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REVIEW

TASER® conducted electrical weapons: misconceptions in the scientific/medical and other literature

James R. Jauchem

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Abstract TASER® conducted electrical weapons (CEWs) have become an important law-enforcement tool. Controversial questions are often raised during discussion of some incidents in which the devices have been used. The main purpose of this paper is to point out some misconceptions about CEWs that have been published in the scientific/medical and other literature. This is a narrative review, using a multidisciplinary approach of analyzing reports from scientific/medical and other literature sources. In previous reports, durations of incapacitating effects and possible associations of CEWs with deaths-in-custody have often been overstated or exaggerated. Comparisons of CEW effects with "electrocution" are misleading. Clarification of these misconceptions may be important during policymaker decisions, practitioner operations, expert witness testimonies, and court proceedings. Despite misconceptions in the literature, CEWs can still be a valuable tool for law enforcement activities. Scientists, medical professionals, legal advisors, and investigators of police tactics should be aware of these misconceptions.

Keywords TASER · Conducted electrical weapon · Conducted energy weapon · Electronic control device · Electro-muscular incapacitation · Non-lethal

Introduction

TASER® conducted electrical weapons (CEWs) have become an important non-lethal law-enforcement tool ["TASER" is a registered trademark of TASER International, Inc. (Scottsdale, AZ)]. The controversial nature of this topic has been reflected in the discussion of some incidents in which the devices have been used. Some misconceptions may result in a lack of public confidence in police and a lack of perceived legitimacy of using CEWs and other non-lethal weapons.

The purposes of this paper are (a) to review possible misconceptions about CEWs that have been published in the scientific/medical and other literature, and (b) to present the current and other authors' perspectives regarding these issues. Details regarding some of these misconceptions may be important during policymaker decisions, practitioner operations, expert witness testimonies, and court proceedings.

This is a narrative review, using a multidisciplinary approach of analyzing reports from recent scientific/medical and other literature sources (including legal, sociological, police-science, news-media, and popular literature). Some of the topics covered in this review are in the form of questions that may be asked of researchers and policymakers. Policies regarding rules of engagement and risk/benefit analyses are beyond the scope of this review.

Historical notes

Wolf and De Angelis [1] stated that "rapid proliferation of" CEWs "became possible only after" (a) "an intensive corporate search for new ways of profiting from heightened consumer fear of crime" and (b) "an institutional incentive for law enforcement to adopt less visibly violent control technologies". In addition to these two points, as CEWs became more effective they were then more widely adopted. Early models of CEWs were essentially ineffective. The 1991 "Rodney King incident" is one recognized failure of these earlier versions [2]. In one experimental study of a conscious animal model, the "Advanced TASER M26"

J. R. Jauchem (✉)
Forensic Pathophysiology, LLC, 999 E Basse Rd Suite 180, San Antonio, TX 78209, USA
e-mail: jrj@forensicpathophysiology.com

CEW was the only device (out of five models that were evaluated) to effectively cause incapacitation [3]. A number of newer models have become available in recent years (including, most notably, the "TASER X26" device). Emerging new technology, sometimes known as "Smart Weapons" by TASER International, include the "X26P" and "X2" CEW models, which will replace the earlier devices. Even though TASER International has been accused of "aggressive marketing/lobbying… for the acceptance of its products" [4], the devices have been regarded as useful for law enforcement by police departments in many countries.

General concepts regarding CEWs and "electricity"

Although CEW technology has been written about by numerous authors and perceived authoritative bodies in the scientific literature, many have erroneously portrayed how these weapons work and what they are (and more importantly, what they are not) capable of. In some cases, an association of the concept of "electricity" with CEWs may result in increased apprehension and bias against the devices [5]. Hehir [6] stated that the devices "incapacitate subjects by passing 50,000 volts of electricity into the body…". As Williams [7] noted, however, although the main capacitor of the X26 device has a peak open circuit with 50,000 V, only 1,200 V may actually be delivered to the body (in comparison, a relatively strong static electric shock may exceed 30,000 V [7]).

Milne [8] claimed that TASER CEWs produce relatively "high current". In fact, very little electric current would be delivered via a CEW to a subject. One author speculated that in one particular case of CEW use, "only one prong [probe] attached, so that 50,000 V entered" the subject's body, "but never left…" [9]. The speculation that such voltage would be deposited into the body and "never leave" is erroneous. If one probe does not make contact (whether directly to the body or indirectly via some other contact surface), a circuit is not completed. A TASER X26 CEW has a peak electrical current of only 3 A if a circuit is completed, while a strong static shock may have a peak electrical current of 30 A [10].

The 2013 release of the International Classification of Diseases, Tenth Revision, Clinical Modification [11] included a code of "Electrocution from electroshock gun (taser)". The use of such terminology may result in confusion regarding effects of CEWs. The principal cause of death during electrocution is "ventricular fibrillation caused by a direct effect of the electric current" [12]. The unfounded assumption of "electrocution" in deaths after use of a CEW has been discussed previously (e.g. [13]). Statements referring to CEWs as causing "uncontrollable spasm of the heart muscles" [14] are also misleading. There is a lack of evidence for such a direct effect.

Lee et al. [15], using a mathematical model, suggested that "safety" during CEW exposure was directly related to current density near the dart closest to the heart. The degree of overall muscle contractions within the body, however, may be more important than direct effects on the heart, since such contractions may result in potentially hazardous physiological sequelae such as primary metabolic acidosis [16]. Such effects, however, might only occur during repeated or long-duration exposures to CEWs.

Equating effects of CEWs with accidents involving domestic power sources (e.g. [17]), and with electroconvulsive therapy (e.g. [18]), is misleading since properties of each type of exposure are vastly different. Kroll [19] graphically summed up the differences between power sources and CEWs.

Incapacitating effects of CEWs: How long do they last?

Humans must perform continuous muscle activity (especially in the legs) to maintain an upright standing posture. For humans or animals to maintain a fixed posture to oppose gravity, agonistic–antagonistic muscle coupling is required for a stable contraction of muscles to occur [20]. A certain degree of ankle torque is required to counter what may be referred to as "gravity toppling torque" [21]. Ho et al. [22] described the primary effects of CEWs related to incapacitation. In some cases, there may be essentially "board-like rigidity" [23]. Behavioral responses to pain may also play a role.

There have been misstatements regarding incapacitating effects of CEWs. One group of authors [24] indicated that a 3–5 s exposure to a "stun weapon" (seemingly including devices manufactured by TASER International) would commonly leave a subject "incapacitated, left dazed and weak for at least five, perhaps, fifteen minutes". Rejali [25] stated the "technology incapacitates the whole body for several minutes". Layman [26] suggested an individual would be "rendered…physically incapacitated… for up to 10 min". In contrast to these assertions, there have been no confirmed reports of such long-lasting effects. In fact, Criscione and Kroll [27] reported that reaction times were normal in subjects immediately (within $\sim$1 s) after cessation of a 5 s exposure from a TASER X26 CEW.

To imply that CEW applications *regularly* result in "falling while unconscious" [14] will lead to further confusion. Although some cases of "loss of consciousness" have been presumed to be due to CEWs [28], head injuries due to falling onto a hard surface may be more likely than any direct effects of a CEW exposure. Nonetheless, there have been cases reported of CEW shots involving the

cranium with loss of consciousness probably unrelated to impact with the ground [29–31]. A seizure, similar to that induced by electroconvulsive therapy, may be provoked directly by such a CEW exposure [31].

