Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects

William P. Bozeman, MD
William E. Hauda II, MD
Joseph J. Heck, DO
Derrel D. Graham, Jr, MD
Brian P. Martin, MD, MS
James E. Winslow, MD, Mph

From the Department of Emergency Medicine, Wake Forest University, Winston Salem, NC (Bozeman, Winslow); the Department of Emergency Medicine, Virginia Commonwealth University, Richmond, VA, and the Department of Emergency Medicine, George Washington University, Washington, DC (Hauda); the Department of Emergency Medicine, University Medical Center Las Vegas, Las Vegas, NV (Heck); and the Department of Emergency Medicine, Louisiana State University Health Sciences Center Shreveport, Shreveport, LA (Graham, Martin).

The opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the Department of Justice.

Study objective: Conducted electrical weapons such as the Taser are commonly used by law enforcement agencies. The safety of these weapons has been the subject of scrutiny and controversy; previous controlled studies in animals and healthy humans may not accurately reflect the risks of conducted electrical weapons used in actual conditions. We seek to determine the safety and injury profile of conducted electrical weapons used against criminal suspects in a field setting.

Methods: This prospective, multicenter, observational trial tracked a consecutive case series of all conducted electrical weapon uses against criminal suspects at 6 US law enforcement agencies. Mandatory review of each conducted electrical weapon use incorporated physician review of police and medical records. Injuries were classified as mild, moderate, or severe according to *a priori* definitions. The primary outcome was a composite of moderate and severe injuries, termed *significant injuries*.

Results: Conducted electrical weapons were used against 1,201 subjects during 36 months. One thousand one hundred twenty-five subjects (94%) were men; the median age was 30 years (range 13 to 80 years). Mild or no injuries were observed after conducted electrical weapon use in 1,198 subjects (99.75%; 95% confidence interval 99.3% to 99.9%). Of mild injuries, 83% were superficial puncture wounds from conducted electrical weapon probes. Significant injuries occurred in 3 subjects (0.25%; 95% confidence interval 0.07% to 0.7%), including 2 intracranial injuries from falls and 1 case of rhabdomyolysis. Two subjects died in police custody; medical examiners did not find conducted electrical weapon use to be causal or contributory in either case.

Conclusion: To our knowledge, these findings represent the first large, independent, multicenter study of conducted electrical weapon injury epidemiology and suggest that more than 99% of subjects do not experience significant injuries after conducted electrical weapon use. [Ann Emerg Med. 2008;xx:xxx.]

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INTRODUCTION

Background

Conducted electrical weapons are commonly used by law enforcement agencies. These weapons deliver a series of electrical pulses intended to temporarily incapacitate and allow apprehension of violent or combative subjects through pain compliance and involuntary muscle contractions. Modern conducted electrical weapons such as the Taser model X26 (Taser International, Scottsdale, AZ) (Figure 1) deliver electrical energy either by direct contact or by a pair of metal probes fired from the weapon by compressed gas. An estimated 640,000 criminal suspects and human volunteers have been exposed to conducted electrical weapon discharges, and more than two thirds of law enforcement agencies in the United States currently use conducted electrical weapons.[1,2]

Importance

Conducted electrical weapons are one of several intermediate force options available to officers faced with violent or combative suspects. Other available options include hand-to-hand combat techniques, chemical irritant sprays, and handheld impact weapons such as metal batons. The use of conducted electrical weapons has been associated with reduced injury rates among both criminal suspects and officers, as well as with reductions in the use of lethal force.[3,4] However, a number of unexpected deaths have been

Editor's Capsule Summary

What is already known on this topic
Anecdotal reports have associated use of conducted electrical weapons such as the Taser with death of restrained individuals. The frequency of adverse events associated with conducted electrical weapons is not known.

What question this study addressed
In this prospective, multicenter, observational study, the frequency and seriousness of injury from conducted electrical weapons was assessed in 1,201 patients.

What this study adds to our knowledge
Serious injury occurred in 3 patients who had received administration of conducted electrical weapons. No cardiac dysrhythmias associated with conducted electrical weapons were documented.

