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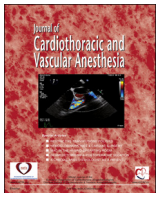

Inappropriate Implantable Cardioverter-Defibrillator Therapy During Surgery: An Important and Preventable Complication

Marc A. Rozner, PhD, MD[*,†], Edward A. Kahl, MD[‡], Peter M. Schulman, MD[‡]

[*]*Department of Anesthesiology and Perioperative Medicine, University of Texas MD Anderson Cancer Center, Houston, TX*
[†]*Department of Cardiology, University of Texas MD Anderson Cancer Center, Houston, TX*
[‡]*Department of Anesthesiology and Perioperative Medicine, Oregon Health and Science University, Portland, OR*

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MOUNTING EVIDENCE suggests that inappropriate high-energy therapy from an implantable cardioverter-defibrillator (ICD), whether antitachycardia pacing (ATP)[1] or shock,[2-4] causes myocardial injury (eg, troponin release or ST-segment changes consistent with injury currents) and increases mortality. In the hospital environment, electromagnetic interference (EMI), which most commonly results from intraoperative monopolar electrosurgery, can precipitate inappropriate ICD therapy, suggesting that failure to prevent or mitigate EMI could increase the risk of patient injury.

This report presents 3 cases from different institutions in which failure to adhere to all recommended precautions from the American Society of Anesthesiologists (ASA)[5] or Heart Rhythm Society (HRS)[6] regarding the perioperative management of ICDs resulted in inappropriate ICD therapy during surgery.

To the authors' knowledge, the frequency of inappropriate high-energy therapy from an ICD during surgery remains unknown, and this problem rarely has been reported in the literature. Because the use of cardiovascular implantable electronic devices (CIEDs) continues to increase and these patients are presenting for surgery and other interventional procedures with increasing frequency, routine postoperative ICD checks are not always performed, and no rule from the Joint Commission or other regulatory agency mandates reporting such events. It is conceivable that inappropriate ICD therapy during surgery constitutes an important and largely preventable patient safety issue that is underrecognized and underreported.[7]

Because these cases were single events, retrospectively reviewed, and without aggregated data, the authors' institutional review board determined that specific written approval for publication was not required.

Case Presentations

Case 1

An 84-year-old man with nasopharyngeal carcinoma, ischemic cardiomyopathy (ejection fraction $< 20\%$), and a Boston Scientific (Natick, MA) E110 dual-chamber ICD, presented for preradiation assessment. His ICD examination revealed the following programmed parameters; mode: VVE-DDDR; lower pacing rate limit: 60 beats/min; upper pacing tracking rate: 130 beats/min; upper pacing sensor rate: 130 beats/min; and ATP or shock rate: > 160 beats/min.

The event log and stored electrogram (Fig 1) demonstrated delivery of inappropriate ATP resulting from EMI during endoscopic sinus surgery at a community hospital. Although preoperative notes from both the surgeon and anesthesiologist acknowledged the ICD, the hospital record contained no discussion of device parameters, plans to mitigate EMI, or recognition that EMI occurred. There was no mention of device reprogramming or magnet application. Operating room

Address reprint requests to Peter M. Schulman, MD, Department of Anesthesiology and Perioperative Medicine, Oregon Health and Science University, 3181 SW Sam Jackson Park Road, Mail Code KPV – 5A, Portland, OR 97239.

E-mail addresses: schulman@ohsu.edu, peterschulman@gmail.com (P.M. Schulman).

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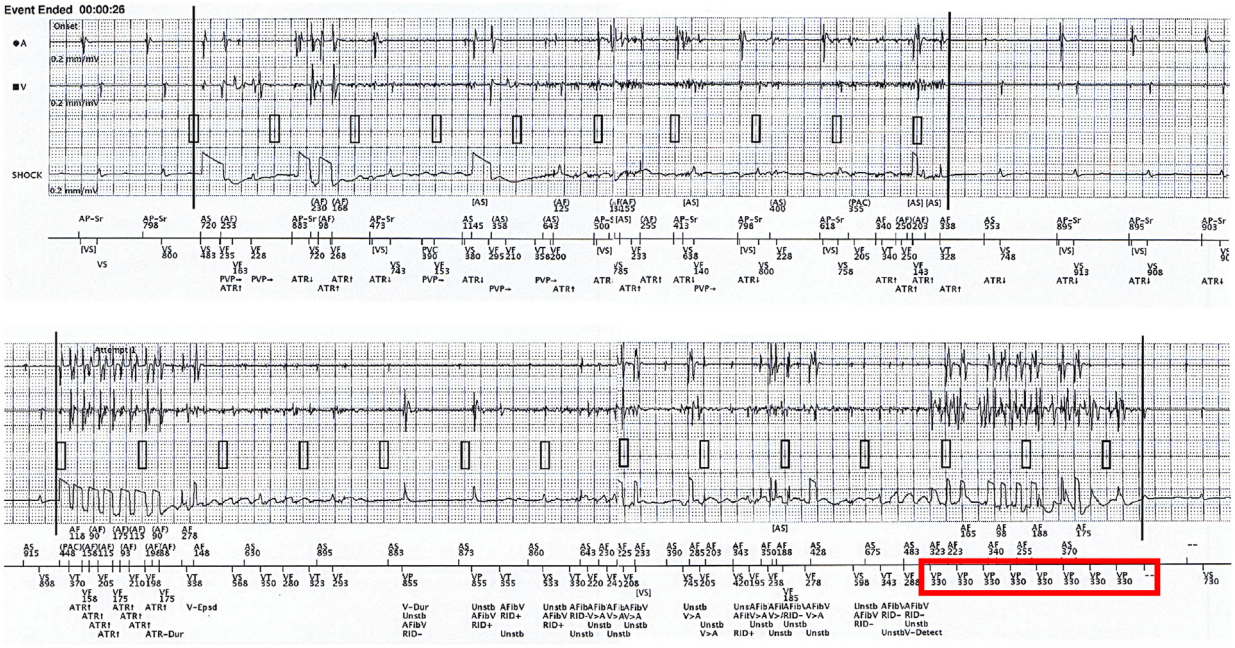