White et al. [32] reported statistically significant decreases in the ability to perform on several tests of cognitive functioning in police recruits after exposure to a CEW. Dawes et al. [33], however, found that other arrest-related stressors during use-of-force scenarios resulted in a similar decline in neurocognitive performance. The result was transient and performance returned to baseline within 1 h post-scenario.

Sussman [34] claimed that CEWs are "even potentially equipping the subject with 'superhuman' strength". This claim was erroneously linked to a warning [35] that: (a) did not include any such causal relationship, and (b) simply included discussion of excited delirium (a syndrome that may occur *independently* of CEW exposures and may include superhuman strength as one of its characteristics). In another article, it was noted that, during CEW exposures, "the mental state may change and even develop to an excited delirium" [36]. Such changes, however, could be independent of any effects of CEW applications.

Feeney et al. [37] stated that "potential complications" of exposure to the TASER X26 CEW included "hyperthermia". The articles cited for this assertion, however (e.g. [38]), again simply included discussion of excited delirium (of which hyperthermia may be one characteristic). Hyperthermia would not be caused by limited CEW exposures [39, 40]. Dawes et al. [41] responded to Feeney et al. and disputed any causal relationship between CEW exposure and an agitated delirious state. Eliades et al. [42] stated that thyroid storm (a disorder characterized by an exaggeration of the natural physiologic response to an overactive thyroid gland) was "induced by electrical shock delivered by a Taser gun". There was, however, no evidence of a causal relationship with the CEW exposure.

Rappert [43] seemed to suggest that CEWs were "designed to cause as much pain as feasible". In addition, in a medical newsletter it was reported that CEWs "work by causing extreme pain" [44]. Rather, most CEWs (other than in "drive stun" mode) have been designed to incapacitate via loss of muscle control.

Severity of injuries associated with CEW usage compared with other non-lethal force

For a full assessment of CEW hazards, one must compare them with effects of other non-lethal weapons. Kirchmaier [45] stated that a military working dog's "injurious effects are relatively minor compared to those of other available non-lethal weapons like the M26 taser…". This idea, however, seems incorrect on the basis of data collected by other investigators, who noted a high potential for serious injury due to canines used in law enforcement [46] (in some police departments, application of a CEW, and deployment of a canine are considered to be at the same level of force [46]). Alpert et al. [47], referring to a survey of non-lethal weapon use, reported "the use of a canine posed, by far, the greatest injury risk to suspects, increasing injury odds by almost 40 fold". With the commonly used "bite-and-hold" technique, injury is practically inevitable [48]. Although there may be differences between rules of engagement for military versus civilian law-enforcement use of canines, it would seem that effects of bites would be similar in both situations. Trained law-enforcement dogs can exert tremendous bite forces (about ten times what would be expected from untrained German shepherds), with a high number of fractures [48].

Gül et al. [49] noted that psychological effects of injuries from dog bites could be permanent. Injuries from canines may be evaluated with "a somewhat higher suspicion for significant injury" [50]. Sloggett and Chesterman [51] suggested that use of a CEW is "often the less injurious solution" when compared with alternatives such as batons, police dogs, or conventional firearms.

Is CEW usage causally associated with deaths?

Reports in the news media are often focused on possible *causation* rather than simply a non-causative association or correlation of CEW events with in-custody deaths. Potential confounding factors involved in cases of deaths that occur at approximately the same time as CEW usage have been summarized previously [52–54]. Despite these factors, causality with the CEW is often assumed, as in the following statement: "…a suspect who was Tasered by law enforcement has died as a result" [55]. Other authors have argued, "…in some cases" of CEW applications, "…even death can result" [56] and "stun guns are capable of causing death" [57]. Even with a temporal relationship between CEW exposures and deaths, however, one cannot automatically presume a causal association. In addition, whether any particular factor is a contributory cause of death versus an irrelevant factor [58] would be dependent on details of the situation. Laima et al. [59] suggested that CEWs had a "dangerous effect on the heart muscle that caused fatal arrhythmias" but concluded that "overt cardiac pathology" and "stress" would be more important in cases of deaths-in-custody.

Lee et al. [60] studied CEW deployment among law-enforcement departments. The authors concluded that usage was associated with a significant increase in deaths-in-custody in the early deployment period. Exposures to CEWs, however, were not verified. There was a low

response rate from agencies queried and "every single one of the top ten cities refused to give" data to the investigators [61]. Kaminski [62] also criticized the study, stating that the authors' "speculation is implausible on its face".

Casey-Maslen [63] stated, "these weapons have been marketed as 'non-lethal', 'less lethal', 'sub-lethal',…although the use of some of these devices has already resulted in significant numbers of deaths and serious injuries". Significant numbers, however, generally have not been directly linked solely to use of the devices. In an example of one study [64], deaths reported after CEW applications occurred overwhelmingly in subjects who exhibited (a) pre-existing cardiovascular disease, (b) an agitated state and long struggles with police officers, or (c) illicit stimulant use. In death-in-custody cases, an assumption that "it was the taser that pushed him off the cliff" [65] cannot be proven. Barua and Vaughn [66] said that CEWs "have caused death when used on individuals with existing or potential health problems". A causal effect directly linked to the CEW device itself, however, was not proven. White and Ready [67] noted that, even though subjects exposed to CEWs were "disproportionately from a vulnerable population that many argue are at higher risk for suffering serious physiological side effects," there was "no evidence of serious injury or death…" (other more recent studies that are similar have been cited previously [54]).

Oriola et al. [68] cited a case in which a subject supposedly "had his heart weakened" in an initial incident that included CEW application and subsequently died after another law-enforcement episode with a CEW being used. The first incident, however, occurred two years prior to the fatal incident. No mechanism for such "weakening of the heart" is apparent.

Langevin [69] claimed that long QT syndrome (a disorder characterized by sudden rapid heartbeats) could be the sole reason for in-custody deaths due to CEW exposures. There is no basis for such a conclusion. In fact, long QT syndrome has been reported during excited delirium (which may occur independently from CEW applications) [70]. The syndrome is often considered to be inherited and can be diagnosed via genetic testing [71].

In one business-news item, the headline was, "Tasers can kill, says American Heart Association" [72]. In fact, results of the cited study [28, 73] simply appeared in a journal published by the association. The entire organization did not review and accept the article. In the article, eight cases of purported atrial fibrillation, myocardial infarction, and death were listed as being due to CEW exposures. Kroll et al. [74], however, noted that potential confounding factors (not related to CEWs) were not accounted for. Other drawbacks to the article have been mentioned previously [54]. For example, it is likely that one of the deaths was due to strenuous exertion combined with the sickle cell trait (without any contribution of CEW applications). Graham [75] also supported this idea.

Omalu [76] seemed to suggest that CEWs themselves could *cause* death due to "nervous system pathologies such as… status epilepticus… repetitive concussive brain injury, etc.". In contrast, such pathologies could be confounding factors during incidents involving use of the weapons (rather than caused by the weapons themselves).

Langsjoen et al. [77] presented a case with use of a CEW purportedly associated with cardiac arrest and anoxic brain injury. Rather than a causal association with the CEW, the syndrome of excited delirium must be considered. In other literature, on the basis of the small number of cases in which a temporal relationship between CEW applications and fatal cardiac arrhythmias was found, a clear causal link can neither be confirmed nor excluded [78]. Kenny and Bovbjerg [79] noted, since there is no appropriate comparison group for epidemiological studies, it is not possible to determine "even whether there are risk factors" for death among those exposed to CEWs.

