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CASE REPORT: CLINICAL CASE SERIES

Inappropriate ICD Shock as a Result of TASER Discharge

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ABSTRACT

Conducted energy weapon (commonly known as TASER) discharge in patients with implantable cardioverter-defibrillators is known to cause electromagnetic interference and inappropriate ventricular fibrillation sensing without delivery of implantable cardioverter-defibrillators therapy during conducted energy weapon application. We report the first known case of conducted energy weapon discharge resulting in inappropriate implantable cardioverter-defibrillators therapy. (**Level of Difficulty: Beginner.**) (J Am Coll Cardiol Case Rep 2020;2:1166–9) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 50-year-old man presented to the emergency department in police custody after TASER X26 (Axon Enterprise, Inc., Scottsdale, Arizona) conducted energy weapon (CEW) discharge related to aggressive and psychotic behavior. The CEW darts were applied to the patient's chest and delivered 2 successive energy applications followed by patient-reported sensation of implantable cardioverter-defibrillator (ICD) shock. On presentation to the emergency room he was noted to be combative with stable vital signs.

LEARNING OBJECTIVES

- To describe the risk factors during conducted energy weapon application that may result in inappropriate ICD therapy.
- To discuss how various tachycardia sensing and therapy algorithms in commercially available ICDs are likely to respond to conducted energy weapon application.

PAST MEDICAL HISTORY

The patient has a history of schizoaffective disorder and long QT syndrome and underwent implantation of a secondary prevention, single-chamber ICD (Inventra 7 VR-T DX, Biotronik, Berlin, Germany) 1 year prior for history of prolonged QTc-related ventricular tachycardia cardiac arrest.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis for patient-reported ICD shock includes:

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, or patient consent where appropriate. For more information, visit the *JACC: Case Reports* author instructions page.

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- Appropriate shock: therapy delivered for an appropriately detected ventricular arrhythmia.
- Inappropriate shock: therapy delivered related to a supraventricular tachycardia, electromagnetic interference (EMI), or device malfunction.
- Phantom shock: there is no therapy delivery that is temporally correlated with the patient reported sensation of shock.

INVESTIGATIONS

The CEW darts were removed from the patient's chest and ICD interrogation revealed a normally functioning device. Programmed ICD tachyarrhythmia therapy parameters are shown in **Table 1**. Review of arrhythmia events revealed 2 discrete episodes of EMI corresponding with 2 CEW discharges, both of which satisfied criteria for ventricular fibrillation (VF) detection, followed by a maximum energy ICD shock during sinus rhythm (**Figure 1**).

Review of the arrhythmia event on device interrogation revealed sinus tachycardia with cycle length 375 to 382 ms (157 to 160 beats/min) before CEW application. Subsequently during CEW ~5-s duration energy delivery, EMI with amplitude >10 mV at 19 Hz (cycle length ~53 ms) results in detected cycle length ~110 ms caused by ICD blanking period. This CEW application satisfies VF detection criteria and results in device charging (**Figure 1A**). Following cessation of energy delivery, 7 long cycle length intervals below the tachycardia detection threshold are detected and the shock diverted (**Figure 1B**). A second CEW discharge is then noted, resulting in redetection of VF (**Figure 1C**). A 45-J ICD shock was delivered ~5.5 s and 11 appropriately sensed, sinus ventricular intervals after cessation of CEW energy delivery (**Figure 1D**).

DISCUSSION

CEWs or neuromuscular incapacitation devices, commonly known as TASER, have been increasingly used in law enforcement. The TASER X26 CEW is a pistol-shaped device that shoots 2 tethered darts that deliver 19 pulses per second with a typical peak voltage of 1,400 to 2,600 V. The device also generates an open-circuit voltage of up to 50,000 V that may arc through air or thick clothing but is not delivered into the body (1). Prior reports of CEW discharge in presence of cardiac implantable electronic devices have reported EMI resulting in inappropriate VF sensing during CEW application (2,3). The first reported CEW discharge in a patient with an ICD was noted on device interrogation to have VF detection without delivery of tachycardia therapy (2). The exposure time to CEW energy was ~5 s, and therapy was diverted because of the presence of a sinus ventricular rate in the reconfirmation period following charging. A subsequent report of CEW applications in 6 patients with cardiac implantable electronic devices described 1 patient in whom CEW discharge resulted in VF detection, again without delivery of ICD therapy because of the presence of sinus rhythm during charging and reconfirmation (3). We present the first known case of inappropriate ICD therapy caused by CEW application.

