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BRIEF REPORT

Electronic Article Surveillance Systems and Interactions With Implantable Cardiac Devices: Risk of Adverse Interactions in Public and Commercial Spaces

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Abstract

Electronic article surveillance (EAS) systems are widely implemented in public spaces and can adversely affect the performance of pacemakers and implantable cardioverter defibrillators. The interaction between implantable devices and EAS systems is a serious problem that can be minimized through appropriate facility design. Careful facility design and employee education along with patient vigilance remain imperative in avoiding potentially life-threatening EAS system–implantable device interactions.

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§=electronic article surveillance; 爠MI=electromagnetic interference; 營CD=implantable cardioverter
brillator; 爠F=ventricular fibrillation?/td>

Implantable pacemakers and implantable cardioverter defibrillators (ICDs) are widely used to manage a broad range of cardiac electrical disorders. Electronic article surveillance (EAS) systems are ubiquitous in public settings, such as shopping venues and libraries, primarily to control the flow of inventory (ie, to prevent theft). More than 1 million EAS systems are installed worldwide. Tags or markers are embedded within property and are sensed when they traverse an electromagnetic field present at a pass-through point or gate setting typically at an exit from the store.^{1,2}

All pacemakers and ICDs incorporate sophisticated algorithms to reject spurious electromagnetic interference (EMI) emanating from a wide variety of extracardiac sources such as EAS systems.^{2,3} Nevertheless, such devices can respond inappropriately to EMI, resulting in clinically important bradyarrhythmias and tachyarrhythmias through “inhibition or triggering of pacemaker stimuli, reversion to asynchronous pacing and spurious ICD tachyarrhythmia detection,”⁴ leading to shocks.⁵

Electromagnetic fields from EAS systems continue to present a potential hazard to persons with implantable devices, although the risk of clinically relevant device dysfunction from EAS systems is generally believed to be low.^{6,7} In a recently published longitudinal observation of an ICD population, during the 16-year period of analysis, no patient received a shock as a result of an EAS system EMI exposure.⁴ Another recent analysis of a large ICD cohort failed to record an episode of inappropriate ICD discharge secondary to EAS system exposure.⁸

Although underreporting is likely, the apparently low incidence of adverse EAS system device interaction is in part due to enhanced awareness of persons with implantable cardiac devices regarding the risks of exposure to EAS systems. This awareness has been achieved through a variety of methods, including efforts from implantable device and EAS system manufacturers, Food and Drug Administration public health notifications,^{9,10} and patient education by medical personnel. Patients with implantable cardiac devices are typically instructed to “don’t linger, don’t lean” as a means of avoiding the EMI from EAS systems. Published guidelines “advise patients to walk normally, and not slowly, through EAS systems and to avoid both lingering within the surveillance gates and direct contact with the gates.”⁷ Routine exposures, such as normally passing through a store exit equipped with an EAS system, are not expected to cause ICD and EAS system adverse interactions.⁶

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Perhaps in an attempt to efficiently use limited retail space, EAS systems may be positioned near checkout counters and/or near items for sale. As such, and despite the advice to “don’t linger, don’t lean,” persons with implantable cardiac devices might unwittingly be exposed to sufficient EMI from the EAS system to cause device dysfunction. Unanticipated, inadvertent, prolonged exposure to an EAS system by a customer with an implantable device may create a medical emergency. Two cases are described; each case involved different commercial retailers and exposed 2 distinctly different devices each to a different EAS system. Each case serves as an important reminder that EAS systems remain a potential threat to persons with implantable pacemakers and ICDs.

REPORT OF CASES

CASE 1

A 71-year-old man with a biventricular ICD (Contak Renewal III, Guidant, now Boston Scientific, Natick, Mass) reported receiving 2 ICD shocks while shopping in the automotive center of a large commercial retail store. He was at the checkout counter and stepped back from the counter momentarily while the clerk completed some paperwork required for the sale.

Shortly after stepping away from the counter, the man received a total of 2 shocks during a 30-second period. At no time was he in direct contact with the EAS system (Sensormatic, Princeton, NJ). The patient sought evaluation in a local emergency department.

At the emergency department, the ICD was interrogated. Pacing thresholds, sensing values, and all impedances were excellent. Electrograms were crisp. Isometric exercises and manipulation of the ICD pocket failed to demonstrate electrical noise on the channels. Retrieval of the stored episode detail report showed that the device charged its capacitors 4 times after meeting ventricular fibrillation (VF) detection

criteria during a period of 41 seconds and ultimately delivered 2 shocks with 2 diverted therapies (Figures 1 and 2).

