacciatore[4], Antonio Rapacciuolo[5]

[1]Department of Cardiovascular Emergency, Internal Medicine and Geriatric, Medical School, Federico II University of Naples, Italy
[2]General Direction, Medical School, Federico II University of Naples, Italy
[3]Department of Medicine, Surgey, Dentistry, Salernitana Medical School, Italy
[4]Department of Translational Medical Sciences, Federico II University of Naples, Italy
[5]Department of Advanced Biomedical Sciences, Federico II University of Naples, Italy

Corresponding author
Maurizio Santomauro, MD, FESC, FHRS, Department of Cardiovascular Emergency, Internal Medicine, Geriatric Medical School, Federico II University, Via Sergio Pansini 5- 80131 Naples-Italy, mobile 00 39 330 502275.

Received: 21 July 2021
Accepted : 23 July 2021
Published: 05 Aug 2021

Abstract
Previous studies have evaluated possible interference between active medical devices and electromagnetic interferences (EMI). There is also a published standard practice in checkpoint metal detector screening for patients with active implantable cardioverter defibrillator (ICD). Medical device manufacturers acknowledged those issues as well and responded to reduce risks associated with potential EMI. I reporting an interesting case of EMI resulting from leak of anti-theft systems located at the entrance of bank causing firing of ICD.

Keywords: Implanted cardioverter defibrillator, Electromagnetic Interferences, anti-theft systems

Introduction
The continuous advancement of medical device technology has led to a dramatic increase in the number of ICD that utilize onboard electronics. At the same time, the usage of external electrical devices has become ubiquitous. Each of these devices is capable of generating EMI that can interrupt or damage ICD. While the European Union, U.S. Federal Communications Commission, and other organizations have regulations in place to help minimize the amount of EMI created, some amounts are unavoidable, and even larger amounts can be generated in rare circumstances, or in the event of device malfunction [1-3]. Thus, preventative measures, including EMI shielding and filtering, must be employed to protect both implantable medical devices and their host patients from harm. ICD are especially sensitive to EMI, as the leads can act as antennas that detect and amplify EMI ambient, to record unnecessarily activate, delivering painful shocks to patients.

Case report
This is a case of a 58-year-old male with a history of non-ischemic cardiomyopathy with severely reduced left ventricular systolic function and ejection fraction of 30%. Patient had received an ICD for primary prevention, which was implanted in June 2014. The device was Incepta ICD F162 made by Boston Scientific. The atrial lead and the right ventricle lead made by Boston Scientific and implanted in June 2014. On his current presentation, he came to see his cardiologist during follow-up. After ICD interrogation by programmer during the January 2020 control in hospital office, the report demontrated one episode of non sustained ventriculat tachycardia (VT) at 190 bpm. In this episode the patient came into contact with the electronics systems located at the entrance of bank (Figure 1). He denied any chest pain, palpitations, headache, lightheadedness, or dizziness during the episode. The device was programmed to detect ventricular fibrillation (VF) at 220 bpm and VT at 200 bpm. Sensitivity was programmed to 0.3 mV. Atrial pacing lead impedance had changed from 690 to 671 ohms and ventricular lead impedance had changed from 1367 to 1331 ohms (Figure 2). Stored intra-cardiac electrograms recorded during this event showed high frequency undulating noise consistent with 60 Hz alternating current for 5 sec (Figure 3). This event was interpreted by ICD as VT.