Why use the term "non-lethal" to refer to CEWs?

The terms "non-lethal weapons" and "less-lethal weapons" (which include CEWs) have been considered by some authors to be "rather euphemistic" [80]. Wright [81] was concerned about a "vexed issue of when is a non-lethal weapon a non-lethal weapon if it isn't really non-lethal". Wright [81] also commented, "…since a submachine gun wounds statistically more often than it kills—is it therefore a non-lethal weapon?". Upton [82] suggested, "Non-lethal implies that TASERs are not capable of lethality…". These statements and related questions can be addressed by referring to Burrows and Cooper [83], who explained that such devices are "weapons, devices or tactics *designed and intended*" to operate "*without substantial risk* of serious or permanent injury or death" (italics for emphasis are mine). The US Department of Defense [84] noted, more recently, that non-lethal weapons "are intended to… minimize risk of fatalities, permanent injuries…however, they shall not be required to have a zero probability of producing these effects". Upton [82] was correct to warn that, if not properly interpreted, use of the term "non-lethal" may result in police officers applying "unnecessary, repeated deployment of TASERs on a suspect". Such deployments should be avoided. It should be noted, however, that other types of forces intended to be non-lethal could result in a lethal outcome (e.g. repeated heavy striking with a flashlight or baton) (also see the section titled "What would constitute excessive use of a CEW?" below).

TASER International [85] has stated "CEW exposure causes certain effects, including physiologic and metabolic

changes" and, "in some individuals, the risk of death or serious injury may increase with cumulative CEW exposure". Such effects, however, would not be expected during short-duration exposures.

Is there unusual bias among the experts who study TASER CEWs?

Controversy regarding different funding sources

Azadani et al. [86] compared funding sources and author affiliations with conclusions regarding whether TASER CEWs were a) "harmful", b) "probably harmful", c) "unlikely harmful", and d) "not harmful" (as identified by "two independent reviewers"). Whether an analysis of any given study would result in such specific conclusions, however, is difficult to determine and open to interpretation [87]. In addition, it would be problematic to use such simple classifications, without considering different durations of exposure and other aspects of methodology [88]. Although a table listing details of classification of each study might be cumbersome (as argued by Azadani et al. [89]), a reader would not be able to reach any reasonable conclusions *without* such details.

In some cases, once an investigator has received supported from TASER International, one may mistakenly presume that the company also supports any future work by that investigator even if the work is independent [90]. I myself have been guilty of this misconception [53].

If experts arrive at different conclusions, is there unwarranted bias?

Expert witnesses often have differing opinions regarding details of cases related to CEW usage. Some would question how such opinions could be different, and would assume that unwarranted "bias" must be present. Beran [91] argued against this idea and noted, "each expert will have an opinion and often that expert will be known to hold a particular view within the context of comparable scenarios… so long as that expert sincerely ascribes to the view for valid reasons, then it is inappropriate to label that expert a 'hired gun'". Since an expert's opinion regarding cause of death will be based partly on "experiences… and just plain personal intuition" [92], it should not be surprising that differing opinions may be presented during courtroom testimony. In addition, the law profession realizes that "scientific conclusions are subject to perpetual revision" [93].

Some bias relating to effects of CEWs "could be the result of the framing or shaping of the actual research questions, which may be more likely to lead to certain conclusions even if the integrity of the research is sound" [94]. In many cases, a court will decide whether an expert's testimony is based on scientific knowledge [95]. In addition, a change of opinion by an expert may be entirely logical as scientific theories evolve [96]. Hope et al. [97] noted that, in cases of "innocent contamination" inadvertent false consistency can lead to allegations of "willful collusion or a cover-up" when none has intentionally taken place.

Cases of oversimplification and exaggeration

Oversimplification of the title of a journal article

Dawes and Ho [98] pointed out a misleading title in a medical article ("Myocardial infarction after TASER exposure"), in a case that included a physical altercation and use of an over-the-counter weightlifting supplement [99]. Two of the authors [100] responded that the title was "factually correct" even if misleading. This is just one example of how titles (often the only part of a scientific paper that some readers will see) are sometimes oversimplified.

Far-reaching conclusions based on incomplete information

It has been assumed by some that results of one CEW study (performed by me and my colleagues [101]) were "leaked to CBS News, fueling controversy about levels of acidosis and troponin T…" [102] (troponin T is a heart-muscle injury marker). Results of the study, however, were not "leaked," but rather were publicly released before any news reports. In a related news story on CBS News [103], a cardiologist stated, "initial impression would be that there'd been some heart muscle damage, threat of a heart attack". More recently, Hibberd [104] also claimed CEW exposures, as performed in the study, caused heart damage. After CEW exposures in our animal-model study, however, there were no statistically significant differences in serum cardiac troponin T from baseline. As explained in the full paper relating to the research [105], since the detection limit of the troponin assay had not been determined, values listed as "zero" at baseline may simply have been below the detection limit (with recent analytical improvements, lower levels of cardiac troponin can be measured more accurately [106]). Even if the troponin concentrations in our study *had* been statistically significantly increased after CEW exposures, such changes would not necessarily be clinically significant. Muscle contractions during physical exercise can result in increased cardiac troponin in the blood [107]. The cause for the increase is not known.

Wolf and De Angelis [108] contended that college students and "non-resisting political protestors" are more

"vulnerable" to the effects of CEWs than the general population. There is no basis for this assertion. A case report of a 15-year-old combative male who was "subdued via taser" and exhibited a "pattern of deficits observed in children who have experienced an anoxic event secondary to cardiac arrest" was presented as illustrating particular vulnerability of adolescents [109]. There is also no basis for this assertion. Gardner et al. [110] reported no significant injuries in 100 consecutive CEW uses against suspects who ranged from 13 to 17 years in age.

Gross et al. [111] presented a case report of an incident in which a CEW was deployed against a 51-year-old 350-pound man. The authors stated "…it seems clear that the use of the TASER played a significant role in his early rhabdomyolysis and renal failure". The patient exhibited markedly elevated creatine phosphokinase (CPK) levels (which can be associated with skeletal muscle damage). It was assumed that the CPK levels "can only be explained in the context of his exposure to the shocks he received from being TASERed" [111]. The subject, however, was so combative that he was administered haloperidol and lorazepam and was placed in four-point restraints. The high levels of CPK seen in the case report were more consistent with cases of excited delirium (e.g. [112]) than with CEW exposures.

Bell et al. [113] presented a case report of a 32-year-old male with a cerebrovascular accident after head exposure to a TASER CEW during an altercation with police. The case was classified as an "isolated electrical neurovascular injury," in part due to the temporal relationship with the CEW application. The authors cited several previous reports of neurological injuries associated with electrical exposures. Any relevance of those cases to CEW exposures, however, is not obvious. For example, one case that was cited [114] was related to use of a high-voltage arc welder. Such equipment operates from 220 to 440 volt alternating current [115], a situation quite different from CEWs. In addition, Bell et al. [113] also suggested that "thermal injury, caused by large quantities of heat produced by the flowing current" might have been involved in their case report. The strength of current passing through the body is a crucial factor in electrical injuries [116]. Such a current, however, does not flow during CEW exposures. A cerebrovascular accident coincident with CEW application may be more likely due to head trauma (which could occur during falling to the ground) than due to any electrical properties of the CEW itself.