Fig 1. Electromagnetic interference (EMI) sensed by the implantable cardioverter-defibrillator (ICD) as atrial fibrillation, ventricular tachycardia, and ventricular fibrillation led to antitachycardia pacing during sinus surgery. The ICD treatment record showed about 9 seconds of EMI, followed by about 4 seconds of no EMI, then just over 1 second of EMI, leading to the episode onset (V-Epsd). The ATP was delayed because of the "unstable" nature of the V-V intervals (an unstable V-V interval is interpreted by the device as atrial fibrillation). Ultimately, antitachycardia pacing (ATP) (*highlighted in the red box*) was delivered because the ventricular rate was greater than the atrial rate and because of the failure of the QRS morphologic match (RID-). Recordings (top to bottom) are atrial lead electrogram, ventricular lead electrogram, shock lead electrogram (approximates a surface electrocardiographic signal), and markers reflecting the ICD decision tree. The *tall rectangles* (added to figure) indicate 1 second intervals (paper at 25 mm/sec). –, uncategorized and ignored event (usually due to blanking issues); AF, atrial fibrillation event; AFibV, indication that the ICD is counting ventricular tachycardia or ventricular fibrillation events even though its mode has been switched for atrial tachyarrhythmia; AP, atrial pace (-SR indicates that the rate sensor was active); AS, atrial sense—(AS) indicates that the AS event was ignored for ventricular pacing purposes; ATR, a counter that determines a pacing mode switch from DDD (atrial tracking) to DDI because of atrial tachyarrhythmia (eg, atrial fibrillation; arrow direction indicates increment [up] or decrement [down]. At ATR-DUR, the ICD began counting a second set of atrial tachyarrhythmia events that would have led to a mode switch with 8 additional counts or a de-arming of the atrial tachyarrhythmia event with 8 normal A-A sequences); PAC, premature atrial electrical event; PVC, ventricular event not preceded by an atrial event during DDD pacing mode; PVP - >, identifies the postventricular atrial refractory period that indicates that the ICD will not track an atrial sensed event; RID-, QRS morphology that does not match the stored QRS image and will lead to high voltage therapy; RID+, QRS morphology that matches the stored QRS pattern and will lead to a delay in high voltage therapy; Unstb, V-V interval variability that exceeds stability criteria used to identify AF with rapid ventricular response, which delays high-energy therapy while the V rate is lower than the VF rate but higher than the minimum treatment rate; V > A, indication that the ventricular rate is greater than the atrial rate—V > A overrides nearly every other parameter that might delay high-energy therapy; V-Epsd, start/end of a ventricular tachydysrhythmic event; VF, ventricular event sensed in the ventricular fibrillation window; VP, ventricular pace; VS, ventricular sense; [VS], ventricular noise event; VT, ventricular event sensed in the ventricular tachycardia window.

records showed use of monopolar electrosurgery during the case and placement of the electrosurgery unit dispersive electrode on the thigh. The data of the prior interrogation stored in the ICD memory demonstrated the lack of preoperative or postoperative examination of the ICD. Neither the patient nor any of his medical providers had any knowledge of this event.

Case 2

A man older than 89 years with recurrent tongue cancer, chronic atrial fibrillation, nonischemic dilated cardiomyopathy (ejection fraction < 30%), and a St. Jude Medical (Sylmar, CA) model 2211-36 dual-chamber defibrillator implanted in the left pectoral position presented for evaluation and treatment planning. His ICD examination revealed the following programmed parameters (mode: VVE-VVIR): Lower pacing rate limit: 75 beats/min; upper pacing sensor rate: 120 beats/min; and ATP or shock rate: > 171 beats/min.

The event log and stored electrogram (Fig 2) demonstrated delivery of an inappropriate shock resulting from EMI during his surgical biopsy at a community hospital. Several of the medical notes incorrectly refer to this device as a pacemaker. The anesthesia record showed "magnet on ICD," but there was no documentation of device parameters or plans to mitigate EMI (this ICD has no method to confirm appropriate magnet placement). The electrosurgery unit dispersive electrode was placed on his right thigh, forcing the path of the electrosurgical unit current to cross the chest and ICD system, likely increasing the development of EMI during the procedure.[8] The ICD discharge during the procedure was not documented. Even though data stored in the ICD showed that the discharge had been reviewed during a previous examination, the patient was unaware that this event had occurred.