How this might change clinical practice
Patients brought to the emergency department after receiving a conducted electrical weapon apprehension should not have serious symptoms solely attributed to the conducted electrical weapon. Instead, a comprehensive evaluation of appropriate traumatic, medical, and toxicologic causes is indicated.

observed after conducted electrical weapon use. Though conducted electrical weapons have not been conclusively linked to these deaths, the temporal relationship has led to controversy about the use and safety of conducted electrical weapons.[5-7] Despite extensive use, the overall risk of serious injury or death after conducted electrical weapon exposure has not been previously reported.

Goals of This Investigation

Controlled studies of the cardiac and physiologic effects and risks of conducted electrical weapons in animals and healthy human volunteers have begun to address the topic of conducted electrical weapon safety. However, these studies may not accurately reflect risks among criminal suspects in whom coexisting medical and psychiatric conditions, alcohol and drug use, and other factors are often present. These factors may increase risk in this population and make epidemiologic investigations during actual use critical to provide a realistic risk assessment of these weapons. We performed the first large multicenter study to determine the incidence of injuries and adverse outcomes after law enforcement use of conducted electrical weapons.

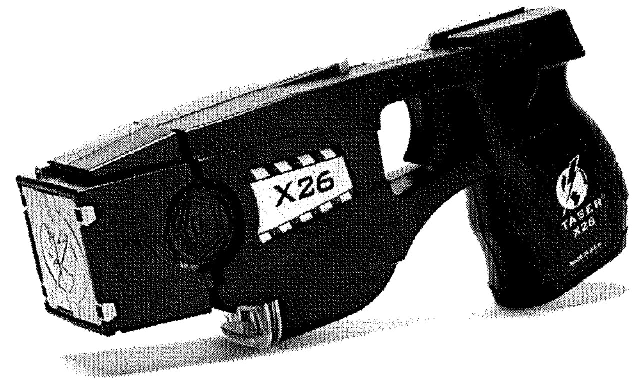

Figure 1. The Taser model X-26 conducted electrical weapon.

MATERIALS AND METHODS

Study Design

A prospective multicenter observational study was performed to identify and classify injuries related to conducted electrical weapon use during apprehension of criminal suspects by law enforcement officers. Physician site investigators reviewed police and medical records to identify and classify injuries sustained by subjects after conducted electrical weapon use.

Conducted electrical weapons are battery-operated devices, similar in appearance to a handgun, that incapacitate by delivering a series of brief electrical pulses that produce pain and muscular tetany. The most commonly used conducted electrical weapon (Figure 1) produces 19 pulses per second. Each 100-ms pulse contains approximately 0.36 J of energy at up to 50,000 V.[8] The devices can be used from a distance by firing 2 barbed metal probes that become imbedded in skin or clothing and remain tethered to the weapon by insulated wires. Both probes must make contact or be in close proximity to the subject (within 1 to 2 inches) to complete an electrical circuit and successfully deliver a discharge. Alternatively, conducted electrical weapons can be used in a direct contact or "drive stun" mode by touching the metal contacts at the front of the weapon to a subject. A standard conducted electrical weapon discharge cycle lasts 5 seconds; this can be terminated early by the operator or extended by holding or repeatedly depressing the trigger.

Setting and Selection of Participants

Participating sites were recruited from among law enforcement agencies across the United States with printed and electronic announcements via law enforcement and medical specialty associations. These included the National Tactical Officers Association, American College of Emergency Physicians, Society for Academic Emergency Medicine, and National Association of EMS Physicians. To qualify for consideration, law enforcement agencies had to use conducted electrical weapons, have a physician already affiliated with the agency's tactical team with access to agency records, provide

Table 1. Injury severity stratification (a priori definitions).

	Mild	Moderate	Severe
Description	Outpatient treatment and Mild or no long-term disability expected	Inpatient treatment and/or Moderate long-term disability expected	Inpatient treatment and Severe long-term disability expected or Threat to life
Examples	Abrasions, contusions, minor lacerations	Hemopneumothorax, Hepatic/splenic lacerations Long bone fracture	Severe head injury Loss of limb or eye Ventricular dysrhythmias

routine preincarceration medical screening examinations to all arrestees, and perform mandatory use-of-force review after each conducted electrical weapon use. The medical screening examination could include jail intake screening, paramedic evaluation at the scene, or physician evaluation at an emergency department (ED).

