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CASE REPORT

Safety and Efficacy of Magnet Use to Temporarily Inhibit Inappropriate Subcutaneous Implantable Cardioverter Defibrillator Therapy in Emergency Situations: A Case Report

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ABSTRACT

Introduction: The subcutaneous implantable cardioverter defibrillator (S-ICD) represents a major advancement in ICD technology. Inappropriate shocks (IAS) occur in more than 3.1% of the population with S-ICD each year and are usually followed by admission to the emergency department (ED). In this setting, the disabling of IAS is mandatory during a pseudo-electrical storm (ES). This report describes the strategies that can be followed in order to temporarily inhibit IAS in critical care settings with the use of magnets. **Case presentation:** An S-ICD was implanted more than 6 weeks prior to presentation in a 68-year-old man with hypertrophic cardiomyopathy. In the ED, the patient experienced 3 IAS in the last hour. A Medtronic magnet was applied to stop IAS, as the specific programmer was not available. The maneuver interrupted the IAS. In order to verify the universal magnetic response of the S-ICD, six different magnets and one smartphone with MagSafe technology were tested. All magnet models suspended arrhythmia detection and IAS, while the smartphone did not cause magnet interferences. **Conclusions:** This report demonstrates the safety and efficacy of all clinical magnet models in inhibiting IAS. In case of pseudo-ES, any type of magnet allows ED providers to easily and rapidly disable the functionality of the devices when appropriate.

ARTICLE HISTORY

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INTRODUCTION

In critical care settings, in cases of cardiac and extracardiac malfunctions of subcutaneous implantable cardioverter defibrillators (S-ICD), a magnet can be used as a first step therapy to temporarily suspend shocks in emergency situations.[1] Clinical scenarios, such as cardiac and extracardiac oversensing that interferes with the functioning of the device and results in an inappropriate shock (IAS), require reprogramming of the S-ICD.[2–17] The reprogramming is usually performed by expert electrophysiology personnel using the corresponding manufacturer programmer.[3,4] However, as these devices have magnet-sensitive switches, clinical magnets can also be used to temporarily inhibit the shock therapy. Magnets do not require special training to be used, making them excellent and rapid tools to switch off S-ICD devices in emergency situations. In general, the application of a magnet switches pacemakers to an asynchronous pacing mode and suspends all antitachycardia therapies of transvenous ICDs.[18] However, in S-ICDs, the application of a magnet suspends arrhythmia detection and shock delivery.[19–23]

CASE PRESENTATION

A 68-year-old man with palpitations, chest pain, and psychological trauma was hospitalized for treatment due to suspected ventricular arrhythmias. The patient had an A219 EMBLEM MRI S-ICD (Boston Scientific) implanted more than six weeks prior to presentation. His medical history included hypertrophic cardiomyopathy, syncope, tachyarrhythmia episodes, and hypertension. In the emergency department, the patient experienced three inappropriate shocks over the course of an hour, and the ECG showed a pseudo-ES caused by high-frequency atrial fibrillation (130 bpm). Because the specific programmer was not available, a Medtronic magnet was applied to stop the IAS. The maneuver interrupted shock delivery, and the patient was stabilized with the rapid infusion of amiodarone, which restored a sinus rhythm at a frequency of 80 bpm. The device was then reprogrammed in the electrophysiology laboratory (shock zone 250 bpm, conditional shock zone 220 bpm). After upgrading the program, the oversensed T waves were appropriately discarded, the detected rate remained below the threshold of the tachycardia zone, inappropriate device shocks were avoided, and the patient was discharged home. No further episodes occurred during a 6-month follow-up.

According to the manufacturer's indications, only the 4520 and the 6860 donut magnets (Boston Scientific) were certified to check for the activation of magnet mode in S-ICDs. We hypothesized that any type of magnet could cause a clinically significant magnet response from the S-ICD system. To verify the universal magnet response of the S-ICD, we tested six magnets from different manufacturers and one new-generation smartphone with MagSafe technology. The tests were conducted in the electrophysiology laboratory under ECG and programmer monitoring. At baseline and immediately after the tests, device interrogation was performed to note the settings and ensure appropriate functions using a Model 3200 ICD programmer (Figure 1). Each magnet was placed directly on the skin, over the patient's device, and a programmer and telemetry were used to check for the activation of magnet response (Figure 1). We used standard donut magnets (models 4520 and 6860, Boston Scientific) and magnets from different manufacturers (Medtronic, Abbott [formerly St. Jude Medical], LivaNova [formerly ELA/Sorin], Biotronik), as well as a smartphone with MagSafe technology (Apple iPhone 12 Pro Max) to activate the magnet response. The response was confirmed by the beeping tones present at one second and for 60 seconds after the magnet has been applied. All interrogations and intracardiac electrocardiograms were adjudicated by at least two members of the electrophysiology team. The results of the test are presented in Table 1.