Ghaheri et al. [117] suggested that cases of Raynaud's syndrome in two "users" and two "sellers" of CEWs might have been associated with vibration from the CEWs. Evidence for such an association is lacking. Dawes and Brave [118] noted that only minimal vibration would be perceived during CEW applications.

What would constitute excessive use of a CEW?

Are some uses of CEWs automatically "excessive"?

Upton [82] analyzed 113 cases of "TASER use of force" (as reported in news articles) and identified 19 of those cases as resulting in death (notwithstanding the lack of a causal association). The author suggested that the remaining cases "involved use of TASER force that may be in question for police misconduct". Another author reported that all deaths in Canada that occurred during incidents of CEW applications were "due to their inappropriate, excessive… use" [119]. Although, in some cases, use of a CEW may truly be excessive [120], not *all* uses would be considered disproportionate. "Determining whether the force used by police is excessive is a fact-laden inquiry" [121] that is a difficult task. Police-science literature related to excessive use of force may not even specifically include cases of justified force [122] or "avoidance of force" [123] for comparison. The ambiguous and nebulous term "appropriate force" "is often defined in hindsight by the courts" [123].

The acceptability, in the public's view, of even equipping the police with CEWs will be dependent on the context in which the weapons are deployed [124, 125]. Use of the device to protect an officer from being assaulted may result in fewer objections from the public than use as a "riot-control weapon" to suppress dissention within a group of protestors.

Robinson [126] hypothesized that increasing efficiency of non-lethal weapons, when combined with legal proportionality requirements, may lead to an increase use of such weapons "in situations where no force would be used today". Since a CEW is relatively easy to deploy, some may argue that police officers are going to be tempted to use it "just to show who is boss" [127]. Bourne [128] suggested that acceptance of CEWs will lower the threshold for use of force. In contrast, in one study of a metropolitan police department, officers equipped with CEWs used the weapons *only* when encountering physical resistance (and *not* in response to simply passive resistance from subjects) [129]. Taylor et al. [130] explained how, despite an increase in the general availability of CEWs to some officers, the actual use of CEWs stayed relatively constant.

The John Howard Society of Alberta [131] considered "the use of tasers by police forces and guards in penal institutions" to be "officially sanctioned excessive use of force". The authors seemed to presume that *all* use of CEWs in a prison setting is excessive. In particular specific prison settings, however, CEWs may be more useful and effective than large tactical teams using shields and batons [132].

If an individual is asked to describe use-of-force incidents in terms of dichotomous variables (e.g. "justified" versus "unjustified," "legal" versus "illegal," "excessive" versus "not excessive"), the person must choose between one extreme position and another [133]. As Flanagan and Vaughn [134] noted, however, the term "excessive use of force" includes a continuum of interactions between police and the public (a full discussion of the placement of CEWs on the use-of-force continuum is beyond the scope of this review). Simply because a death occurred after use of a CEW, unreasonable or excessive force should not be inferred [135].

Police departments have the ability to implement a variety of improvements in their operations to decrease complaints of excessive force, including specifically for CEW usage. Policies need to be clear regarding what is required of law-enforcement personnel in different situations [136]. In general, the use of CEWs is not usually associated with a greater number of liability claims of excessive force against police departments, at least in the US [137].

Is all use of CEWs "torture"?

CEWs have been referred to as a "refinement" of "electro-torture" [138] and as having origins "in Argentina in the early twentieth century" for use in "torture and interrogation of human subjects by police" [139]. These beliefs, however, are in contrast with the original intent of the development of the weapons as a non-lethal alternative to other uses of force. Langevin [63] indicated that any use of a CEW is *automatically* in breach of a treaty of the United Nations Committee against Torture. The committee, however, did not intend for the term "torture" to be applied to lawful actions [140]. An act of torture only occurs when "severe pain or suffering… is intentionally inflicted on a person for such purposes as obtaining… information or a confession, punishing… or intimidating or coercing…" [140]. Some uses of CEWs *could* be inappropriate (such as to simply obtain compliance in some situations, e.g. [141] or "repeated drive stuns without justification" [142]). Although psychiatric sequelae after CEW exposures [143] may be similar in some respects to effects of torture (including post-traumatic stress disorder [144]), use of the devices during most law-enforcement activities would not fit within a description of "torture."

Cusac [145] suggested that CEWs are used more often for "torture and abuse rather than as a substitute for lethal force". Empirical data for such a claim are lacking. Actually, any object can be used as a torture device. Haberland [146] noted, considering the wide variety of practices that may be used for torture, "it seems slightly unfair to simply brand [non-lethal weapons] as potential torture instruments".

Wright [81] complained, "no one calls these products torture technologies. Instead… Orwellian euphemisms are used, such as e.g. electro muscular disruption technology". Such a description of the technology, however, is more reasonable than use of the term "torture."

Should CEWs be used only as an alternative to deadly force?

Some have suggested that CEWs are designed for "replacement of firearms" [147]. A CEW, however, is usually not intended to "replace" a firearm [148]. In one police department, although the chief stated that CEW use was, in essence, "an alternative to deadly force," the department's general orders included a statement that CEWs were "not a substitute for lethal force" [149]. Ijames [150] explained how describing a CEW as an alternative to deadly force is inaccurate when law-enforcement officers face impending deadly jeopardy. Instead, a CEW is simply one type of non-lethal weapon; there should be no intent to use it in situations where deadly force is necessary.

Individual police officers have, at times, been justified (ethically and legally) to use deadly force, but did not [151]. The availability of a CEW may have been a factor in some of these decisions. Conversely, if use of a CEW is initially ineffective, in some situations officers are subsequently justified in employing lethal weapons [152]. Scott [153] noted that a CEW is "not a replacement for existing means of managing conflict situations, but is an option to be considered alongside all other available tactics". If CEWs were to be banned, law-enforcement officers may instead rely on other forms of physical force that could result in injuries. In addition, Ho et al. [154] noted that escalation to deadly force might be avoided in many confrontations with mentally-ill patients (or suicidal situations) simply by the presence of a CEW.

Should all police officers that are certified to carry a CEW be exposed themselves?

When officers are trained in the use of CEWs, it has been common for instructors to allow trainees to experience a short period of exposure [102]. Martinelli and Staton [155] stated that a law-enforcement officer cannot "convince the general public and/or a plaintiff attorney that" CEWs are "safe and effective… when you refuse to be exposed yourself". This may be a commendable attempt to facilitate acceptance of the use of CEWs. Other personnel, however, usually physically support the volunteers to prevent them from falling down (or the volunteers are provided with a padded area to fall onto). After this experience, officers in

the field may not actively focus on the fact that severe traumatic head injuries can result from subjects falling to the ground after a CEW application (separate from any "direct" effects of the devices). Kleinig [156] explained the psychosocial difference between experiencing a CEW exposure as part of a training exercise and as part of a use-of-force situation in the field. In a survey of one county in the US, Gerhardstein [142] reported that one-third of police departments did not specifically instruct their officers to consider any risk of impact to subjects falling off an elevated surface subsequent to CEW use. This lack of consideration may be reinforced during the training-exercise CEW exposures.