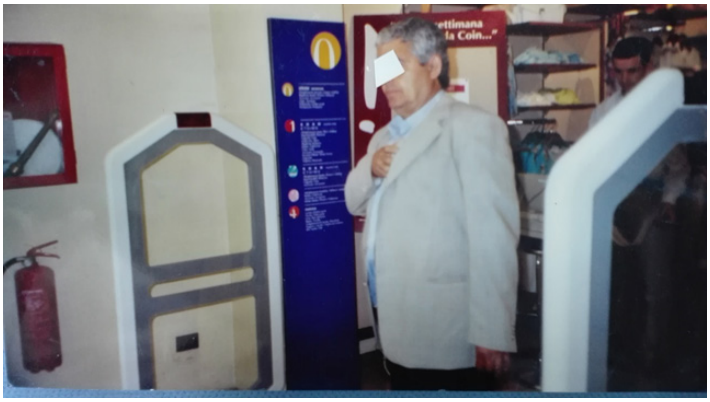
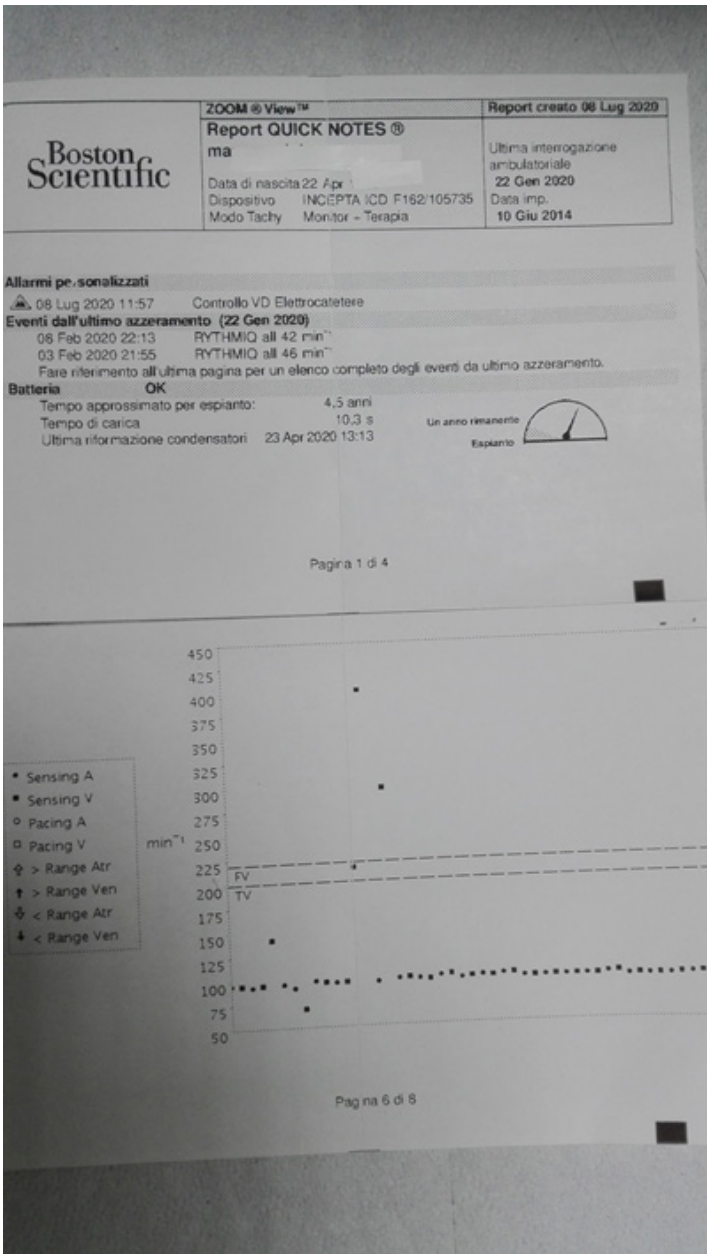
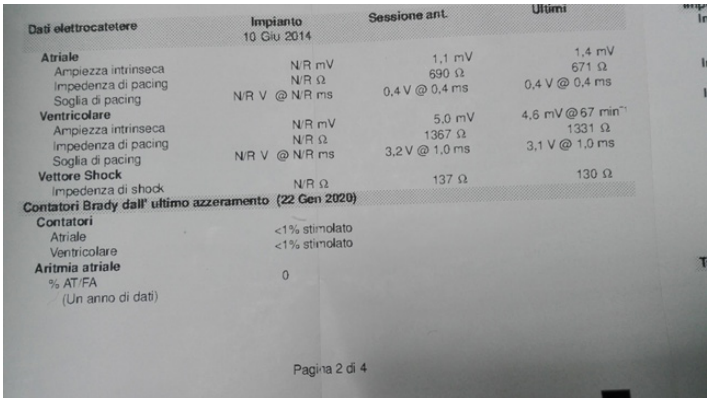


Figure 1. Anti-theft systems in public and commercial spaces.