Methods of Measurement

An *a priori* classification of injury severity was developed (Table 1). This classification was used by site investigators to stratify injury severity as mild, moderate, or severe. Injuries related to the metal probes or electrical discharge of the conducted electrical weapon were termed *direct injuries*, whereas injuries related to falls or other effects caused by conducted electrical weapon use were termed *indirect injuries*. Injuries that were of uncertain relationship to conducted electrical weapon use were recorded and classified as uncertain. Injuries determined to be unrelated to conducted electrical weapon use (eg, vehicular trauma, impact weapon use, firearm use) were not recorded.

The primary outcome measure was significant injuries, a composite of moderate and severe injuries. These injuries require hospital admission, may produce significant long term disability, or may represent a threat to life. These are believed to be most pertinent to both clinical and administrative perspectives about the use of conducted electrical weapons. Cases with no identified injuries and mild injuries were also grouped for analysis.

An *a priori* sample size determination was performed. According to a desired confidence interval (CI) of no greater than $\pm 1.5\%$ for the observed proportion of significant injuries, this indicated a required sample size of at least 335 subjects.

A study steering committee composed of medical and law enforcement experts served as a data and safety monitoring committee during the course of the study. The committee advised investigators on study design and site selection. At 2 predefined enrollment intervals, the committee reviewed results of interim analyses to assess overall safety and consider early study termination if excessive risk was demonstrated.

Institutional review board approval was obtained initially at the central study site and at each participating site before initiation of prospective case surveillance.

To qualify for inclusion, each case had to include delivery of a conducted electrical weapon electrical discharge to a criminal suspect. Cases in which a conducted electrical weapon was displayed or discharged without delivery of the electrical current to the subject did not qualify for inclusion.

Data Collection and Processing

Conducted electrical weapon uses were prospectively identified from June 2005 through June 2008. Individual sites began case surveillance on approval from their own institutional review board and continued until completion of the study period. Two sites terminated collection early because of investigator relocation and reassignment. Deidentified case report forms were completed by site investigators based on police and medical records gathered in the process of the use-of-force investigation. Data included incident and deployment information, subject demographics, injury information, and outcomes. Probe impact sites and injury sites were recorded on body outline sketches by site investigators. Study staff regionalized these using standardized data abstraction techniques and anatomic markers into 7 body regions: head/face/neck, chest, abdomen/pelvis, back, upper extremities, lower extremities and buttocks, and genitals (Figure 2). For reporting, these were further grouped into trunk, extremities, and potentially sensitive (head/face/neck and genitals) areas.

Primary Data Analysis

Data were entered into a database and spreadsheet (Excel, Microsoft Corporation, Redmond, WA). Descriptive analysis was performed and observed proportions were determined with standard methods. CIs were calculated with the Blyth-Still-Casella CI (StatXact, version 8.0; Cytel Software Corporation, Cambridge, MA), an exact method specific to small numerators. A consulting biostatistician performed or reviewed all statistical calculations.

RESULTS

Characteristics of Study Subjects

During the study period, officers at 6 participating law enforcement agencies used conducted electrical weapons against 1,201 criminal suspects. All uses were reviewed. Participating agency characteristics are shown (Table 2). All subjects received preincarceration medical screening, 386

