Unintentional magnet reversion of an implanted cardiac defibrillator by an electronic cigarette

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Introduction

Electronic cigarettes, or e-cigarettes, are nicotine delivery systems initially thought be a safer alternative to cigarette smoking as well as useful adjuncts for smoking cessation. More recently, attention has been directed by the Centers for Disease Control and Prevention at serious pulmonary complications from e-cigarette use, raising important public health concerns. This has been echoed in the scientific literature by demands for stricter regulations for commercialization of these products. Cigarette smoking is a well-established risk factor for cardiovascular events and a sizeable fraction of patients with implanted cardiac devices are active smokers. Here, we report the first case of unintended temporary magnetic reversion of an implantable cardioverter-defibrillator (ICD) by an e-cigarette system.

Case report

A 48-year-old male with a history of cardiac sarcoidosis (left ventricular ejection fraction of 30%) underwent implantation of a primary-prevention ICD in 2010. In June 2017, he underwent left ventricular endocardial radiofrequency ablation for frequent ventricular ectopy, which targeted areas along the posteromedial papillary muscle. He was also noted to have a minimally prolonged HV interval. His device was found to be nearing the elective replacement indicator. Owing to the prolonged HV, the decision was made to upgrade him to a dual-chamber ICD (Medtronic Evera MRI XT DR DDMB1D1, Minneapolis, MN). He continued to experience symptomatic nonsustained ventricular tachycardia and was started on sotalol.

Following his admission, the patient contacted our office to report that he heard his device “beep” several times, which he described as an audible “single steady tone.” There were no symptoms associated with these episodes and the patient denied any clinical ICD shock. There had been no recent reprogramming of his device. A remote transmission demonstrated normal device function without any alert notifications. He denied any recent magnetic exposure but reported hearing the audible tone in several locations in his home as well as at his work location. Medtronic Technical Services were contacted to further analyze the data from the remote transmission and identified that there were 4 magnet interactions with the device. These corresponded with the dates and times when the patient heard the steady tone from his device.

Upon further questioning, the patient recalled using his e-cigarette (JUUL vape device), which he frequently stored in his left breast pocket overlying the device. This specific device includes magnetic components used in the charging process. We held the JUUL

vape device up to his ICD, which elicited the steady magnet tone. The patient was educated about the magnet feature of the ICD system and the importance of keeping any type of magnet at least 6 inches from the device. The patient subsequently had a syncopal event in February 2019 corresponding to a remote transmission demonstrating an episode of ventricular tachycardia that required ICD therapy for termination.

With Medtronic, Biotronik, and Boston Scientific devices, neither in-office nor remote interrogations contain data regarding magnetic reversions. These data are accessible through the company's technical services and can be made available to clinicians on request. St. Jude/Abbott ICDs do date and time stamp magnet reversions as long as they occur as part of an electrogram trigger. Otherwise, the magnet reversion data are unavailable.

Manufacturers are not routinely required to specify the strength of the magnetic fields and safety information for interference with medical-grade devices. There are commercially available magnetic field meters, and even several smartphone applications, that can be used to estimate the strength of a magnet. Practically speaking, most cardiac implantable devices have a magnetic exposure upper limit of 10G and manufacturers typically recommend a 2:1 safety margin for safe clinical operation. As such, finding the distance at which the magnetic field is 5G or less would, in principle, provide adequate clearance for safe clinical operation of cardiac implantable devices.

In our case report, we did not determine a safe distance, but we would recommend that any magnetic device or component not be placed immediately over an implanted defibrillator.

Discussion

To our knowledge, this is the first reported case of magnetic reversion of an ICD by an e-cigarette and highlights the ever-increasing variety of commercially available devices that may interact with implantable cardiac devices, as well as the awareness required from practitioners caring for patients with implantable cardiac devices.