All of the tested magnet models suspended shock delivery; however, the smartphone had no observable effects on the device. No ECG anomalies were noted during the magnet tests, and there were no changes in battery volt-

TABLE 1. Test results

Magnet and Smartphone Type	Response
6860 magnet (Boston Scientific)	Inhibition of shock therapy
4520 magnet (Boston Scientific)	Inhibition of shock therapy
Biotronik	Inhibition of shock therapy
Medtronic	Inhibition of shock therapy
Liva Nova (Ela/Sorin)	Inhibition of shock therapy
Abbott (St. Jude Medical)	Inhibition of shock therapy
iPhone 12 Pro Max	No observable effect on the device

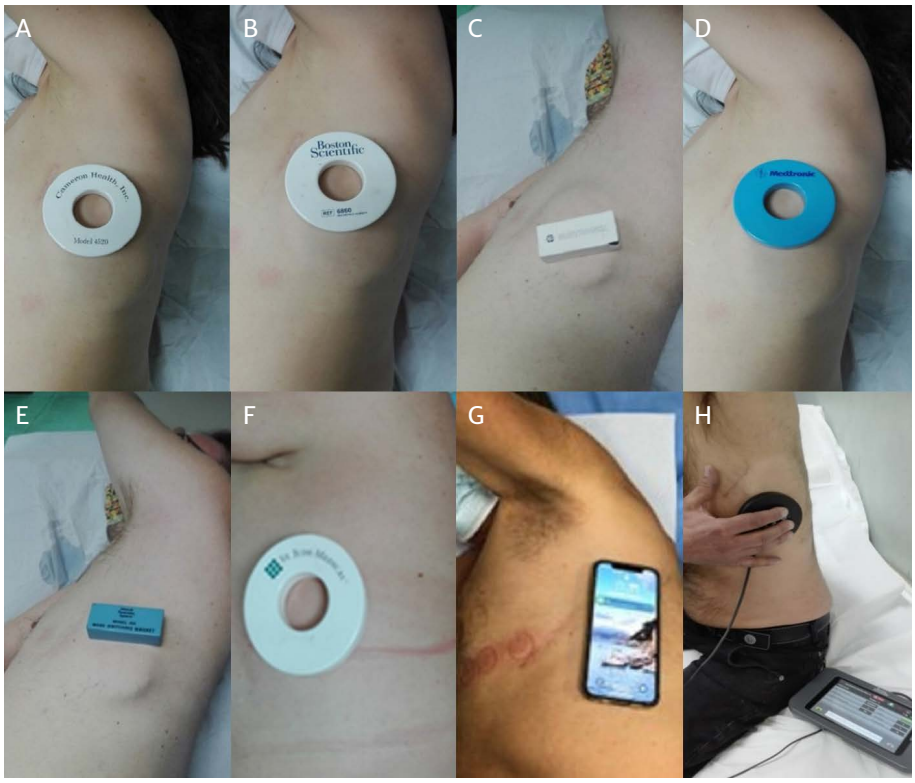

FIGURE 1. The tested magnet in vivo with the 4520 Boston Scientific model (**A**), the 6860 Boston Scientific model (**B**), the Biotronik model (**C**), the Medtronic model (**D**), the LivaNova (formerly ELA/Sorin) model (**E**), the Abbott (formerly St. Jude Medical) model (**F**), the iPhone 12 Pro Max (**G**); the interrogation of the S-ICD device with the Model 3200 programmer (**H**)

age, in the ability to detect the QRS signal, or in the stored diagnostic data from the device memory. The patient did not report any pulling or twisting of the can, or pain or heating from the subcutaneous electrode. The patient agreed to the publication of his data and gave written informed consent. Our institution approved the publication of the case.

DISCUSSIONS

The malfunctioning of an S-ICD increases the risk of sudden cardiac death. During the experience with the first generation of S-ICDs, the rate of IAS was high, with a risk of 2.5% to 25%.[2–6] A review of the literature shows that each year 3.1% of patients with S-ICD experience IAS.[16] In a patient who receives multiple shocks and ventricular tachycardia/ventricular fibrillation (VT/VF) is not seen on the monitor prior to the device firing, a magnet placed correctly over the device could terminate the arrhythmia. If, at any time, VT or VF appear on the cardiac monitor, the magnet needs to be removed, to allow for the arrhythmia detection to resume. In case of repetitive IAS, prompt deactivation of the anti-tachycardia therapy is needed in order to prevent pain and psychological trauma to the patient. The shock therapy functions of the device can be temporarily stopped with donut magnets; these, however, are not standard equipment for many EMD crews due to their rare usage. In the emergency department, an interrogation of the S-ICD will likely be performed to identify the cause of the initial shock series, and device therapies will be programmed to off (Figure 2). In all cases of malfunction, in the absence of a suitable programmer, the first step consists in using a magnet to disable shocks.