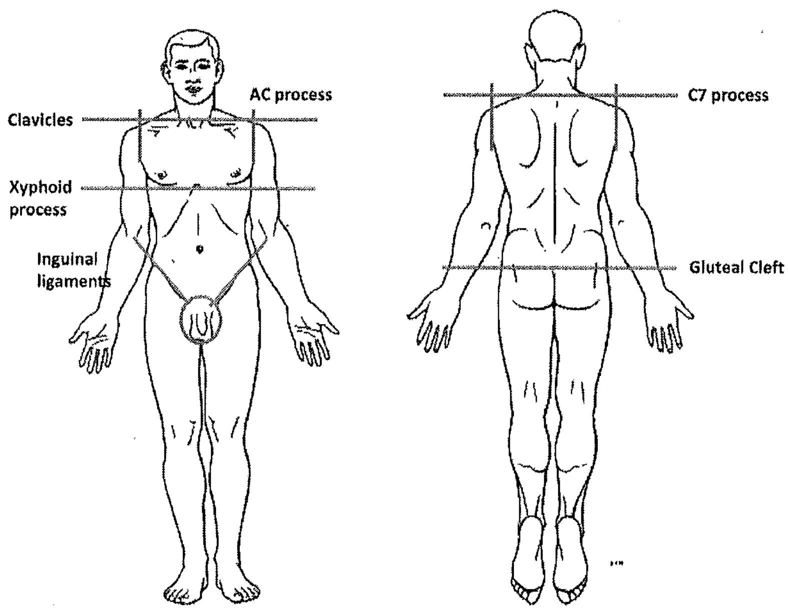

Figure 2. Body impact and injury regions.

Table 2. Characteristics of participating law enforcement agencies.

State	Agency	Population Served	Land Area, Square Miles	FTEs	Sworn FTEs	Data Collection Period, Months	CEW Uses
AZ	Chandler Police Department	247,097	70	500	330	10	46
IL	NIPAS*	5,288,655	945	N/A	N/A	32	7
VA	Fairfax County Police Department	991,000	395	1,772	1,390	31	214
NV	Las Vegas Metropolitan Police Department	1,070,972	7,560	3,970	2,635	36	663
LA	Shreveport Police Department	202,000	101	831	346	36	205
FL	Marion County Sheriff's Office	259,277	1579	894	574	18	66

FTE, Full time equivalent; *CEW*, conducted electrical weapon; *N/A*, not applicable.
*The Northern Illinois Police Alarm System (NIPAS) is a multiagency police emergency services team that responds to high-risk tactical situations in 80 police jurisdictions in the Chicago, IL, area. The system responds to approximately 30 activations per year.

subjects (32%) were evaluated by emergency medical services personnel, and 205 subjects (17%) were transported to a hospital for medical or psychiatric evaluation.

The mean subject age was 32 years (range 13 to 80 years; median 30 years; SD 10.7). Mean height was 69 inches (range 54 to 80 inches; median 69 inches; SD 3.7), mean weight was 184 pounds (range 90 to 390 pounds; median 180 pounds; SD 38), and 1,125 suspects (94%) were men. Alcohol or other drug intoxication was documented in 593 cases (49.5%).

In 1,183 cases in which the conducted electrical weapon model was recorded, the Taser model X26 was used in 1,148 (97%), whereas the Taser model M26 was used in 35 (3%). Deployment details are shown (Table 3). Probe mode was used in 784 cases (65.3%), drive stun (direct contact) mode in 327 cases (27.2%), and both modes in 90 cases (7.5%). The mean number of conducted electrical weapon discharges was 1.8; the median was 1. The back and chest were most commonly contacted when conducted electrical weapons were used in probe mode, whereas the back and lower

Table 3. Conducted electrical weapon deployment details.

	Deployment Mode			
Cases	**Probe**	**Drive Stun**	**Both**	**Total**
No.	784	327	90	1,201
%	65.3	27.2	7.5	100.0
Discharges				
Mean	1.6	1.8	3.3	1.8
Minimum	1	1	1	1
Maximum	9	6	10	10
Median	1	1	3	1
Discharges				
1	484	173	2	659 (54.9%)
2	195	88	37	320 (26.6%)
3	70	46	22	138 (11.5%)
4+	35	20	29	84 (7.0%)

Table 4. Body impact areas in 1,201 conducted electrical weapon uses (n=2,239 recorded impact areas).

	Probe Mode (n=1,703 Impact Areas)			Drive Stun Mode (n=536 Impact Areas)		
Body Area	**No.**	**(%)**	**Region, %**	**No.**	**(%)**	**Region, %**
Back	628	(36.9)	Trunk, 80	249	(46.5)	Trunk, 66
Chest	424	(24.9)		50	(9.3)	
Abdomen/pelvis	301	(17.7)		52	(9.7)	
Lower extremities	189	(11.1)	Extremities, 19	116	(21.6)	Extremities, 31
Upper extremities	134	(7.9)		50	(9.3)	
Head/face/neck	24	(1.4)	Sensitive, 1.6	16	(3.0)	Sensitive, 3.5
Genitals	3	(0.2)		3	(0.6)	

Table 5. Injuries sustained after conducted electrical weapon use.

