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EDITORIAL COMMENT

A Shocking Tale*

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Conducted energy weapons (CEWs) have long been a mainstay of law enforcement agencies as an alternative to lethal force. The most well-known CEW is colloquially known as a TASER device and is currently sold to both law enforcement agencies and the public. The origin of the word *TASER* is perhaps not widely known but is an abbreviation of "Tom Swift and His Electric Rifle," invented by Jack Clover, a NASA scientist, in the 1960s (1).

The holy grail for law enforcement personnel is to be able to subdue a person who either puts him- or herself or other people at risk of serious injury or death without jeopardizing the safety of the person concerned, other members of the public, and the law enforcement personnel themselves. Therefore, owing to its ability to subdue individuals at minimal risk, the TASER device has become popular as an alternative to lethal force.

In this issue of *JACC: Case Reports*, Barbhaiya et al. (2) describe a case with an inappropriate shock from an implantable cardioverter-defibrillator (ICD) secondary to the use of a TASER X26 device (Axon, Scottsdale, Arizona) with 2 energy bursts of 5 s each administered in close succession. As discussed in their report, the device is a pistol-shaped device weighing 205 g that has a limited power source (a battery of two lithium camera cells) and shoots 2 tethered probes and delivers 19 short-duration pulses per second, with a peak voltage of approximately 1,900 V (3). This results in neuromuscular incapacitation after stimulation of type A-α motor neurons, which control skeletal muscle contraction, and type III A-δ sensory neurons, which mediate the sensation of sharp pain. Thus, the typical subject will experience local paralysis and sharp pain. The length of the X26 barb is approximately 9.6 mm, and the penetration depth in any given individual will be affected by many factors, such as clothing and body habitus. The newer-generation X2 model has a slightly longer barb length of 11.6 mm (**Figure 1**).

The first energy burst was detected by the ICD as ventricular fibrillation (VF) prior to resumption of sinus rhythm. However, a second energy burst fell into the redetection zone, and once VF redetection criteria were met, the ICD was committed to delivering a shock despite the resumption of sinus rhythm.

In an individual with an ICD who has received a TASER shock, the theoretical risks that may increase the risk of sudden death are: 1) inappropriate delivery of therapy or pacing inhibition due to electromagnetic interference (EMI) (4); 2) direct myocardial capture resulting an inappropriately high heart rate (5), which may lead to VF; and 3) a "commotio cordis"-like phenomenon (6,7). Whether CEWs increase the risk of death when used is a controversial issue (8). In animal studies, VF can be triggered when the barbs of the device are placed near the heart. The critical dart to heart distance in humans is unknown but has been estimated to be approximately 3 mm (9). In this case, the authors do not detail exactly where the barbs entered the skin on the patient's chest, but presumably the energy delivered was sufficient to allow the safe restraint of the individual concerned.

CEW use has been associated with cardiac arrhythmias such as asystole (10), VF (6,8,11), and atrial fibrillation (12); however, the circumstances in which these arrhythmias occur are often complicated by the use of physical restraint and presence of various intoxicants.

What is clear is that the electrical energy delivered by the TASER device can be detected by the ICD and

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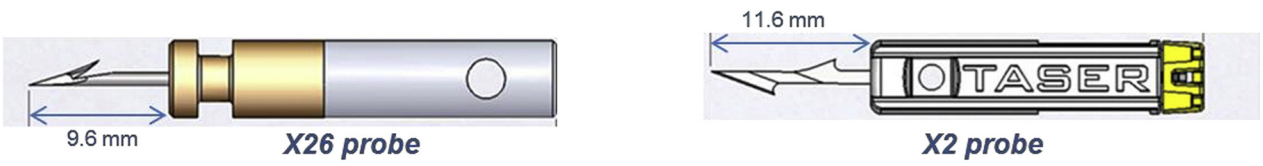
FIGURE 1 **TASER Probes**



Structure of the TASER probe and barbs for the X26 and X2 TASER models. Reprinted with permission from the National Police Chiefs' Council (19).

interpreted as VF, as most often this will fall into the VF zone and potentially result in therapy (13). In practice, as most shocks last for 5 s with the TASER model used, this is not sufficiently long enough for shock delivery to take place, as during reconfirmation the normal cardiac rhythm will resume and therapy will be aborted. However, the shock duration can be extended longer than 5 s if the trigger-pull is sustained. In the latest-generation device, the T7 (Axon), shock delivery can take place with up to 4 electrodes (from 2 separate pairs) and an individual electrode can see a pulse rate of between 11 and 35 pulses/s (14). In consumer versions of the TASER device, therapy delivery will take place for up to 30 s in order for the user to escape from any assailant (15). Thus, there are scenarios involving the use of CEWs that can increase the likelihood of inappropriate therapy in an individual who has an ICD. So far, there are no published cases on consumer TASER use in individuals with pacemakers or ICDs.

The authors should be congratulated for describing an unusual scenario in which ICD therapy was delivered following TASER use. However, the main teaching point of this case is to highlight the fact that any source of EMI can be detected by modern ICDs as VF and that redetection, when it occurs, relies on less stringent criteria to reduce the risk of appropriate therapy being withheld. It may not be widely appreciated that once VF is redetected, most ICDs would be committed to giving an unsynchronized shock, thus exposing the patient to the risk of VF if a shock is delivered during the vulnerable period of the T-wave during the presumably normal underlying cardiac rhythm. The authors nicely summarize the manufacturer-specific criteria for a shock to be aborted and the tachycardia redetection criteria among the major device manufacturers. They highlight that devices from only 1 major manufacturer would result in a shock being withheld in the scenario described in this case report.

EMI in the range of 0 to 60 Hz overlaps the cardiac signal range (13). In practice, the most common form of EMI is seen in the hospital environment as a result of electrocautery (16,17). Other possible sources of EMI in the hospital environment include use of transcutaneous electrical nerve stimulators, use of magnetic resonance imaging, lithotripsy, radiofrequency ablation, and electroconvulsive therapy. In the nonmedical environment, potential sources of EMI include suboptimally shielded electrical mains supplies and electrical equipment, mobile phones, electronic article surveillance gates, and magnets (18).

The TASER device used in this case report delivers electrical energy at 19 Hz, which is also well within the cardiac signal range. This makes it difficult to incorporate strategies such as bandpass and notch filtering to reduce the risk of EMI being sensed inappropriately by the device. On the tracings provided, the individual 19-Hz electric pulses can be seen and signal saturation indicates that the sensed amplitude of the interference clearly exceeded >10 mV.

In conclusion, the scenario described here is clearly unusual; however, the general principle that EMI can result in inappropriate therapy from an ICD holds true if the duration of EMI is sufficiently long enough. This case also illustrates that shorter periods of intermittent EMI can result in inappropriate therapy despite resumption of normal sensing after cessation of EMI if the periods of EMI are close enough together. Redetection of a "tachyarrhythmia" during a subsequent period of EMI can result in a committed shock. Device physicians should be aware of these nuances in tachyarrhythmia detection when consulting on ICD patients.

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