After a claim of a compression fracture of the thoracic spine, some police departments prohibited such training exposures [102]. Such fractures, though very rare during CEW training exposures, have been reported at thoracic vertebrae 6, 7, and 8 [157, 158]. Another trainee exhibited vertebral body compression fractures at T8 and T9, and bony contusion of the T7 and T10 superior endplates, after a CEW application to the ventral part of the body [159]. A scapular fracture was reported in another police officer [160]. An unusual case was mentioned (in a news article) of a subject "breaking the humerus bones, in his upper arms, dislocating his shoulders, and fracturing his shoulder sockets" purportedly caused by "muscles convulsing the bones" during a CEW exposure [161]. Although fractures occurring after common household electric shock are usually the result of falling onto a hard surface, very rare cases of the electricity itself causing enough tetanus to produce a fracture have been reported [162]. Fractures of the humerus were the most frequent. In addition, older volunteers may suffer fractured hips [163], and any loss of bone mineral density would increase the risk for fracture.

Key points

1. The scientific/medical and other literature contains many misconceptions regarding the use of conducted electrical weapons (CEWs) during law-enforcement operations.
2. Durations of incapacitating effects and possible associations of CEWs with deaths-in-custody have often been overstated or exaggerated.
3. Assumptions that all uses of CEWs constitute excessive force or torture are misleading and unwarranted.
4. Clarification of these and other misconceptions may be important during policymaker decisions, practitioner operations, expert witness testimonies, and court proceedings. Scientists, medical professionals, legal advisors, and investigators of police tactics should be aware of these misconceptions.

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References

1. Wolf B, De Angelis J. Fear, legitimacy crises, and invisible violence: a structural analysis of the proliferation energy weapons. Conference papers, American Society of Criminology, Chicago; 14–17 Nov 2008.
2. Meyer G. Conducted electrical weapons: a user's perspective. In: Kroll MW, Ho JD, editors. TASER® conducted electrical weapons: physiology, pathology, and law. New York: Springer; 2009. p. 1–9.
3. Sherry CJ, Brown GC, Beason CW, Jauchem JR, Dayton TE, Ross JA, et al. An evaluation of the electrical properties and bio-behavioral effects of four commercially available TASER®s and the Jaycor Sticky Shocker. US Air Force Research Laboratory Technical Report AFRL-HE-BR-TR-2003-0089. Jun 2003. http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA416553&Location=U2&doc=GetTRDoc.pdf. Accessed 20 Nov 2014.
4. Leman-Langlois S. Afterward: technopolice. In: Leman-Langlois S, editor. Technocrime: technology, crime and social control. Devon: Willon Publishing; 2008. p. 243–6.
5. Ho JD, Dawes DM, Nystrom PC, Collins DP, Nelson RS, Moore JC, Miner JR. Reply to Strote, "Lay person use of conducted electrical weapon research. Forensic Sci. Int. (2014) page e20". Forensic Sci Int. 2014;2014(238):e21–2.
6. Hehir B. Vulnerable targets. Can using Tasers on mental health patients ever be justified? An alternative to providing a mental health service. Nurs Stand. 2013;27(40):27.
7. Williams HE. TASER electronic control devices and sudden in-custody death: separating evidence from conjecture. Springfield: Charles C. Thomas; 2007.
8. Milne R. The development of a wireless electrostatic mark lifting method and its use at crime scenes. JFI. 2012;62(2):154–64.
9. Yakasovich K. Taser use in Canadian police forces. Lethal dependence on the "non-lethal" weapon. Law Justice Online J. 2009;1(1). http://julianhermida.com/lawandjusticejournal/journalvol1Katie.pdf. Accessed 22 Dec 2014.
10. Brave M. TASER® X26—electrical demonstrations. 24 Oct 2006. http://www.ecdlaw.info/outlines/TASER%20X26%20demos%2010-24-06%20005.pdf. Accessed 20 Nov 2014.
11. US Centers for Disease Control and Prevention. International classification of diseases, tenth revision, clinical modification (ICD-10-CM). Atlanta, GA; 27 Aug 2012.
12. Michiue T, Ishikawa T, Zhao D, Kamikodai Y, Zhu BL, Maeda H. Pathological and biochemical analysis of the pathophysiology of fatal electrocution in five autopsy cases. Leg Med (Tokyo). 2009;11(Suppl 1):S549–52.
13. Kroll MW, Panescu D. Physics of electrical injury. In: Ho JD, Dawes DM, Kroll MW, editors. Atlas of conducted electrical weapon wounds and forensic analysis. New York: Springer; 2012. p. 25–46.
14. Wansbrough L. Less than legal force? An examination of the legal control of the police use of force in New Zealand. Auckl Univ Law Rev. 2008;14:176–216.
15. Lee J, Seo JK, Woo EJ. Mathematical framework for current density imaging due to discharge of electro-muscular disruption devices. ESeriesAIM: Math Model Numer Anal. 2007;41:447–59.
16. Maher PJ, Walsh M, Burns T, Strote J. Prehospital resuscitation of a man with excited delirium and cardiopulmonary arrest. CJEM. 2014;16:80–3.

