

Brief Report

INTERFERENCE WITH AN IMPLANTABLE DEFIBRILLATOR BY AN ELECTRONIC ANTITHEFT-SURVEILLANCE DEVICE

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IMPLANTABLE cardioverter-defibrillators have an important role in the treatment of patients with ventricular arrhythmias. Electromagnetic interference with permanent pacemakers and implantable defibrillators may have deleterious effects.¹⁻¹¹ Electronic antitheft-surveillance devices, which are widely used in stores, libraries, and other places to prevent theft, are a potential source of electromagnetic interference. Approximately 400,000 of these devices are in use worldwide.

Electromagnetic interference with implantable defibrillators can generally be divided into four types. The most common type involves an overcounting of the ventricular rate. Misinterpretation of rapid rates may lead to inappropriate antitachycardia pacing or the delivery of shocks. Since the current generation of implantable defibrillators provides bradycardia pacing, overcounting may also lead to inappropriate inhibition of pacing. With a second type of electromagnetic interference, a noise-reversion mode is triggered, which results in asynchronous pacing and inhibits the detection of true tachycardias and defibrillation for them. Much less common types of interference are inadvertent reprogramming of the functions of the defibrillator and permanent damage to the circuitry. Clinical problems caused by electromagnetic interference with implantable defibrillators have been infrequent and without severe consequences. We report a life-threatening interaction between an electronic antitheft-surveillance system and an implantable defibrillator.

CASE REPORT

While standing in a bookstore, a 72-year-old man with an implantable defibrillator (placed because of cardiac arrest due to ventricular tachycardia) had complete atrioventricular block in the absence of antecedent symptoms. He received a shock from his

defibrillator. Presyncope developed, and a second shock was delivered. Shortly thereafter, third and fourth shocks were delivered. A quick-thinking bystander, who was a registered nurse, noticed that he was standing next to the store's electronic antitheft-surveillance equipment and pulled him away. No further shocks were delivered, and he soon recovered. The antitheft system was a Sensormatic Ultra-Max (Sensormatic, Boca Raton, Fla.).

Four months earlier, in September 1997, the patient's defibrillator system had been upgraded to allow dual-chamber pacing. The new system included a CPI-Ventak atrioventricular generator (model 1815, Guidant, St. Paul, Minn.) coupled to an endocardial right ventricular defibrillator lead (Transvene, model 6966, Medtronic, Minneapolis) and an active-fixation right atrial lead (model 4058, Medtronic). The device was programmed to respond with 33-J shocks if the heart rate exceeded 165 bpm.

Stored intracardiac electrograms that had been recorded during the episode revealed electrical "noise" (nonphysiologic electrical activity) on both atrial and ventricular channels. The defibrillator responded to the noise by overcounting the ventricular rate, which was interpreted as a tachycardia above the programmed detection threshold, with the result that pacing was inhibited and multiple shocks were delivered (Fig. 1). The presyncope that occurred before the second shock was attributable to ventricular asystole during the inhibition of pacing.

The simultaneous presence of electrical noise on the atrial and ventricular channels strongly suggested an external source of interference rather than a lead abnormality. Lead impedances and pacing thresholds were unremarkable. Manipulation of the defibrillator pocket (generator site) did not reproduce noise on either channel.

The patient confirmed that the episode had started while he was at a magazine rack located approximately 0.3 m (1 ft) from the electronic surveillance equipment. This fact, coupled with the resolution of the symptoms (and shocks) when he was pulled away, strongly suggested that the episode was caused by electromagnetic interference from the surveillance equipment.