Magnet reversion is a universally available function in permanent pacemakers and ICDs. Historically, this feature was used to assess battery life and initiate communication with the device by closing the reed switch. Newer systems, in particular magnetic resonance imaging–conditional devices, have alternative sensors that can respond to an applied magnetic field without the need of a ferromagnetic reed switch. Ferromagnetic materials generate a magnetic field, measured in Tesla (T) or Gauss (G) units (1 T = 10^4 G); the strength of a magnetic field is inversely proportional to the distance from the source and vectorial. For example, the earth's magnetic field is on the order of 0.00005 T (0.5 G), that of a standard refrigerator magnetic is 0.001 T (10 G), and an average magnetic resonance imaging scanner is 1.5 T (15,000 G). A magnetic field in the order of 0.001 T (10 G) applied directly to a pacemaker or ICD is typically required to initiate the magnet reversion response. Magnetic fields can also induce nonphysiological signals and cause electromagnetic interference.

The response to magnet application depends on the type of device (pacemaker vs ICD), device model, and vendor.[4] Asynchronous pacing in magnet mode can be clinically useful, such as during diagnostic and surgical procedures where electrocautery may be used. Application of a magnet over an ICD temporarily suspends tachyarrhythmia detection and therapies without affecting bradycardia pacing. Some vendors allow for customization of ICD response to magnet application (Boston Scientific and St. Jude/Abbott), making magnet reversion response in ICD subject to reprogramming. Also, ICDs may or may not emit a tone to signal magnet reversion, on a vendor-by-vendor basis. For example, for Medtronic ICDs, as was the case in our patient, the device will emit a steady tone for 10 seconds to verify that notifications are operational and no alert conditions have been met, whereas St. Jude/Abbott and Biotronik systems typically do not. In contemporary ICD systems, tachycardia therapies are universally reinstituted upon removal of the magnet from the ICD.

Magnets are ubiquitous in commercially available electronic devices. The general recommendation is that any portable electronic devices or magnetic sources should be maintained at least 6 inches away from any implanted device; higher-grade systems such as engines, electric fences, and high-voltage power lines require a larger distance to ensure reliable device function. More recently, commonly used medical appliances, such as continuous positive airway pressure masks (magnetic field density 0.0136 T or 136 G), have been implicated in magnetic interaction with ICDs.[5] To our knowledge, our case is the first reported instance of an e-cigarette leading to magnet reversion of an ICD. Given the increasing use of e-cigarettes, recognition of the potentially serious interaction appears clinically important. In our case, there was no adverse event from the e-cigarette-induced ICD magnet reversion. However, suspension of tachycardia therapies from inadvertent magnet application to the ICD could have fatal consequences, if coincidental with a tachycardia episode.

The manufacturer of the electronic cigarette interacting with the ICD in this case was JUUL Labs (San Francisco, CA). The JUUL electronic cigarette is a battery-operated closed-system vapor product that is often used an as alternative to regular cigarette smoking. The device is operated by a lithium-ion battery and uses a magnetic USB charging dock. Each piece of the JUUL charging system joins magnetically to ensure they do not become separated during charging. This magnet is the likely culprit in our patient's ICD magnet reversion. Interestingly, the manufacturers of this product indicate that all parts comply with international and US safety and quality standards, specifically Restriction of Hazardous Substances and Electromagnetic Compatibility. Their website does nevertheless recommend keeping the device away from key cards, credit cards, and other items with magnetic strips, as well as pacemakers.

Conclusion

Implantable pulse generators have the potential to interact with many commonly used electronic devices. This case report illustrates a repetitive magnet interaction between an

ICD and an electronic cigarette. It is incumbent on electrophysiologic practitioners to be aware of such device-device interactions to avoid potential negative outcomes in patients. While no serious injury was observed as a consequence of the magnet reversion and suspension of ICD therapies in this particular case, there is potential for unintentional temporary programming and arrhythmic complications when an electronic cigarette is placed in close proximity to an ICD or pacemaker.

References

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