An illustrative stored electrogram from the device recorded during the episode showed a paced rhythm followed by the onset of high-frequency noise followed quickly by transient pacing inhibition and device declaration of VF. The presence of distinct QRS (native and paced) complexes during the episode clearly indicated that this was not VF. A brief charging period was followed by delivery of a stored 21-J shock. Additional stored electrograms showed that continued exposure to the EMI from the EAS system led to declaration of VF 3 additional times, with 1 episode resulting in delivery of a stored 41-J shock; 2 of the 3 episodes were aborted during the reconfirmation window. The patient staggered from the shocks and fell away from the vicinity of the EAS system, preventing his ICD from further inappropriate response to the EMI.

Because the time and date stamp of the event as recorded by the ICD correlated precisely with the patient's exposure to the EAS system, additional challenging of the patient (exposing him to the EAS system to confirm that this was the source of the EMI) was not believed to be necessary. At no time was the patient in the automotive repair area, thus potentially exposing him to other equipment that may have been a source of hazardous EMI.

Guidant * Patient Data *		CONTEX REMEDIAL S INC	
Patient		802-OCT-2005 899-52	
Institution			
Model	H179	2288 Programmer	054001
Serial	628 Version 1.0	2285 Software	4.12
Episode Detail Report			
Episode	Date	Time	Type
3	06-JUN-2006	15:00	Spontaneous
Programmed Initial Detection Parameters			
>>> VF			
Elapsed Time			
	Initial Detection	VF Zone	
	Pre-attempt Avg A Rate	381 bpm	
	Pre-attempt Avg V Rate	274 bpm	
	Measured V Rate > A Rate	False	
	Measured Stability	328 ms	
	Measured QRS	72 %	300 ms
	A Fib	Off	
00:02	Attempt 1: VF Shock 1	21J, Biphasic	
	Therapy Delivered	0.8 sec	
	Charge Time	49 s	
	Shockline Impedance	273 bpm	
	Post-attempt Avg A Rate	118 bpm	
	Post-attempt Avg V Rate		
	Redetection	VF Zone	
	Pre-attempt Avg A Rate	360 bpm	
	Pre-attempt Avg V Rate	267 bpm	
	Measured V Rate > A Rate	True	
	Measured Stability	140 ms	
	A Fib	Off	
00:10	Attempt 2: VF Shock 2	Diverted -Reconfirm	
	Therapy Delivered	7.2 sec	
	Charge Time		
	Shockline Impedance	356 bpm	
	Post-attempt Avg A Rate	250 bpm	
	Post-attempt Avg V Rate		
	Redetection	VF Zone	
	Pre-attempt Avg A Rate	167 bpm	
	Pre-attempt Avg V Rate	240 bpm	
	Measured V Rate > A Rate	True	
	Measured Stability	82 ms	
	A Fib	Off	
00:25	Attempt 3: VF Shock 2	41J, Biphasic	
	Therapy Delivered	0.5 sec	
	Charge Time	49 s	
	Shockline Impedance	361 bpm	
	Post-attempt Avg A Rate	262 bpm	
	Post-attempt Avg V Rate		
	Redetection	VF Zone	
	Pre-attempt Avg A Rate	189 bpm	
	Pre-attempt Avg V Rate	282 bpm	
	Measured V Rate > A Rate	False	
	Measured Stability	129 ms	
	A Fib	Off	
00:41	Attempt 4: VF Maximum Shock	Diverted -Reconfirm	
	Therapy Delivered	0.4 sec	
	Charge Time		
	Shockline Impedance	364 bpm	
	Post-attempt Avg A Rate	60 bpm	
	Post-attempt Avg V Rate		
01:17	End of Episode		
End of Report			

FIGURE 1. Episode detail report from the implantable cardioverter defibrillator after exposure to the electronic article surveillance system. Note the relatively brief duration of the episode leading up to the second shock (41 seconds), suggesting that prolonged exposure is not required to cause device dysfunction.

CASE 2

A 76-year-old woman underwent ablation of the atrioventricular node and implantation of a single-chamber pacemaker (Guidant Insignia I Plus) in 2002 in the setting of chronic atrial fibrillation with rapid ventricular response. After the procedure she had atrioventricular block and was pacemaker dependent. A satisfactory clinical result was obtained with appropriate device function.