The present case illustrates a previously undescribed scenario of appropriately diverted ICD therapy following initial CEW application, followed by a second CEW application before fulfillment of criteria for end of arrhythmia episode, resulting in delivery of a committed, unsynchronized ICD shock during sinus rhythm. In a study by Lakkireddy et al. (4) of CEW energy delivery in a porcine model, a total of 7 ICDs were implanted and tested with a 5-s CEW discharge. All ICDs sensed the energy application as VF and appropriately aborted therapy delivery. Calton et al. (5) investigated the CEW discharge of varying durations in a similar model and demonstrated a 15-s CEW discharge resulting in VF detection, delivery of an ICD shock during CEW discharge, redetection of VF after ICD shock, and delivery of a committed shock several seconds after cessation of CEW discharge. Our case illustrates that multiple CEW applications in quick succession can similarly result in delivery of committed ICD therapy.

Redetection criteria are less strict than initial detection criteria to guard against withholding appropriate therapy because of undersensing of VF (6,7). Redetection criteria, criteria to abort shock during or after charging, and criteria for end of episode vary by ICD manufacturer and are displayed in **Table 2**. The patient's Biotronik ICD initially aborted shock because of the presence of more than 3 of 4 intervals categorized as sinus during charging. A second CEW energy delivery occurs after only 7 sinus intervals (12 of 16 sinus intervals required to terminate episode), thus the VF detection is categorized as