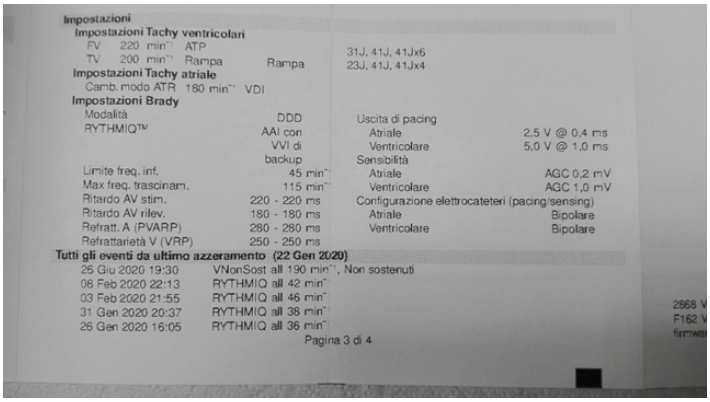


Figure 2. Report of paramethers of implanted cardioverter defibrillator during the interrogation at last hospital office control.

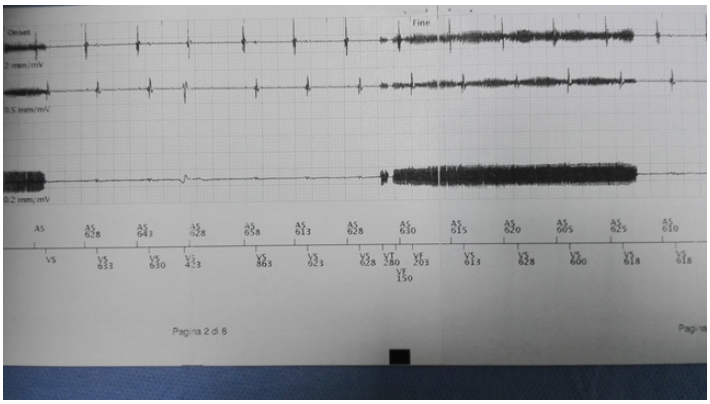


Figure 3. Intra-cardiac electrocardiograms recorded by the device during the event showing, high frequency electromagnetic interference in the background of normal QRS morphology.

Discussion

EMI occurs when a devices function is affected by the electromagnetic fields generated by a nearby device. Since EMI can be radiated, it can travel through the air and originate from many possible sources, including everyday consumer devices, such as anti-theft devices and metal detectors. A conductive case, known as an EMI shield, can prevent radiated EMI from reaching a device. However, since ICD are not closed systems, EMI shields must have openings that allow the shielded device to transmit signals or deliver treatment (Figure 4). Unfortunately, the wires used to transmit data and affect treatment can act as antennas, beaming harmful noise signals directly into devices, mixing with the intended signals, and resulting in potentially disastrous consequences [4-12]. ICD cannot be completely shielded from their environment, as many of them must interact with the body by sensing and distributing electrical impulses. Since ICD need to be both well-protected from EMI and able to send and receive signals from

