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CASE REPORT

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Inappropriate shock delivery as a result of electromagnetic interference originating from the faulty electrical installation

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Abstract

We present a case report of a 74-year-old male patient with an implantable cardioverter defibrillator who suffered an inappropriate defibrillation shock while bathing in the tub. Insight in the ICD stored electrogram episodes revealed electromagnetic interferences, with a typical 50 Hz electrical artifact mimicking fast ventricular tachycardia as a device misinterpreted. After this event, the maintenance workers investigated the electrical installation in the bathroom and revealed that there was voltage leaking between electrical installation and metal pipes. After the repair was completed without any additional programming, the patient has had no subsequent shocks.

KEYWORDS
electrical installation, electromagnetic interference, implantable cardioverter defibrillator, inappropriate shock

1 | BACKGROUND

Implantable cardioverter defibrillators (ICDs) are known to be susceptible to strong electromagnetic interference (EMI). EMI is the interference caused by one electrical or electronic device to another by the electromagnetic fields set up by its operation. For EMI, we consider a phenomenon that can occur when an electronic device undergoes the influence of an electromagnetic field, which may cause temporary or definitive malfunctioning of the device itself (Napp et al., 2014). Even though their circuits are well protected from most electromagnetic wave sources and there are numerous protection algorithms incorporated in ICD, the ICD functioning can be significantly compromised by electromagnetic fields even today (Lacour et al., 2021).

2 | CASE REPORT

A 74-year-old male with a history of ventricular tachycardia and with implanted a single lead ICD in 2015. Underlying cardiac diseases was non-ischemic cardiomyopathy with a left ventricular ejection fraction of 30%, recorded at the last annual examination. Pulse generator replacement was performed for elective replacement indicator status in 2015.

During an unscheduled follow-up examination, the patient reported that he had experienced multiple shock discharges a few days prior to examination. These events happened during bathing in the tub. He noticed that the electrical installations in the bathroom were old and faulty.

The patient denied loss of consciousness, palpitations or any cardiac symptoms before, during or after the event. There was no evidence of myocardial ischemia or cardiac decompensation.

ICD interrogation revealed inappropriate ICD shocks due to electromagnetic interferences during bathing in the tub (Figure 1). The intracardiac electrograms showed a clear sinus rhythm, where R waves are visible and RR intervals were approximately 940 ms. However, at one point the electrocardiogram showed a sudden onset of a 50 Hz electrical artifact mimicking fast ventricular tachycardia which the device misinterpreted as such. The device then delivered a 34.8 joules shock while the patient was actually in sinus

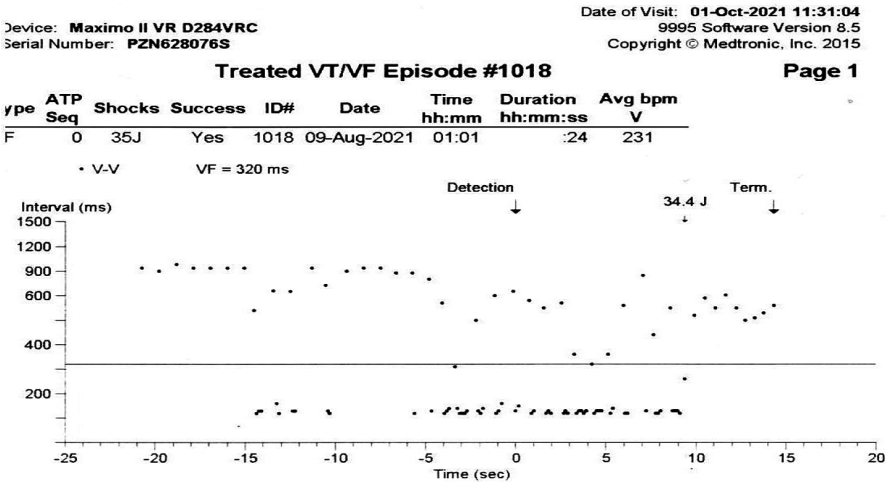

FIGURE 1 Plot diagram demonstrates typical oversensing pattern, inappropriate VF detection and cessation following the delivery of the shock (due to patient dislocation from EMI source)

