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IMAGING VIGNETTE

CLINICAL VIGNETTE

Inappropriate Extravascular ICD Shock Due to Wet Car Seat

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ABSTRACT

Inappropriate shocks from an Intracardiac defibrillator are associated with increased mortality and may be caused by external electromagnetic interference. This case illustrates that water is an excellent conductor of electricity and that determined investigation may reveal the cause of inappropriate shocks. (J Am Coll Cardiol Case Rep 2024;29:102289)

A 25-year-old man was diagnosed with dilated cardiomyopathy following an episode with cardiac arrest and the novel extravascular implantable cardioverter-defibrillator (EV-ICD) was successfully implanted before discharge. The EV-ICD lead is placed in an intrathoracic substernal position without any active fixation of the distal part that consist of 2 shock coils and 2 ring electrodes (**Figure 1A**). No new episodes with arrhythmias were observed at routine follow-up visits until 2 years later when he was hospitalized following 6 shocks form his EV-ICD. That day, he had been swimming in the ocean before he entered his car wearing wet swimming trunks. When turning on the seat heater, the EV-ICD delivered therapy within seconds. He was brought to his local hospital with stable vital signs including blood pressure of 143/71 mm Hg and a heart rate of 50 beats/min. Physical exam at arrival was unremarkable and device interrogation revealed oversensing and subsequent inappropriate ICD shocks.

A field trip was organized to reconstruct the episode to confirm the source of external electromagnetic interference (EMI). Tachycardia therapy was turned off to avoid new episodes of inappropriate shocks. Sitting in his car wearing dry clothes and with the engine running, a normal electrogram was displayed. Low amplitude noise was observed when the seat heater was turned on but without oversensing (**Figure 1B**). Tap water was used to moisten the car seats. After re-engaging the seat heater, a gradual increase of oversensing and incorrect heart rate detection equivalent to ventricular fibrillation was observed (**Figure 1D**).

Dry skin is the major barrier against EMI with an impedance up to 100,000 ohms. However, an extensive decline in impedance to approximately 1,000 ohms is observed on wet skin resulting in values comparable to an ICD lead. Water is a very good conductor of electricity and, in this case, we believe that a complete electrical circuit was established when water soaked all the way into the electric components in the fabric material car seat. Electric malfunction might be a confounder and this car has not been investigated by a certified mechanic. We did, however, see the exact same result in both car seats.

Similar to other ICDs, the EV-ICD has filters and algorithms for detecting EMI. The sensing circuit is normally programmed between the ring electrodes resulting in a larger bipolar circuit compared to most transvenous ICD leads. Still, it has an intrathoracic position and thus a good protection to EMI by dry skin. The patient in

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ABBREVIATIONS AND ACRONYMS

EGM = intracardiac electrogram

EMI = electromagnetic interference

EV-ICD = extravascular intracardiac defibrillator

this case report received 6 inappropriate ICD shocks due to EMI. His EV-ICD did correctly interpret the "tachycardia" as EMI. However, the device was programmed to ignore all discrimination algorithms after 3 minutes. The rationale for this safety function is that the ICD might be incorrect in its analyses as 3 minutes of continuous EMI is very uncommon. This function is active by default but may be turned off based on a clinical decision.

EMI is a major concern for all ICD patients regardless of the implant variant and may be magnified by water. The ability of ICD therapy to prevent sudden cardiac death is well documented. However, this therapy does not come without complications.[1] Inappropriate ICD shocks are associated with increased mortality and have remained a challenge for both transvenous and subcutaneous ICDs. Recently, the initial published results of the EV-ICD showed efficacy and safety.[2] Long-term observational data of the amount of inappropriate ICD shocks in the EV-ICD are not yet available. EMI, however, seems to represent a challenge in ICD therapy despite new ICD technology.

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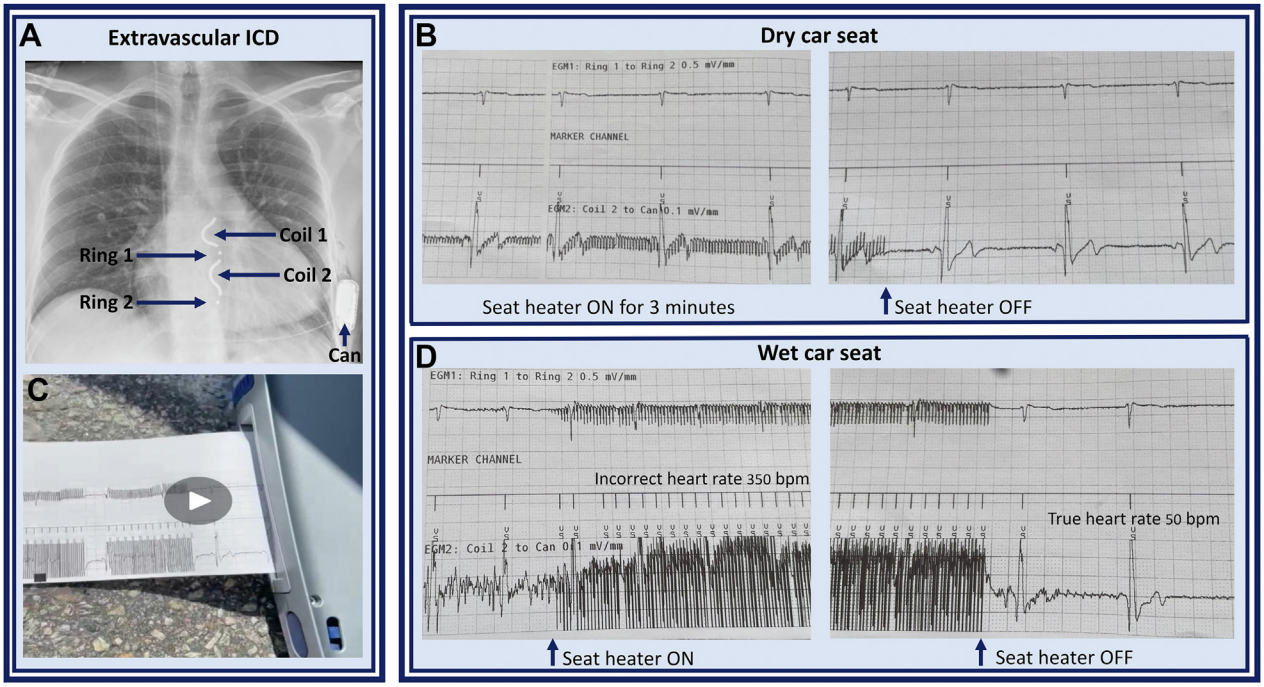
FIGURE 1 EV-ICD and Electromagnetic Interference



(A) Chest x-ray displaying the lead and generator of an extravascular implantable cardioverter-defibrillator (EV-ICD). (B) Intracardiac electrogram (EGM) from the patient's ICD when sitting in a dry car seat. Electromagnetic interference (EMI) is observed on EGM 2 with the car seat heater on but not on EGM 1 which represent the true sensing circuit between the ring electrodes on the ICD lead. (C) Video 1 displaying the abrupt termination of oversensing when the seat heater is turned off. The voice on the video says, in Norwegian, "please turn off the seat heater." (D) EGM from the patient's ICD when sitting in a wet car seat. EMI is seen on EGM2 with the car seat heater on but now also on EGM1 resulting in oversensing and wrong heart rate detection.

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KEY WORDS extravascular intracardiac defibrillator, inappropriate shock

APPENDIX For a supplemental video, please see the online version of this paper.