17. Dingfelder S. Stun guns may cause brain injury. Monit Psychol. 2008;39(6):12.
18. Green C. Do stun guns cause brain injury? Advances in the history of psychology. 24 Jun 2008. http://ahp.apps01.yorku.ca/?p=480#more-480. Accessed 20 Nov 2014.
19. Kroll M. Why I would rather be shot with a TASER device than back a lift bucket into an overhead transmission wire. In: 51st annual meeting of the Association of Defense Counsel of Northern California and Nevada, San Francisco; 9–10 Dec 2010.
20. Santillán M, Hernández-Pérez R, Delgado-Lezama R. A numeric study of the noise-induced tremor in a mathematical model of the stretch reflex. J Theor Biol. 2003;222:99–115.
21. Masani K, Sayenko DG, Vette AH. What triggers the continuous muscle activity during upright standing? Gait Posture. 2013;37:72–7.
22. Ho J, Dawes D, Miner J, Kunz S, Nelson R, Sweeney J. Conducted electrical weapon incapacitation during a goal-directed task as a function of probe spread. Forensic Sci Med Pathol. 2012;8:358–66.
23. Ho JD, Dawes DM, Kunz SN, Miner JR, Sweeney JD. Conducted electrical weapon effectiveness: old vs. new technology. In: 7th European symposium on non-lethal weapons, Ettlingen, Germany; 3–5 Jun 2013. p. 28-1–28-9.
24. OMEGA Foundation. Crowd control technologies (an appraisal of technologies for political control). Final study. Luxembourg City: European Parliament; 2000.
25. Rejali D. Torture and democracy. Princeton: Princeton University Press; 2007.
26. Layman EL. How therapeutic are tasers? J Am Psychol Nurses Assoc. 2000;6(3):97–9.
27. Criscione JC, Kroll MW. Incapacitation recovery times from a conductive electrical weapon exposure. Forensic Sci Med Pathol. 2014;10:203–7.
28. Zipes DP. Sudden cardiac arrest and death associated with application of shocks from a TASER electronic control device. Circulation. 2012;125:2417–22 (Erratum in: Circulation 2012;126:e27. Erratum in: Circulation 2013;127:e839).
29. Rehman TU, Yonas H, Marinaro J. Intracranial penetration of a TASER dart. Am J Emerg Med. 2007;733:e3–4.
30. Mangus BE, Shen LY, Helmer SD, Maher J, Smith RS. Taser and Taser associated injuries: a case series. Am Surg. 2008;74:862–5.
31. Bui ET, Sourkes M, Wennberg R. Generalized tonic-clonic seizure after a taser shot to the head. CMAJ. 2009;180:625–6.
32. White MD, Ready JT, Kane RJ, Dario LM. Examining the effects of the TASER on cognitive functioning: findings from a pilot study of police recruits. J Exp Criminol. 2014;10:267–90.
33. Dawes DM, Ho JD, Vincent AS, Nystrom PC, Moore JC, Steinberg LW, et al. The neurocognitive effects of simulated use-of-force scenarios. Forensic Sci Med Pathol. 2014;10:9–17.
34. Sussman A. Shocking the conscience: what police tasers and weapon technology reveal about excessive force law. UCLA Law Rev. 2012;59:1342–415.
35. TASER International. Product warnings—law enforcement. 8 Jun 2006. http://www.storesonlinepro.com/files/1791046/uploaded/Police%20Taser%20Warning.pdf. Accessed 20 Nov 2014.
36. Leitgeb N. Cardiac fibrillation risk of taser weapons. Health Phys. 2014;106:652–9.
37. Feeney C, Vu J, Ani C. Acute agitated delirious state associated with taser exposure. J Natl Med Assoc. 2010;102:1254–7.
38. Lutes M. Focus on: management of TASER injuries. Am Coll Emerg Physicians News. 2006. http://www.acep.org/content.aspx?id=8332. Accessed 22 Dec 2014.
39. Dawes DM, Ho JD, Johnson MA, Lundin E, Janchar TA, Miner JR. 15-Second conducted electrical weapon exposure does not cause core temperature elevation in non-environmentally stressed resting adults. Forensic Sci Int. 2008;176:253–7.
40. Aguilar Pallarès A, Morante Barragán JF, Novelle Rodríguez M, Subirana Domènech M. Electronic control devices: what is known? What is unknown? Cuad Med Forense. 2013;19:75–86.
41. Dawes DM, Ho JD, Cole JB. Response to "Acute agitated delirious state associated with TASER exposure". J Natl Med Assoc. 2011;103:986–8.
42. Eliades M, Jaimungal S, Mohtasebi Y, Munir KM, Patil-Sisodia K. Thyroid storm induced by electrical shock delivered by a taser gun. Paper presented at the Endocrine Society's 96th Annual Meeting and Expo, Chicago; 21–24 Jun 2014.
43. Rappert B. Moralizing violence: debating the acceptability of electrical weapons. Sci Cult. 2004;13:3–35.
44. Anonymous. Excessive stun gun use in New York documented in newspaper. Alcohol Drug Abuse Wkly. 2013;25(11):8.
45. Kirchmaier CT. Unleashing the dogs of war: using military working dogs to apprehend enemy combatants. Army Lawyer. 2006;27:1–12.
46. Mesloh C, Henych M, Wolf R. Less lethal weapon effectiveness, use of force, and suspect and officer injuries: a five-year analysis. Report to the National Institute of Justice, Document No. 224081. Fort Myers, FL: Florida Gulf Coast University; 2008. www.ncjrs.gov/pdffiles1/nij/grants/224081.pdf. Accessed 20 Nov 2014.
47. Alpert GP, Smith MR, Kaminski RJ, Fridell LA, MacDonald J, Kubu B. Police use of force, TASERs and other less-lethal weapons. Washington, DC: National Institute of Justice; 2011.
48. Hutson HR, Anglin D, Pineda GV, Flynn CJ, Russell MA, McKeith JJ. Law enforcement K-9 dog bites: injuries, complications, and trends. Ann Emerg Med. 1997;29:637–42.
49. Gül Z, Hekim H, Terkeşli R. Controlling police (excessive) force: the American case. Int J Hum Sci. 2013;10(2):285–303.
50. Adedipe A, Maher PJ, Strote J. Injuries associated with law enforcement use of force. Trauma. 2013;15:99–106.
51. Sloggett D, Chesterman S. Exclusive: changing the rules of engagement? Policing Today Teddington, Middlesex, UK: Pavilion Publishing and Media; 2014. http://www.policingtoday.co.uk/exclusive_changing_the_rules_of_engagement_31386.aspx. Accessed 20 Nov 2014.
52. Jauchem JR. Deaths in custody: are some due to electronic control devices (including TASER® devices) or excited delirium? J Forensic Leg Med. 2010;17:1–7.
53. Jauchem JR. Pathophysiologic changes due to TASER® devices versus excited delirium: potential relevance to deaths in custody? J Forensic Leg Med. 2011;18:145–53 (Erratum in: J Forensic Leg Med. 2013;20:370).
54. Jauchem JR. Exposures to conducted electrical weapons (including TASER® devices): how many and for how long are acceptable? J Forensic Sci. 2014;. doi:10.1111/1556-4029.12672.
55. Moran M. The growing legal implications of Tasers. A primer on the development, uses, and consequences of Tasers. AALL Spectrum (Am Assoc Law Libr). 2011;15(9):8–10.
56. Lerner CS, Lund N. Heller and nonlethal weapons. Hastings Law J. 2009;60:1387–414.
57. Volokh E. Nonlethal self-defense (almost entirely) nonlethal weapons, and the rights to keep and bear arms, defend life, and practice religion. Stanf Law Rev. 2010;62:1–66.
58. Yu X, Wang H, Feng L, Zhu J. Quantitative research in modern forensic analysis of death cause: new classification of death cause, degree of contribution, and determination of manner of death. J Forensic Res. 2014;5(2):1000221.
59. Laima S, Fomin D, Jasulaitis A, Andriuškevičiūtė G, Chmieliauskas S, Sabaliauskas V, Sergejevas V. The effect of conducted electrical weapons on the human body. Acta Med Litu. 2014;21(2):73–80.