Injuries	**No.**	**Percent**	**95% CI**
None	938	78.1	75.7-80.4
Mild	260	21.6	19.4-24.1
Moderate	2	0.2	0.03-0.6
Severe	1	0.1	0-0.5

extremities were most commonly contacted when conducted electrical weapons were used in drive stun mode (Table 4).

Main Results

Overall, 1,198 of the 1,201 subjects (99.75%; 95% CI 99.3% to 99.9%) experienced no injuries or mild injuries only (Table 5). Of the 492 mild injuries identified, the majority (n=408; 83%) were superficial puncture wounds from conducted electrical weapon probes. Other mild injuries occurred in 62 of the 1,201 subjects (5.2%; 95% CI 4.0% to 6.6%) and were primarily related to blunt trauma from falls. These included contusions (n=49), lacerations (n=29), and others, including 2 superficial burn marks, a finger fracture, a nasal fracture, a case of epistaxis, and a chipped tooth.

Three subjects (0.25%; 95% CI 0.07% to 0.7%) sustained significant injuries after conducted electrical weapon use. Two were head injuries sustained in falls related to conducted electrical weapon use. The less severe of these was a 6.5-mm temporoparietal intraparenchymal contusion. The more severe was an 8-mm cerebellar epidural hematoma. Both subjects were admitted to the hospital for observation and discharged after 48 to 72 hours without neurosurgical intervention or long-term sequelae.

The third significant injury was a case of rhabdomyolysis of unclear relationship to conducted electrical weapon use. In that case, a 33-year-old man was apprehended by police on a hot summer day after a foot pursuit, physical struggle, and 3 discharges from a conducted electrical weapon fired in probe mode. The subject was evaluated at the scene by paramedics and transported to an ED for evaluation. He admitted to crack cocaine use but had no complaints and after a negative evaluation result was discharged to jail. An officer participating in the apprehension was also treated for heat exhaustion. Two days later, the suspect presented again to the ED from jail with flank pain and decreased urine output. Rhabdomyolysis was diagnosed and he was admitted to the hospital for supportive care. Admission creatine phosphokinase level was 61,116 units/L and creatinine level was 5.5 mg/dL. A renal ultrasonogram was normal. Dialysis was not required, and all results trended back to normal by discharge. He was discharged after 8 days without permanent sequelae.

Two suspects in the study cohort died unexpectedly while in police custody. Both cases were men in their 30s who struggled violently with police both before and after conducted electrical weapon use and on whom other physical force was used to take them into custody. One subject had a high body mass index and was involved in a foot pursuit and prolonged physical struggle with police, during which 2 conducted electrical weapon discharges were used. He collapsed approximately 20 minutes later. At autopsy, he was found to have a dilated cardiomyopathy and cocaine was present in the serum. The second subject was agitated and violent, with a history of mental illness. After an extensive struggle, during which pepper spray and 2 conducted electrical weapon discharges were used, he was restrained in a prone position. He collapsed an estimated 5 minutes after conducted electrical weapon use. An autopsy revealed no anatomic cause of death, but olanzapine at 170 ng/mL was present in the serum. Conducted electrical weapon use was not determined to be causal or contributory to death by the medical examiner in either case.

LIMITATIONS

This study has several limitations. The information abstracted for study purposes was based on review of written officer reports and medical records, which has well-recognized limitations. Criminal suspects may be less than fully cooperative and forthcoming during the apprehension and incarceration process. Some subjects may have sustained injuries that were self-assessed as mild or trivial and denied complaints on medical screening. Because specific testing could not be mandated in this observational trial, the incidence of minor injuries may have been underestimated. Anticipating this limitation, subjects with mild injuries and no injuries were grouped together by an *a priori* decision. Because routine medical screening was performed, it is thought to be unlikely that subjects with the primary outcome measure (significant injuries requiring hospitalization or likely to produce long-term disability or threat to life) were missed. The presence of alcohol or drugs was based on officer reports, rather than toxicologic testing, which may overestimate or underestimate the association of conducted electrical weapon use and drug or alcohol intoxication. Although the number and duration of conducted electrical weapon discharges are recorded in law enforcement reports and confirmed by an electronic recording device within the weapon, confirming the number or duration of discharges that subjects actually received is not currently possible. A subject may fail to receive the energy from a conducted electrical weapon discharge because of incomplete contact by one or both probes or electrodes on the front of the weapon. A number of subjects likely received partial discharges or fewer discharges than recorded, especially in cases in which conducted electrical weapon use did not have any discernable effect. Although site investigators had access to use of force investigation materials, only deidentified summary case report forms could be submitted for study purposes. This precluded assessments of interobserver agreement. It is believed that expert physician review, along with clear guidelines developed for injury severity assessment, minimize this limitation.