ABBREVIATIONS AND ACRONYMS

CEW = conducted energy weapon

EMI = electromagnetic interference

ICD = implantable cardioverter-defibrillator

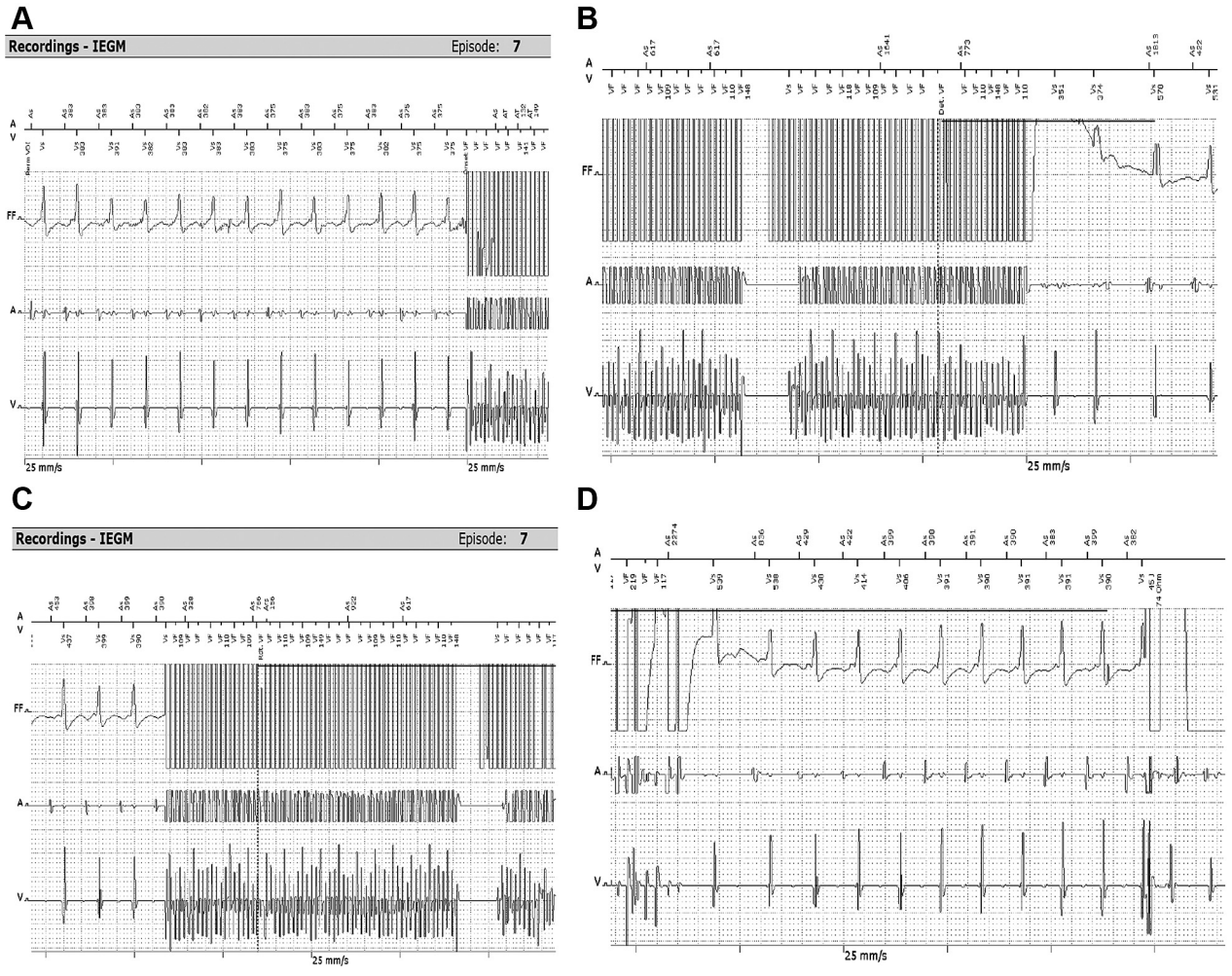
VF = ventricular fibrillation

TABLE 1 Programmed Tachyarrhythmia Treatment Parameters of Implanted Device

	Zone Limit	1st ATP	2nd ATP	1st Shock	2nd Shock	3rd–nth Shock
VT1	330 ms	Off	Off	Off	–	–
VT2	Off	Off	Off	–	–	–
VF	300 ms	Burst	Burst	45 J	45 J	6 * 45 J

ATP = antitachycardia pacing; VF = ventricular fibrillation; VT = ventricular tachycardia.

FIGURE 1 **Intracardiac Electrograms**



Intracardiac electrograms with marker channel demonstrating conducted energy weapon application sensed as ventricular fibrillation **(A)**, diversion of therapy following cessation of conducted energy weapon energy delivery **(B)**, redetection of ventricular fibrillation **(C)**, and delivery of a committed shock during sinus rhythm **(D)**.

a "redetection" and triggers a committed shock. Applying the scenario in the present case to our compilation of manufacturer-specific redetection criteria (Table 2), a committed shock seems likely to have been delivered by all manufacturer's devices except those made by Abbott, which would have ended the arrhythmia episode after 5 sinus intervals.

TABLE 2 **Manufacturer-Specific Episode Criteria**

Device Manufacturer	Abort Shock During Charging Criteria	Abort Shock After Charging Criteria	Tachycardia Redetection Criteria	End of Episode Criteria	Committed Shock After Redetection
Abbott	5 consecutive sinus intervals*	5 consecutive sinus intervals*	6 tachycardia intervals†	5 consecutive sinus intervals*	No
Biotronik	3 of 4 sinus intervals*	3 of 4 sinus intervals*	8 of 12 tachycardia intervals†	12 of 16 sinus intervals*	Yes
Boston Scientific	5 of 10 sinus intervals*	2 of 3 sinus intervals*	6 of 10 tachycardia intervals*	No redetection criteria for 30 s*	Yes
Medtronic	4 of 5 sinus intervals*	4 of 5 sinus intervals*	12 of 16 tachycardia intervals†	8 consecutive sinus intervals*	Yes

"Sinus" refers to sensed intervals longer than tachycardia detection cycle length. "Tachycardia intervals" refers to sensed intervals shorter than the ventricular tachycardia detection cycle length.
*Not programmable. †Programmable.

CONCLUSIONS

Inappropriate ICD therapy is a previously undescribed risk of CEW application in patients with ICDs. In our patient, successive energy applications from a single device resulted in a committed ICD shock. Multiple successive CEW applications from different devices may result in a similar outcome. The unsynchronized nature of the committed shock increases the likelihood of shock-related proarrhythmia (8), thereby resulting in risk for subsequent, appropriate ICD therapy. This risk of VF related to inappropriate shock may be additive to a previously described, low risk of VF related directly to CEW discharge (9,10).

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