60. Lee BK, Vittinghoff E, Whiteman D, Park M, Lau LL, Tseng ZH. Relation of Taser (electrical stun gun) deployment to increase in in-custody sudden deaths. Am J Cardiol. 2009;103:877–80.
61. Tseng Z. Lessons learned during 5 years of studying sudden cardiac death; genetics, tasers, and an RO1. University of California, San Francisco. 21 May 2010. http://vimeo.com/14048082. Accessed 19 Sep 2014.
62. Kaminski RJ. Research on conducted energy devices. Findings, methods, and a possible alternative. Criminol Public Policy. 2009;8:903–13.
63. Casey-Maslen S. Non-kinetic-energy weapons termed "non-lethal": a preliminary assessment under international humanitarian law and international human rights law. Geneva, Switzerland: Geneva Academy of International Humanitarian Law and Human Rights. Oct 2010. http://www.geneva-academy.ch/docs/projets/Non-Kinetic-EnergyOctober2010.pdf. Accessed 20 Nov 2014.
64. Strote J, Hutson RH. Taser use in restraint-related deaths. Prehosp Emerg Care. 2006;10:447–50.
65. Wilson L. The implication of taser failure to warn liability for police misconduct lawsuits. Police Misconduct Civil Rights Law Rep. 2011;10:1–12.
66. Barua V, Vaughn MS. Legal liabilities for use of tasers and stun guns by jail and prison officers. In: 60th annual meeting of the American Society of Criminology. St. Louis, MO, 12–15 Nov 2008.
67. White MD, Ready J. The TASER as a less lethal force alternative. Findings of use and effectiveness in a large metropolitan police agency. Police Q. 2007;10:170–91.
68. Oriola T, Neverson N, Adeyanju CT. 'They should have just taken a gun and shot my son': Taser deployment and the downtrodden in Canada. Soc Ident J Study Race Nation Cult. 2012;18:65–83.
69. Langevin T. Conductive electronic weapons and their faults. Raleigh: Lulu Press; 2011.
70. Bozeman WP, Ali K, Winslow JE. Long QT syndrome unmasked in an adult subject presenting with excited delirium. J Emerg Med. 2013;44:e207–10.
71. Kshemada K, Kartha CC, Mehta JL. Forensic sciences and growth of cardiology. J Forensic Res. 2013;5(1):1000e115.
72. Smith D. Tasers can kill, says American Heart Association. International Business Times. 24 May 2012. http://www.ibtimes.com/tasers-can-kill-says-american-heart-association-study-699859. Accessed 20 Nov 2014.
73. Zipes DP. Response to letters regarding article, "Sudden cardiac arrest and death following application of shocks from a TASER electronic control device". Circulation. 2013;127:e261–2.
74. Kroll MW, Lakkireddy DR, Stone JR, Luceri RM. TASER electronic control devices and cardiac arrests: coincidental or causal? Circulation. 2014;129:93–100.
75. Graham M. Declaration of Michael A. Graham, MD, Eighth District Court, State of Louisiana, Parish of Winn, No. 41476, expert report: Thomas-Pikes v. TASER International, Inc. St. Louis; 9 Sep 2010.
76. Omalu B. Pathophysiological nervous system consequences of conducted electrical devices and sudden, unexpected death. J Forensic Nurs. 2011;7:51–3.
77. Langsjoen J, Aguayo Rico A, Thoreson L. Use of electronic control device (TASER) associated with cardiac arrest and severe anoxic brain injury. J Hosp Med. 2013;8(Suppl 1):736.
78. Kroll MW, Lakkireddy DR, Stone JR, Luceri RM. TASER electronic control devices can cause cardiac arrest in humans. Circulation 2014;129(1):101–11. Circulation. 2014;129:111.
79. Kenny JM, Bovbjerg V. Epidemiology study of human electromuscular disruption (EMD) associated deaths. Report for US Marine Corps Contract No. M67004-03-D-0014-0045. State College, PA: Pennsylvania State University Applied Research Laboratory; 2007.
80. Clough NL. Constituent space: re-theorizing the geographies of contestation and control. PhD Dissertation, University of Minnesota; 2011.
81. Wright S. Policing borders in a time of rapid climate change. In: Scheffran J, Brzoska M, Brauch HG, Link PM, Schilling J, editors. Climate change, human security and violent conflict: challenges for societal stability (Hexagon series on human and environmental security and peace, vol. 8). Heidelberg: Springer; 2012. p. 351–70.
82. Upton LL. Zapped: a typology of use and misuse of the TASER. Masters in Science Thesis, Eastern Kentucky University; 2011.
83. Burrows C, Cooper G. UK policing and less lethal technologies—an operational, legal and medical perspective. Med Leg J. 2006;74(Pt 3):83–98.
84. US Department of Defense. Instruction no. 3200.19. Non-lethal weapons (NLW) human effects characterization. 17 May 2012.
85. TASER International. TASER® handheld CEW warnings, instructions, and information: law enforcement. 2013. http://www.taser.com/images/resources-and-legal/product-warnings/downloads/law-enforcement-warnings.pdf. Accessed 20 Nov 2014.
86. Azadani PN, Tseng ZH, Ermakov S, Marcus GM, Lee BK. Funding source and author affiliation in TASER research are strongly associated with a conclusion of device safety. Am Heart J. 2011;162:533–7.
87. Vilke GM, Sloane CM, Chan TC. Comment on "Funding source and author affiliation in TASER research are strongly associated with a conclusion of device safety". Am Heart J. 2012;163:e5.
88. Kunz SN. Comment on "Funding source and author affiliation in TASER research are strongly associated with a conclusion of device safety". Am Heart J. 2012;163:e7–8.
89. Azadani PN, Tseng ZH, Ermakov S, Marcus GM, Lee BK. In response to the letters from Dr Vilke and colleagues and Dr Kunz regarding "Funding source and author affiliation in TASER research are strongly associated with a conclusion of device safety". Am Heart J. 2012;163:e9.
90. Vilke GM, Sloane CM, Chan TC. Clarification of funding sources in "electronic control device exposures: a review of morbidity and mortality". Ann Emerg Med. 2012;59:366.
91. Beran RG. The role of the expert witness in the adversarial legal system. J Law Med. 2009;17:133–7.
92. Jentzen JM. Death investigation in America: coroners, medical examiners, and the pursuit of medical certainty. Cambridge: Harvard University Press; 2009.
93. Daubert v Merrell Dow Pharmaceuticals, 509 US 579, 597; 113 S Ct 2786, 2799. US Supreme Court; 1993.
94. Council of Canadian Academies and Canadian Academy of Health Sciences. The health effects of conducted energy weapons. Ottawa, Ontario: The expert panel on the medical and physiological impacts of conducted energy weapons; 2013.
95. Harrison JL. Reconceptualizing the expert witness: social costs, current controls and proposed responses. Yale J Regul. 2001;18:253–313.
96. Chamberlain M. "I no longer agree with my trial testimony": the legal implications of changed expert opinions. In: Proceedings of the 66th annual meeting of the American Academy Forensic Science, Seattle; 17–22 Feb 2014. p. 254–5.
97. Hope L, Gabbert F, Fraser J. Postincident conferring by law enforcement officers: determining the impact of team discussions on statement content, accuracy, and officer beliefs. Law Hum Behav. 2013;37:117–27.
98. Dawes DM, Ho JD. RE: Myocardial infarction after TASER exposure, J La State Med Soc 2010;162:291–295. J La State Med Soc. 2011;163:64.