In April 2006, the patient visited a large commercial retail store. The patient sought help from the store employees with loading materials in her vehicle at the exit of the store. Pausing between the pedestals of the EAS system (Sensormatic), she summoned help and then suddenly collapsed. She regained consciousness while supine, and an employee propped her upright against the pedestal of the EAS system. The patient lost consciousness again and fell flat. This cycle was repeated 5 times until she was finally moved well away from the EAS system. The patient was taken to a nearby emergency facility for further evaluation.

In the emergency department, electrograms recorded during the episode were retrieved from the single-chamber pacemaker. Electrograms were crisp, and pacing threshold was excellent. Manipulation of the pocket failed to show noise on the intracardiac electrograms. [Figure 3](#) demonstrates one of several illustrative rhythm strips stored in the device memory. A paced rhythm followed by superimposition of high-frequency noise was seen. The marker channel suggests an ongoing rate of approximately 200 beats/min. During this time the patient was asystolic because the pacer was inhibited by the EAS system EMI. Review of the area near where the patient collapsed showed no other plausible source of EMI.

DISCUSSION

Pacemakers and ICDs are representative of a growing range of implantable electronically active devices (eg, deep brain stimulators), all of which are susceptible to the effects of EMI. The Food and Drug Administration's communication on EAS systems suggests "labeling or signage on electronic anti-theft systems will enable implant wearers to take appropriate precautions to further minimize the risk of interference, namely to avoid lingering around or leaning on such systems."¹⁰

The presence of the EAS system may be announced by signage. However, the value of such labeling is substantially diminished when retail space is configured in such a manner as to subvert the awareness of the EAS system, effectively preventing adherence to the dictum "don't linger, don't lean." Having the counter space in proximity to (38 in) and facing away from the EAS system effectively places the customer with an implantable device in harm's way and in a state of unawareness. Architects and designers of retail space might avoid placing the checkout area (spaces where lingering is likely to occur) close to where EAS systems will be positioned. As has been suggested previously,⁵ items of interest (eg, retail goods, books at a library) should not be positioned in such a way as to encourage prolonged proximal exposure to an EAS system. Additionally, we are concerned with EAS systems that are "camouflaged" as advertising kiosks, thereby potentially rendering them "invisible" to the customer as a source of dangerous EMI or, even worse, drawing the customer with an implantable device toward them to view more closely the advertisements on the EAS pedestal.