DISCUSSION

In the course of their duties, law enforcement officers are required to apprehend combative and violent subjects by using various levels of physical force up to and including deadly force. Conducted electrical weapon use is generally regarded as an intermediate level of force and is authorized in situations that would also justify the use of physical strikes, chemical irritant sprays, and handheld impact weapons such as metal batons. Mild injuries such as contusions and abrasions are common among both officers and suspects after such encounters, and serious or fatal injuries are known to occur.[3] Prevention of significant or fatal injuries is desirable and an important consideration in discussion of the safety of intermediate force options, including conducted electrical weapons.

Reports from a variety of law enforcement agencies indicate that the implementation of conducted electrical weapons has been associated with reductions in suspect injuries (24% to 82% reduction), officer injuries (20% to 93% reduction), and the use of firearms (50% to 66% reduction).[3,9] Although suggesting a significant overall safety benefit of conducted electrical weapon use compared with alternative force options, these reports are limited because they are based on internal agency reviews. If conducted electrical weapon use is associated with a substantial risk of serious injury or death, then these weapons may pose a significant public health concern because more than two thirds of United States law enforcement agencies currently use conducted electrical weapons.

To our knowledge, this investigation represents the first large multicenter assessment of injuries sustained by criminal suspects after conducted electrical weapon use. The primary finding that 99.75% of subjects experienced mild or no injuries represents the first assessment of the safety of this class of weapons when used by law enforcement officers in field conditions. Most of the mild injuries observed (83%) were skin punctures caused by the conducted electrical weapon probes; this is an expected consequence of conducted electrical weapon use. Other mild injuries were observed in 5.2% of subjects. This injury profile compares favorably with other intermediate force options available.[3,4,10] These findings support the continued use of conducted electrical weapons in settings in which they can be safely substituted for more injurious intermediate force or lethal force options.

Two of the 3 significant injuries after conducted electrical weapon exposure were head injuries sustained in falls. Although both subjects were observed without surgical intervention and ultimately had good outcomes, conducted electrical weapons do have the potential to cause serious or fatal injuries because of falls, and at least 1 such fatality has occurred.[11,12] This study observed the incidence of such injuries to be 0.16% of subjects after conducted electrical weapon exposure. This low incidence of significant injuries does not allow identification of subgroups that may be at greater risk for serious injury.

The third significant injury in this series was a case of rhabdomyolysis diagnosed 2 days after incarceration, with an uncertain relationship to conducted electrical weapon exposure. Although a conducted electrical weapon was discharged 3 times (up to 15 seconds of total exposure) during apprehension,

Table 6. Experimental studies of conducted electrical weapon applications in human volunteers, grouped by duration of conducted electrical weapon exposure.