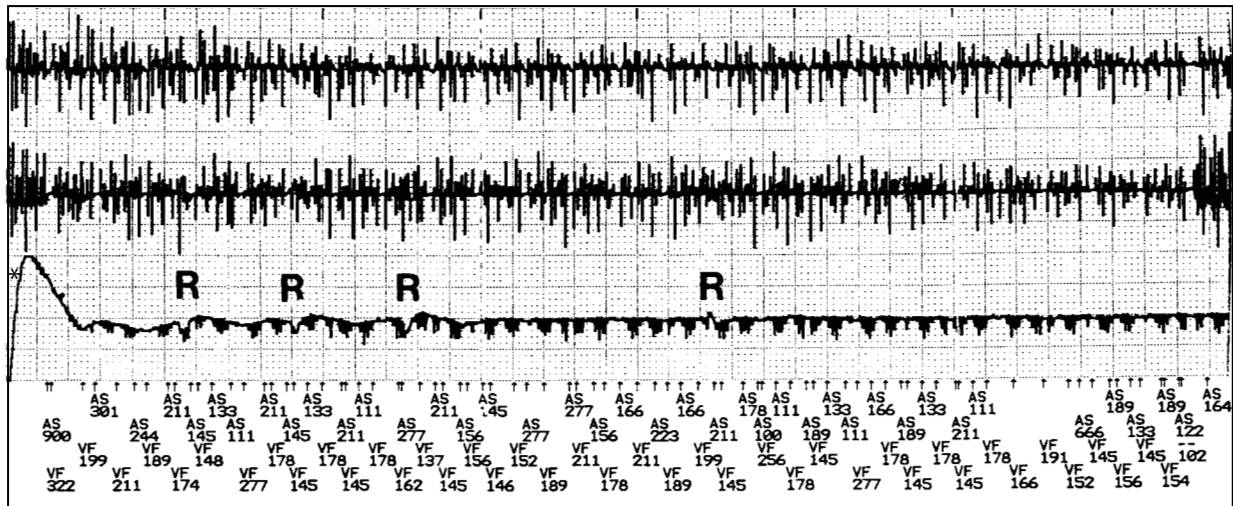
To confirm that the surveillance equipment was the cause of the electromagnetic interference (and to assess the effect of changing the detection threshold to the least sensitive setting), a "rechallenge" was performed under controlled circumstances. Another antitheft device of the same model was set up, and a Sensormatic representative confirmed that it was functioning properly. At a distance of about 0.3 m, electromagnetic interference from the antitheft device affected the defibrillator on three separate occasions, resulting in an abrupt inhibition of ventricular pacing and asystole (the mechanism for delivering shocks was disabled). Presyncope occurred, and the antitheft device had to be disabled rapidly to prevent syncope. The fact that the interference was reproduced with a surveillance unit exactly like the one in the bookstore makes it highly unlikely that the episode in the bookstore was caused by a malfunction of the particular unit. Intracardiac electrograms confirmed the presence of oversensing in both chambers (which was interpreted as sustained ventricular fibrillation), and the defibrillator would have delivered shocks if the mechanism for doing so had not been deactivated. Reducing the ventricular detection threshold to the least sensitive setting did not eliminate the interference, although it occurred only when the patient was in closer proximity to the electronic surveillance device.

DISCUSSION

We describe a case of life-threatening interference with the function of an implantable defibrillator by electronic antitheft-surveillance equipment. Previously reported interactions with sources of electromagnetic interference (i.e., slot machines, remote-control devices for toys, and electronic antitheft-surveillance equipment)³⁻⁶ have caused only transient oversensing, resulting in either the inhibition of pacing for

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Figure 1. Stored Intracardiac Recordings from an Implantable Defibrillator, Showing the Atrial-Rate, Ventricular-Rate, and Shock Electrograms (Top, Middle, and Bottom Tracings, Respectively) during an Episode of Electromagnetic Interference.