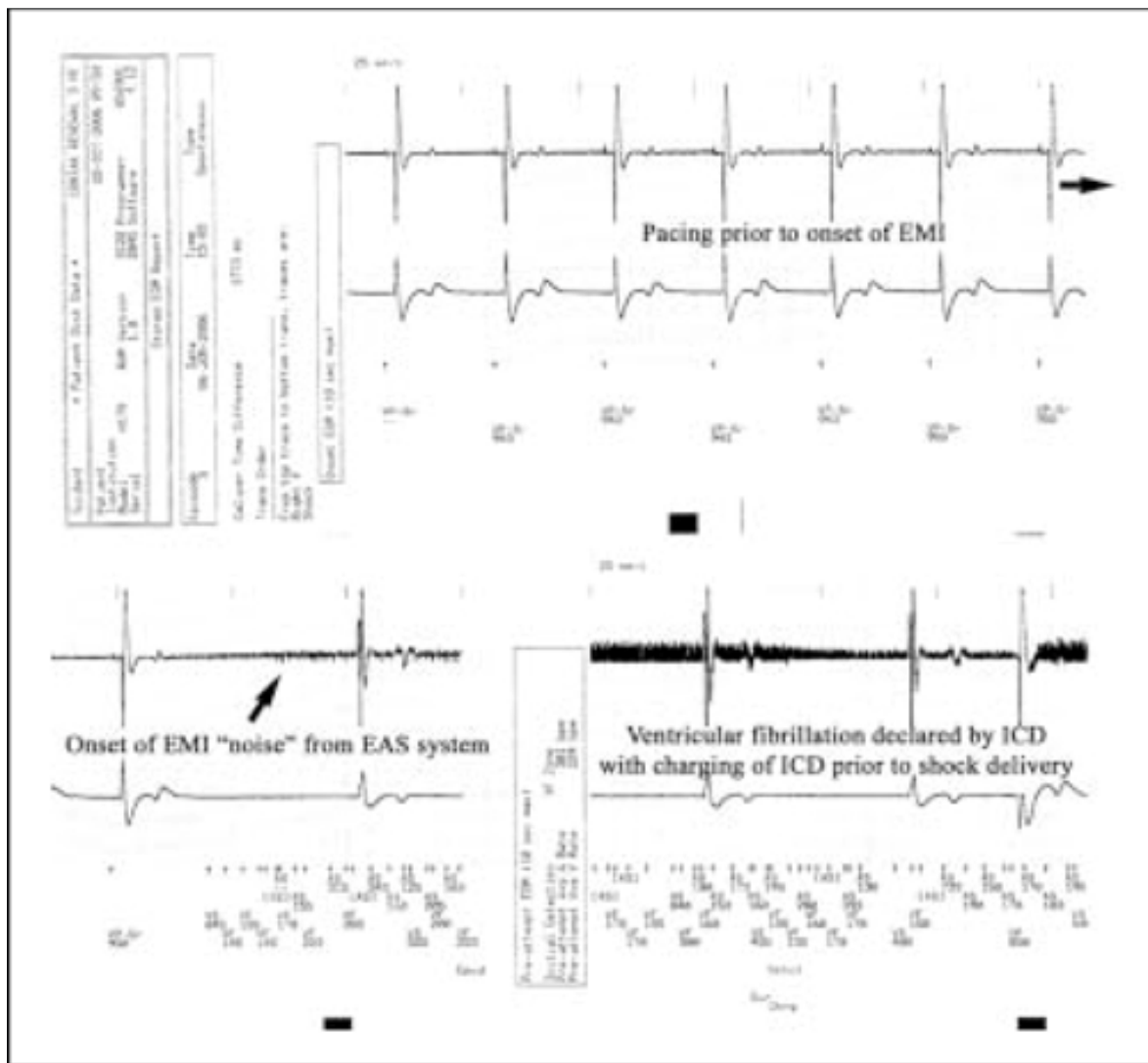


FIGURE 2. Implantable cardioverter defibrillator (ICD) electrograms. Paced rhythm transitions to intrinsic escape rhythm after superimposition of high-frequency electromagnetic interference (EMI) noise from the electronic article surveillance (EAS) system. Spurious detection of ventricular fibrillation leads to charging of ICD capacitors, which is followed by delivery of an ICD shock (not shown).

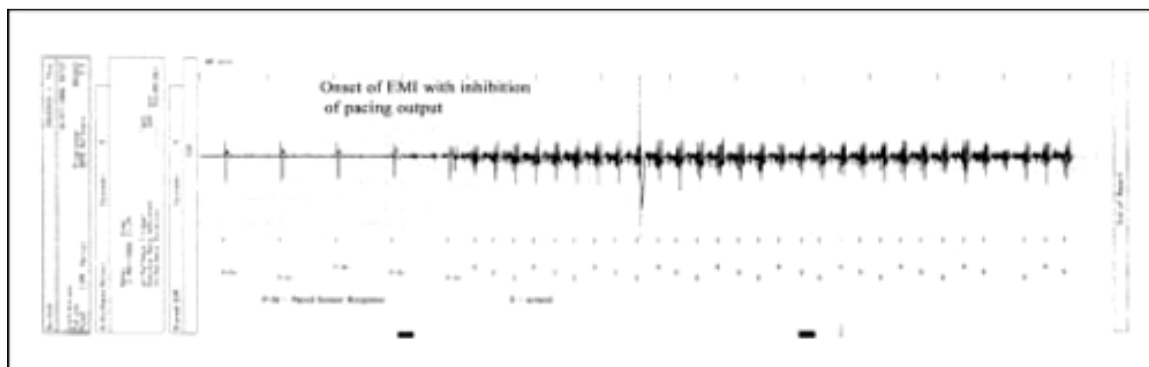


FIGURE 3. Pacemaker stored electrogram. Paced rhythm followed by onset of electromagnetic interference (EMI) (noise) with consequent pacemaker inhibition leading to asystole.

CONCLUSION

When security measures that require EAS systems are needed in public spaces, human factors design should take into account the proliferation of implantable devices. The increasing use of implantable cardiac devices coupled with the widespread use of EAS systems creates the risk for more frequent, potentially dangerous interactions. The efficient use of limited space to maximize commercial transactions cannot override the need for safety for persons with implantable devices.

Consideration might also be given to instructing facility workers that if an individual collapses near an EAS system, that person, barring any suspected cervical trauma, should be moved several feet from the EAS system to eliminate any potential EMI effects from the EAS. From a patient perspective, both cases highlight the need for patients with electronically active implantable devices to remain aware of potential EMI sources. Finally, health care professionals need to periodically remind patients with implantable cardiac devices of the importance of managing exposure to EMI.

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