The correct placement of the magnet is variable, depending on the device S-ICD model.[24,25] This variability also depends on field strength and distance from the magnet, the field strength of the magnet being 90 gausses at a distance of 3.8 cm from the magnet surface. To reduce the distance between the magnet and the device, we suggest to manually modify the position of the device inside the muscular pocket, until the beeping sound is heard, with the aid of a stethoscope if necessary. For obese patients, Boston Scientific suggests the use of multiple magnets (Figure 3A, Figure 3B).[24] In all other patients, it is sufficient to put a magnet on the device pocket (Figure 3C, Figure 3D). Essandoh *et al.* suggest that shock inhibition

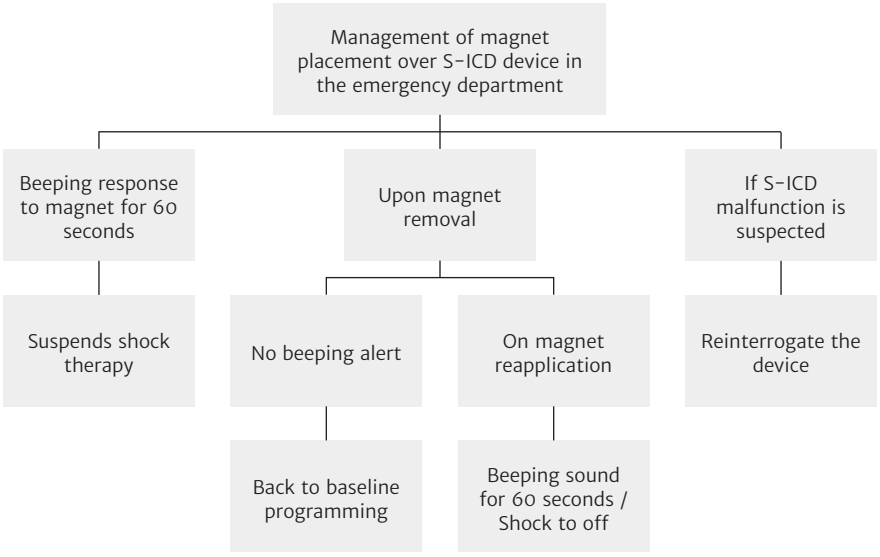

FIGURE 2. Flowchart of S-ICD device management in the emergency department

requires two magnets applied over the header and/or the lower edge of the device.[26]

Magnet inhibition of an S-ICD should also be used during cardiopulmonary reanimation (CPR) maneuvers. During CPR initiation for slow rhythm (<43 bpm), there is an inactivation of the SMART-Pass filter and an oscillating baseline produced by the sternal compressions at a rate of 100–120 times per minute. This will decrease the device's detection rate of 200 bpm, which will result in the summation of the positive and negative components of the wide oscillating waves and a higher counted heart rate. This will paradoxically increase the sensitivity further, leading to oversensing and IAS.[27,31] In these emergency situations, the American Society of Anesthesiologists Practice Advisory and the Heart Rhythm Society recommend the use of a clinical magnet when the programmer is not available.[31,32]

Emergency departments should be aware of the differences between T-ICD and S-ICD systems and the different behavior of these devices regarding magnet application.[33,34] When a patient is unable to provide the device's identification card, the location of the surgical pocket (subclavicular for T-ICD and subaxillary for S-ICD) can easily help to distinguish between the different devices. Similarly to the study of Nadeem *et al.*[35], our report shows that new-generation smartphones with MagSafe technology do not cause magnet interference on S-ICDs and have no potential to inhibit lifesaving therapies.

CONCLUSIONS

This case report demonstrates the safety and efficacy of all clinical magnet models for the inhibition of shock ther-

FIGURE 3. Correct position of double magnets and specific donut magnet position. **A** – Double magnet application in obese patients with Emblem S-ICD A209 – the magnet should be applied on the upper edge; **B** – Double magnet application in obese patients with Emblem S-ICD A219 – the magnet should be applied on the lower edge; **C** – Emblem S-ICD A209 – the magnet should be applied on the upper edge; **D** – Emblem S-ICD A219 – the magnet should be applied on the lower edge

apy in S-ICD devices. The use of magnets allows emergency department providers to easily and rapidly disable the functionality of the devices when appropriate. The application of the magnet temporarily inhibits shock therapy only when it is correctly positioned and does not permanently alter the function of the S-ICD. With proper training, the emergency medical staff will be able to help prevent further disabilities for these patients with the use of any magnet model in a hospital setting.

CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

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