their environment, device engineers must employ EMI filters capable of separating the signals from the noise. Filtering can either be active or passive. The simplest form of filtering, suitable for most of the high-frequency noise present in the environment, is passive filtering, generally achieved through the use of a capacitor. A capacitor can filter electromagnetic noise by absorbing and smoothing out an incoming signal. High-frequency changes in voltage quickly charge and discharge capacitors and cause the high-frequency noise to interfere with itself and cancel out the disruptive signal (Figure 5). Absorbing this energy to ground can neutralize or block certain frequencies from passing through a circuit. When a capacitor is embedded in an EMI shield, feedthrough filters typically are the EMI filter of choice. Active filters comprise multiple active and passive circuit components, such as capacitors and operational amplifiers. Active filters, while suitable for many applications, require a power source to operate and can be limited in their upper frequency, so they are not commonly chosen for filtering in ICD. In the case of ICD, defibrillator testing with VF induction may be necessary to evaluate appropriate sensing of fibrillation waves with sensitivity settings lower than the manufacturer's recommendations (Figure 6). Prolonged detection intervals and elevation of the VT/VF zones as mentioned in several studies may prevent inappropriate shocks without impairing the outcome of the patients [13]. Therefore, to be able to programme a lower sensitivity it is important to achieve a stable anchoring of the lead with good sensing amplitudes during the implantation procedure. Patients with recent EMI events, should first be advised to maintain a greater distance (usually >30 cm) to the source of EMI, followed by a careful evaluation of the technical integrity of the ICD [14,15]. In the experience of Guang et al [16], transient EMI effects were observed for two pacemakers and one implantable neurostimulator exposed to the fields created in the simulator. The affected EMI returned to pre-exposure condition without user intervention within a few seconds after removal from the simulated exposure fields. Because the observed effects were transitory and with no lasting effects, it appears the risks associated with EMI exposure could likely be mitigated by taking precautions such as appropriate separation distance and limiting exposure time. Furthermore, remote monitoring of ICD may be of great help for early EMI detection. The likelihood for EMI is dependent on exposure-related parameters and on implant, as well as on lead, related parameters.

Figure 4. The long lead in traditional implantable cardioverter defibrillators can act like antennas and magnify electromagnetic interferences.

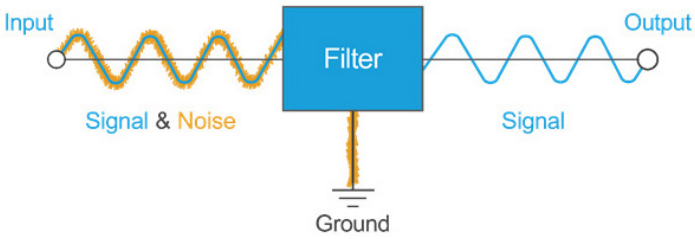


Figure 5. This diagram illustrates the basic concept behind passive electromagnetic interference filtering: A low-frequency signal is passed through while high-frequency noise is removed.

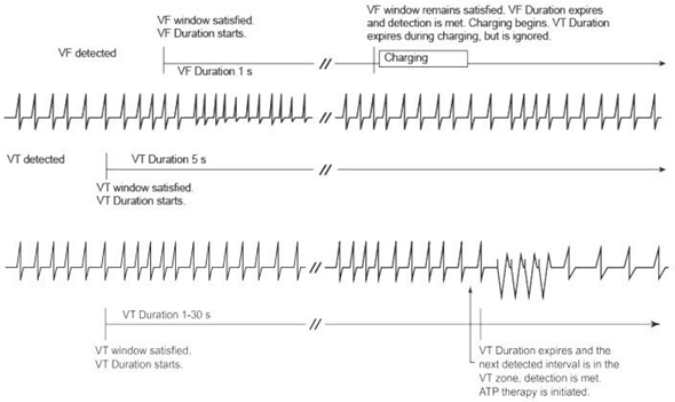


Figure 6. Algorithm of Ventricular fibrillation and ventricular tachycardia window detections.

Conclusions

ICD can be designed to withstand most daily exposure to EMI. If the protection is not implemented properly, the device will remain vulnerable to malfunction, damage, or a reduced lifespan. In this case report, patient was counseled to be should carry their device identification card for the purpose of obtaining security clearance in bank and avoid prolonged exposure to electronic gates or anti-theft systems and direct contact with the gates.