					Assessments* Performed						
Study	**Abstract vs Manuscript**	**CEW Exposure (Seconds)**	**Other Conditions**	**No.**	**Vital Signs**	**ECG**	**Cardiac Enzymes**	**Metabolic Laboratory Tests**	**Respiratory Function**	**Other**	**Duration of Follow-up**†
Vilke, 2008[37]	M	1-5		32		X					Immediate
Levine, 2007[35]	M	1-5		105	X	(X)					Immediate
Barnes, 2006[34]	A	1-5		84	X	(X)					Immediate
Sloan, 2008[36]	M	1-5		66		(X)	X				6 h
Vilke, 2007[26]	M	5		32	X		X	X	X		6 h
Ho, 2006[14]	M	5		66		X	X	X			24 h
Vilke, 2007[30]	A	5	Exercise	8	X			X			1 h
Vilke 2008[31]	A	5	Exercise	22				X			1 h
Dawes, 2007[51]	A	5		15						Salivary α-amylase, cortisol	1 h
Ho, 2008[38]	M	10		34	X					Cardiac ultrasonography	Immediate
Ho, 2008[15]	A	10, 15		21			X	X			24 h
Ho, 2007[24]	M	15		52	X				X		Immediate
Dawes, 2007[22]	A	15		18	X			X	X		Immediate
Ho, 2008[52]	A	15		44	X					Cardiac ultrasonography	Immediate
Ho, 2007[29]	A	15	Exercise	44			X	X			Immediate
Ho, 2007[27]	A	15	Exercise	25		X					Immediate
Ho, 2007[28]	A	15	Exercise	37	X					Cardiac ultrasonography	Immediate
Moscati, 2007[25]	A	15	Alcohol	26			X	X		EtOH level	24 h
Dawes, 2008[53]	M	15		31						Core Temp	Immediate
Dawes, 2007[23]	A	15-45		50				X	X		Immediate

A, Abstract; *M*, manuscript.
*Assessments of vital signs include pulse rate, respiratory rate, and blood pressure. ECGs include serial 12-lead ECGs, indicated with an "X," and single-lead rhythm strips during a period of time, indicated with an "(X)." Cardiac enzymes include serum measurements of troponin, creatine kinase, or myoglobin levels. Metabolic laboratory tests include serum measurements of venous or arterial pH, lactate level, electrolyte levels, bicarbonate level, renal function, or others. Respiratory function measurements include tidal volume, minute ventilation, end-tidal O_2 and CO_2, transcutaneous oximetry, etc.
†Follow-up durations of less than 1 hour are indicated as immediate.

several other potential causes or contributors were present, as have been described in other reports of rhabdomyolysis after conducted electrical weapon exposure.[13] These include high ambient temperatures, prolonged physical exertion, and cocaine use. Experimental studies have not demonstrated evidence of rhabdomyolysis after conducted electrical weapon exposures of up to 15 seconds in healthy volunteers, making the association between conducted electrical weapon exposure and rhabdomyolysis speculative.[14,15]

Two in-custody deaths occurred after conducted electrical weapon exposure among the study cohort. These were judged to be unrelated to conducted electrical weapon exposure, excluding these cases from analysis according to *a priori* design decisions. Both subjects actively resisted arrest both before and after conducted electrical weapon use, and physical collapse occurred at least 5 and 20 minutes after conducted electrical weapon exposure, making electrically induced fatal dysrhythmias unlikely. Both of these cases are consistent with previous reports of unexpected deaths in police custody, which commonly involve bizarre or combative behavior, psychiatric disease, heart disease, or drug use.[16-19] Only a minority, approximately one third, of these deaths appear to occur after conducted electrical weapon use.[20] Other factors that have been described but are more controversial include restraint in the prone position, use of pepper spray, and neck restraint holds. Both fatalities in this series involved features typical of these in-custody deaths. The olanzapine level found in one case was above that in which deaths have been attributed to olanzapine toxicity alone.[21] None of the significant head injuries or deaths occurred after numerous (3 or more) conducted electrical weapon discharges.

A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.[14,15,22-26] Other studies of conducted electrical weapon exposure in combination with exercise designed to simulate the physiologic effects of fleeing from or struggling with police demonstrate changes in pH, lactate, and other markers comparable to that induced by exercise of the same duration.[27-31] No study has demonstrated a pathophysiologic mechanism or effect that would account for delayed deaths minutes to hours after conducted electrical weapon exposure. Findings from independent investigations have been concordant with those performed with industry support. Collectively, these data are broadly reassuring and constitute the current best understanding of the human physiologic effects of conducted electrical weapons.