The shock tracings (bottom) are similar to a surface electrocardiogram, with visible P waves preceding most QRS complexes. Panel A shows the onset of the episode, with initially crisp recordings of atrial and ventricular activity giving way to electromagnetic interference. The last ventricular paced beat occurs early because of oversensing that begins first in the atrial channel, with an attempt to track a rapid atrial rate. The electromagnetic interference is interpreted as ventricular fibrillation, with suppression of pacing. As Panel B shows, after the first shock is delivered, the noise disappears, possibly because of changes in recording amplitude or because the patient has moved slightly beyond the field of interference, but it quickly reemerges, with the suppression of pacing and asystolic pause, best seen in the shock tracing. Panel C shows severe noise due to electromagnetic interference on all channels, with persistent interpretation by the device as ventricular fibrillation. The arrows beneath the tracings indicate atrial and ventricular marker channels, the dashes indicate unclassified paced or sensed events (related to storage restrictions), and the asterisks indicate the delivery of a shock. VP denotes ventricular pacing, R native QRS complex, AS atrial sensed event, VS ventricular sensed event, and VF ventricular sensed event in fibrillation zone. Intervals between events are shown in milliseconds.

exposure to surveillance equipment will clarify the cause in some patients and avoid unnecessary replacement of the lead. Replicating the exposure under controlled conditions may be helpful in uncertain cases.

Electromagnetic interference with the function of pacemakers has been well documented.⁷⁻¹¹ Since implantable defibrillators are designed to be more sensitive to intracardiac electrical activity than pacemakers (permitting optimal detection of ventricular fibrillation), their sensitivity to electromagnetic interference may also be increased. There are ways to decrease the risk of interference. The sensitivity of some defibrillators can be reduced. This must be done with extreme caution, however, because a low level of sensitivity carries the risk that true ventricular fibrillation will not be detected and that potentially lifesaving shocks will be withheld or delayed. The noise-reversion mode offers some protection against electromagnetic interference. In the noise-reversion mode, the defibrillation function is inhibited, and asynchronous pacing is automatically initiated. However, the noise-reversion mode may fail, as in this case. Even if it operates properly, there is a

slight possibility that asynchronous pacing will induce tachyarrhythmia. In addition, induced (or spontaneous) true arrhythmias will not be sensed or treated in the noise-reversion mode. Thus, it is at best a partial solution.

These points underscore the limitations of protective mechanisms for defibrillators. The most important protection is the patient's awareness of the possibility of electromagnetic interference and avoidance of prolonged exposure to electronic surveillance equipment. With the surveillance devices typically used in stores and libraries, the customer passes through a detection system on exiting. Only brief exposure to electromagnetic interference is involved in walking through the equipment at a normal pace. Transient exposure does not result in serious problems of interference, and in most cases, the interference is not manifested clinically. Thus, under usual circumstances, the risk of inappropriate shocks should be minimal. At most, an aborted shock may be triggered, without untoward clinical consequences.

Determining the susceptibility of various defibrillator sensing systems to this type of interference will require further investigation. It is noteworthy, how-

ever, that the sensing system in this patient was a true bipolar configuration (involving a separate tip and ring electrode rather than a right ventricular coil). This configuration is generally considered the least susceptible to external signals.

The Sensormatic equipment that caused the interference in this patient relies on the emission of a pulsed electromagnetic signal, which can be a source of interference. Although this type of equipment is quite common, not all antitheft devices rely on this mechanism. The problem we describe may not occur with other surveillance systems involving different mechanisms. Interference with pacemaker function has occasionally been documented with other types of surveillance systems.¹¹

Several measures can be undertaken to reduce the risk of electromagnetic interference. The most important is to make physicians and patients aware of the potential for interference. Patients should be instructed not to linger near electronic surveillance equipment. Although the equipment is usually easily visible, it may be concealed near an exit. All customers should be made aware of the presence of such units. Ideally, merchandise should not be displayed next to electronic surveillance equipment. Unless there is a strong reason not to do so, defibrillators should be programmed, after charging, to confirm the persistence of arrhythmia (the current practice with implantable defibrillators) in order to prevent the delivery of shocks in response to transient electromagnetic interference. In this regard, it

may be problematic that confirmation of persistent arrhythmia generally occurs only with the first shock of any episode. Finally, for patients dependent on pacing support from their defibrillators, cautious programming to reduce the sensitivity to electromagnetic interference may be considered.

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