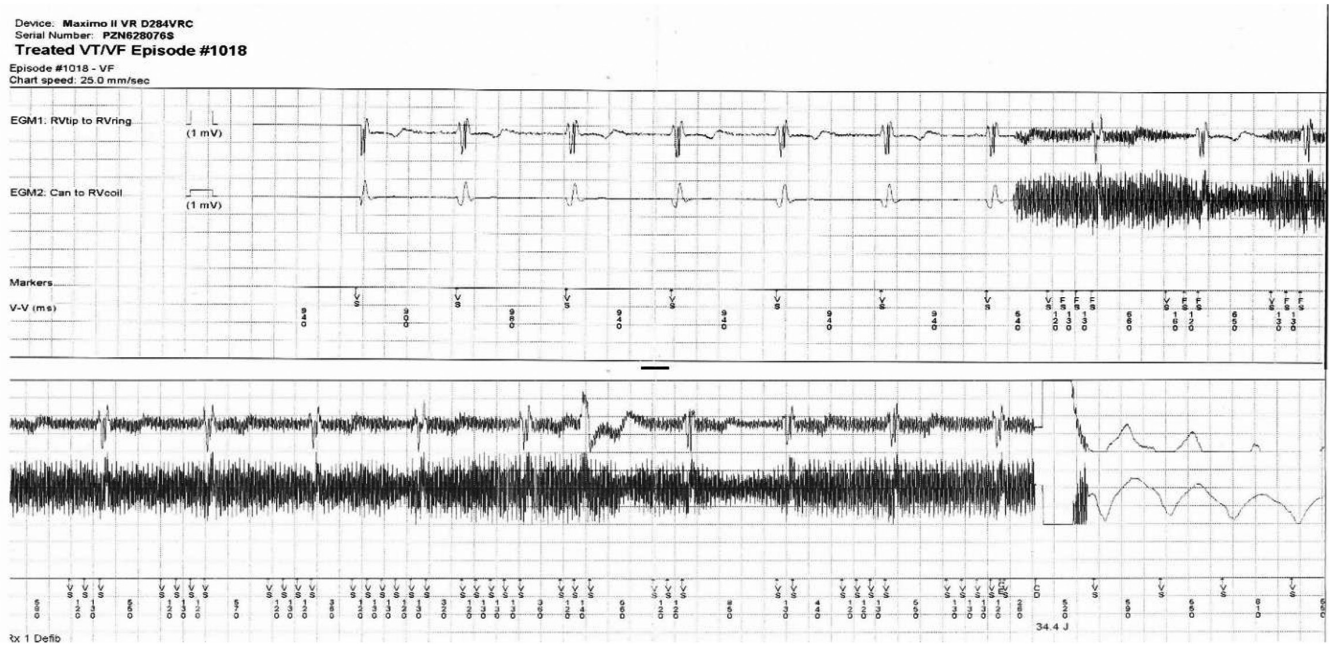

FIGURE 2 Intracardiac electrocardiogram at 25 mm/second, clearly shows a sinus rhythm with EMI detected as ventricular fibrillation, resulting in delivery of an inappropriate shock. Notice that external EMI usually has lower amplitude on channels recorded from small, closely spaced electrodes ("RV tip to RV ring") than on those recorded from widely spaced electrodes or those that include a large defibrillation electrode ("Can to RV coil")

rhythm. Despite the constant amplitude of the EMI source, oversensing may vary because of automatic adjustment of sensitivity and postural variation in the orientation of the sensing bipole relative to the electric or magnetic field. (Figure 2). The patient was not injured. The ICD function was correct except suboptimal sensing value of 2.4mV to 4mV.

After this event, the maintenance workers investigated the electrical installation in the bathroom and found that there indeed was leaking voltage between the electrical installation and the metal pipes. The electrical installations were subsequently repaired and there were no significant changes in the ICD parameters after the event. The patient has not experienced any further ICD shocks, nor ICD noise reversion episodes.

3 | DISCUSSION

The large distance between sensing electrodes results in the lead functioning as a large "antenna" with potential negative effects regarding EMI. Sustained EMI exposure may result in oversensing of the RV channel with subsequent inappropriate shock delivery (Napp et al., 2015). A survey conducted in France showed that 16% of 855 physicians are confronted with EMI among their patients with cardiac implants at least once per year (Hours et al., 2014). It is a well-known fact that inappropriate shocks can be potentially proarrhythmic and are associated with reduced overall survival (Daubert et al., 2008; Ruwald et al., 2013). The international guidelines for environmental and occupational electromagnetic fields exposure

neglected patient with Cardiovascular implantable electronic device (CIED) but noted that interference with pacemakers may occur at levels below the recommended reference levels (International Commission on Non-Ionizing Radiation Protection, 2010). ICDs and modern pacemakers with bipolar sensing configurations seem to be well shielded against external low-frequency magnetic fields and usually EMI is solved using noise algorithms, but there are several examples that electrical leaks or bad grounding can lead to inappropriate ICD shocks (Al Khadra et al., 2006; Chongtham et al., 2007; Shenasa et al., 2018; Tiikkaja et al., 2013). In these cases, patient education and solving the external causes of the problem are essential (Sweesy et al., 2004).

As our case confirms, the diagnosis can often be confirmed by a history of exposure at the time of the stored episode, but distinguishing atypical EMI may be challenging. Some types may be difficult to distinguish from myopotentials or lead failure based on morphology and frequency content alone (Swerdlow et al., 2014).

There are potential industrial sources of EMI, such as welding equipment, electric motors, and degaussing coils. Recipients should be advised to avoid close contact with electric (Beinart et al., 2013), but our case also indicates the importance of maintaining the highest safety levels of household electrical appliances and electric installations.

4 | CONCLUSION

Nowadays, the risk of inappropriate shock delivery as a result of EMI is significantly reduced but our case confirms that EMI remains a clinically relevant problem. Diagnosis of an inappropriate ICD shock depends on history and proper interpretation of intracardiac electrograms. It is of extraordinary importance that all patients with ICD should get household electrical appliances and electrical installations checked for electrical leaks.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTION

Milos D Babic contributed to conceptualization, data collection and manuscript preparation. Maja Milosevic, Branko Djurdjevic and Vasko Zugic performed analysis with discussion. Milosav Tomovic and Aleksandra Nikolic contributed by supervising - reviewing and editing.

ETHICAL APPROVAL

Written informed consent was obtained from the patient.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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