The possibility of direct cardiac effects is a common concern with conducted electrical weapons.[32,33] Experimental studies in human volunteers have found no cardiac dysrhythmias, ischemia, or necrosis after standard (5-second) or prolonged (15-second) conducted electrical weapon exposure.[14,15,25-27,29,34-38] However, animal studies of conducted electrical weapon discharges in anesthetized swine have produced contradictory results. Some have shown no cardiac dysrhythmias with standard conducted electrical weapon outputs and large safety margins before dysrhythmia induction.[39,40,41] Other studies have observed myocardial capture or ventricular dysrhythmias with standard conducted electrical weapon discharges.[39,42-45] Extrapolation of these contradictory results to humans is problematic, and conclusive human evidence is currently lacking.[1,46] Additional investigations of the dysrhythmogenic potential of conducted electrical weapons are needed in human subjects and animal models.[47]

Although this study of 1,201 consecutive conducted electrical weapon uses with subsequent medical screening does not document any cases with an immediate fatal collapse suggesting conducted electrical weapon–induced dysrhythmia, the possibility is not excluded.[48] The upper limit of the 95% CI of such a fatal event is 0.3%. This is in concordance with a previously reported experience of 421 consecutive conducted electrical weapon uses in a single city, with immediate subsequent medical evaluation, which also found no fatal dysrhythmias or major injuries.[49] This information is useful in assessing the overall risk of conducted electrical weapons.

In addition to assessing the risk of significant injury or fatality, this case series provides an important description of current conducted electrical weapon usage. Findings include that the mean number of conducted electrical weapon discharges used is less than 2 5-second cycles and that 93% of subjects receive 3 or fewer discharges. None of the subjects with significant injuries or death were in the group with more than 3 discharges. Approximately two thirds of conducted electrical weapon uses were with the probe mode, whereas one quarter used the drive stun (direct contact) mode, and fewer than 10% used both modes. When the weapon is used in probe mode, approximately 80% of probe impact sites are at the trunk. When it is used in drive stun mode as an adjunct to physical restraint techniques, conducted electrical weapon impact sites most commonly occur at the back and lower extremities.

Several novel design methods were used in this study. Conducted electrical weapon uses were identified through the law enforcement agency's mandatory use-of-force investigation and review process, allowing reliable identification of conducted electrical weapon deployments within each agency. Because federal privacy laws permit law enforcement agencies to access protected health information in specific instances, including abuse, neglect, and criminal and administrative investigations, law enforcement agencies were able to retrieve medical records as part of their use-of-force investigation process.[50] Interpretation of these records by a physician was incorporated in the use-of-force review process, and deidentified information was extracted for study purposes. These methods improve on previous studies that collect only the subset of subjects brought to medical attention. Physician review of medical and police records allows injury identification, classification, and severity stratification that is very important from both clinical and policy perspectives and represents a significant improvement on previous reports using a binary injured/uninjured determination based on officer impression alone.

In this large multicenter cohort, the observed risk of significant injury after conducted electrical weapon use by law enforcement officers is 0.25%. This risk compares favorably to other force options available to officers, and these findings support the overall safety of conducted electrical weapon use.

Although uncommon, conducted electrical weapons are clearly capable of producing serious injuries. Subjects exposed to a conducted electrical weapon discharge should be assessed for injuries, and appropriate medical evaluation should be provided when nontrivial injuries are evident or suspected. It should also be appreciated that existing medical or psychiatric conditions may cause or contribute to behavior that leads to law enforcement intervention. These underlying conditions may require medical assessment and treatment independent of conducted electrical weapon exposure.

Continued studies of conducted electrical weapon safety are necessary and should focus on assessing and reducing risks to criminal suspects and law enforcement officers. The ongoing discussion of appropriate use of conducted electrical weapons should continue among researchers, law enforcement agencies, oversight agencies, human rights organizations, and the general public. These discussions must be based on scientific study and should consider both the demonstrated risks and benefits of conducted electrical weapon use within the context of available alternative force options.

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Address for correspondence: William P. Bozeman, MD, Wake Forest University School of Medicine, Department of Emergency Medicine, Medical Center Blvd, Winston Salem, NC 27157; 336-716-1740, fax 336-716-1705; E-mail wbozeman@wfubmc.edu.

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Editor's Capsule Summary: *What question this study addressed:* In this prospective, multicenter, observational study, the frequency and seriousness of injury from conducted electrical weapons was assessed in 1,201 patients. *What this study adds to our knowledge:* Serious injury occurred in 3 patients who had received administration of conducted electrical weapons. No cardiac dysrhythmias associated with conducted electrical weapons were documented.