Conflict of interest

The author has no conflict of interest to disclose.

References

1. Beinart R, Nazarian S (2013). Effects of External Electrical and Magnetic Fields on Pacemakers and Defibrillators: From Engineering Principles to Clinical Practice. Circulation 128: 2799–2809.
2. Makaryus JN, Angert-Gilman J, Yacoub M, et al. (2014). Inappropriate Implantable Cardioverter-Defibrillator Shocks Attributed to Alternating-Current Leak in a Swimming Pool. Texas Heart Institute Journal 41: 61-63.
3. Boivin W, Coletta J, Kerr L. (2003). Characterization of the magnetic fields around walk-through and hand-held metal detectors. Health physics 84: 582–593.
4. Kolb C, Schmieder S, Lehmann G, et al. (2003). Do airport metal detectors interfere with implantable pacemakers or cardioverter defibrillators? J Am Coll Cardiol 41: 2054–2059.
5. Akhtar M, Bhat T, Tantray M, et al. (2014). Electromagnetic Interference with Implantable Cardioverter Defibrillators Causing Inadvertent Shock: Case Report and Review of Current Literature. Clinical Medicine Insights: Cardiology 8: 63–66.
6. Napp A, Stunder D, Maytin M, et al (2015). Are patients with cardiac implants protected against electromagnetic interference in daily life and occupational environment? Eur Heart J 36: 1798–1804.
7. Tiikkaja M, Alanko T, Lindholm H, et al (2012). Interference of low frequency magnetic fields with implantable cardioverter-defibrillators. Scand Cardiovasc J 46: 308–314.
8. Seckler T, Stunder D, Schikowsky C, et al. (2017). Effect of lead position and orientation on electromagnetic interference in patients with bipolar cardiovascular implantable electronic devices. Europace 19: 319–328.
9. Driessen S, Napp A, Schmiedchen K, et al. (2019). Electromagnetic interference in cardiac electronic implants caused by novel electrical appliances emitting electromagnetic fields in the intermediate frequency range: a systematic review. EP Europace. 21: 219–229.
10. Misiri J, Kusumoto F, Goldschlager N (2012). Electromagnetic Interference and Implanted Cardiac Devices: The Nonmedical Environment (Part I). Clin. Cardiol. 35: 276–280.
11. Leitgeb N, Niedermayr F, Fuchs C (2012). Impact of a Radio Fre-

quency Electronic Article Surveillance (EAS) System on Active Implants. Journal of Electromagnetic Analysis and Applications 4: 353-357.
12. Jilek C et al. (2011). Safety of screening procedures with hand-held metal detectors among patients with implanted cardiac rhythm devices: A cross-sectional analysis. Ann Intern Med. 155: 587-592.
13. Zanker N, Schuster D, Gilkerson J et al. (2016). Tachycardia detection in ICDs by Boston Scientific. Herzschr Elektrophys. 27: 186–192.
14. Guag, J., Addissie, B. & Witters, D. (2017). Personal medical electronic devices and walk-through metal detector security systems: assessing electromagnetic interference effects. BioMed Eng OnLine. 16: 33-40.
15. Hours M, Khati I, Hamelin J. (2014). Interference between active implanted medical devices and electromagnetic field emitting devices is rare but real: results of an incidence study in a population of physicians in France. Pacing Clin Electrophysiol. 37: 290–296.
16. Gimbel JR, Cox JW Jr. (2007). Electronic article surveillance systems and interactions with implantable cardiac devices: Risk of adverse interactions in public and commercial spaces. Mayo Clinic proceedings. Mayo Clinic. 82: 318–322.

Cite this article: Maurizio Santomauro, Carla Riganti, Gianluigi Iovino, Andrea Santomauro, Francesco Cacciatore, Antonio Rapacciuolo (2021) Implanted Cardioverter Defibrillator interactions with Electromagnetic fields in the daily life environment: Case- report. Japan Journal of Medical Science 2: 84-87.