99. Baldwin DE, Nagarakanti R, Hardy SP, Jain N, Borne DM, England AR, et al. Myocardial infarction after taser exposure. J La State Med Soc. 2010;162:291–2, 294–5.
100. Baldwin DE, Glancy DL. Authors' response to "RE: Myocardial infarction after TASER exposure, J La State Med Soc 2010;162:291–295". J La State Med Soc. 2011;163:66.
101. Jauchem JR. Effectiveness and health effects of electro-muscular incapacitating devices. 6th Annual Non-Lethal Technology and Academic Research Symposium, Winston-Salem, NC; 16 Nov 2004. http://www.unh.edu/ntic/NTAR%20talks%20pdf/Jauchem.pdf. Accessed 19 Sep 2014.
102. Battershill P, Naughton B, Laur D, Panton K, Massine M, Anthony R. TASER technology review. Final report. Victoria, British Columbia, Canada: Office of the Police Complaint Commissioner, Victoria Police Department. 14 Jun 2005. http://www.theiacp.org/Portals/0/pdfs/BC-TaserReport.pdf. Accessed 20 Nov 2014.
103. Holguin J. Study questions stun gun safety. CBS Evening News. 11 Feb 2005. http://www.cbsnews.com/stories/2005/02/09/eveningnews/main672709.shtml. Accessed 20 Nov 2014.
104. Hibberd J. Tasers are unsafe even when used properly. In: Lankford RD, editor. Tasers. Detroit: Baker and Taylor, Greenhaven Press; 2012. p. 26–34.
105. Jauchem JR, Sherry CJ, Fines DA, Cook MC. Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of Sus scrofa following repeated TASER® exposures. Forensic Sci Int. 2006;161:20–30.
106. Bohula May EA, Bonaca MP, Jarolim P, Antman EM, Braunwald E, Giugliano RP, et al. Prognostic performance of a high-sensitivity cardiac troponin I assay in patients with non-ST-elevation acute coronary syndrome. Clin Chem. 2014;60:158–64.
107. Neilan TG, Januzzi JL, Lee-Lewandrowski E, Ton-Nu TT, Yoerger DM, Jassal DS, et al. Myocardial injury and ventricular dysfunction related to training levels among nonelite participants in the Boston marathon. Circulation. 2006;114:2325–33.
108. Wolf B, De Angelis J. Tasers, accountability, and less lethal force: keying in on the contentious construction of police electroshock weapons. Int J Criminol Sociol Theory. 2011;4:657–73.
109. Miller J, Kelly K, Stanford LD. Taser tots: neuropsychological outcome of an adolescent Taser victim. J Int Neuropsychol Soc. 2007;13(Suppl 1):154.
110. Gardner AR, Hauda WE 2nd, Bozeman WP. Conducted electrical weapon (TASER) use against minors: a shocking analysis. Pediatr Emerg Care. 2012;28:873–7.
111. Gross ER, Porterieko J, Joseph D. Rhabdomyolysis and oliguric renal failure after use of TASER®: is it really safe? Am Surg. 2013;79:E337–9.
112. Byard RW, Summersides G, Thompson A. Confluent muscle pallor: a macroscopic marker of cocaine-induced rhabdomyolysis. Forensic Sci Med Pathol. 2001;7:364–6.
113. Bell N, Moon M, Dross P. Cerebrovascular accident (CVA) in association with a Taser-induced electrical injury. Emerg Radiol. 2014;21:211–3.
114. Johansen CK, Welker KM, Lindell EP, Petty GW. Cerebral corticospinal tract injury resulting from high-voltage electrical shock. AJNR Am J Neuroradiol. 2008;29:1142–3.
115. Suruda A, Smith L. Work-related electrocutions involving portable power tools and appliances. J Occup Med. 1992;34:887–92.
116. Dettmeyer RB, Verhoff MA, Schütz HF. Electricity, lightning, and gases. Forensic medicine. Fundamentals and perspectives. Berlin: Springer; 2014. p. 213–26.
117. Ghaheri H, Karimi M, Assari S. Frequent use of stun gun may be associated with vibration-induced Raynaud's phenomenon: a case series. IJCRI. 2014;5(2):95–8.
118. Dawes D, Brave M. 'Stun gun' link to Raynaud's syndrome unconvincing. IJCRI. 2014;5:465–7.
119. Mack T. Stunning revelations that may shock you to death. Law Justice Online J. 2009;1(1). http://julianhermida.com/lawandjusticejournal/journalvol1tracy.pdf. Accessed 22 Dec 2014.
120. US Department of Justice. Re: Albuquerque Police Department. Washington, DC: Civil Rights Division, Office of the Assistant Attorney General. 10 Apr 2014. http://www.justice.gov/crt/about/spl/documents/apd_findings_4-10-14.pdf. Accessed 20 Nov 2014.
121. Smith MR. Toward a national use-of-force data collection system: one small (and focused) step is better than a giant leap. CPP. 2008;7:619–27.
122. Stenning P, Birkbeck C, Adang O, Baker D, Feltes T, Gabaldón LG, et al. Researching the use of force: the background to the international project. Crime Law Soc Change. 2009;52:95–110.
123. Baker D. Police confirmation of use of force in Australia: 'To be or not to be?'. Crime Law Soc Change. 2009;52:139–58.
124. Rappert B. Non-lethal weapons as legitimating forces? Technology, politics and the management of conflict. London: Frank Cass; 2003.
125. Waddington PAJ. Public order: then and now. In: Henry A, Smith DJ, editors. Tranformations of policing. Hampshire: Ashgate Publishing Limited; 2007. p. 113–42.
126. Robinson PH. A right to bear firearms but not to use them? Defensive force rules and the increasing effectiveness of non-lethal weapons. Boston Univ Law Rev. 2009;89:251–64.
127. Anonymous. Psychology—give cops a weapon and they will use it! Social Science in the News. Essex: Tendring Technology College; 2011.
128. Bourne K. Shock tactics threaten police authority: the use and misuse of tasers in Australia. Alt Law J. 2011;36:42–6.
129. Sousa W, Ready J, Ault M. The impact of TASERs on police use-of-force decisions: findings from a randomized field-training experiment. J Exp Criminol. 2010;6:35–55.
130. Taylor B, Alpert G, Kubu B, Woods D, Dunham RG. Changes in officer use of force over time: a descriptive analysis of a national survey. Policing. 2011;34:211–32.
131. The John Howard Society of Alberta. An examination of citizen involvement in complaints regarding police. Edmonton, Alberta, Canada. 2005. www.johnhoward.ab.ca/docs/police/police.pdf. Accessed 20 Nov 2014.
132. Mahaffey D. Security and technology—the human side. Correct Today. 2004;66(4):8.
133. Jefferis E, Butcher F, Hanley D. Measuring perceptions of police use of force. Police Pract Res. 2011;12:81–96.
134. Flanagan TJ, Vaughn MS. Public opinion about police abuse of force. In: Geller WA, Toch H, editors. And justice for all: understanding and controlling police abuse of force. Washington, DC: Police Executive Research Forum; 1995. p. 113–32.
135. Condon MW, Bersani MD. Trends and case law on the use of TASERs®. Illinois Sheriff's Association Chief Deputy/Jail Administrator Conference. Peoria, IL; 20 Apr 2010. www.hcbattorneys.com/publications/Sheriff_Conference2010.pdf. Accessed 20 Nov 2014.
136. Prenzler T, Porter L, Alpert GP. Reducing police use of force: case studies and prospects. Aggress Violent Behav. 2013;18:343–56.
137. Bastianelli BT. TASERs in healthcare: myths and merits. J Healthc Prot Manag. 2014;30:30–4.
138. Huq AZ. Democratic torture. Has Mill's safeguard weakened? World Policy J. 2008;24(4):99–107.
139. Anaïs S. Conducted energy weapons: governing through neutralization. In: Dam S, Hall J, editors. Inside and outside the law: perspectives on evil, law and the state. Oxford: Inter-Disciplinary Press; 2009. p. 49–60.
140. United Nations. Convention against torture and other cruel, inhuman or degrading treatment or punishment. New York: United Nations; 1984.

141. Anonymous. Man tasered in hospital bed, forced to give urine sample. New York: Associated Press; 2005.
142. Gerhardstein AA. TASER risks in Hamilton County Ohio. Cincinnati; 2012. http://www.nlg-npap.org/system/files/Taser%20Risks%20in%20Hamilton%20County%20Ohio.pdf. Accessed 20 Nov 2014.
143. Strote J, Walsh M, Angelidis M, Basta A, Hutson HR. Conducted electrical weapon use by law enforcement: an evaluation of safety and injury. J Trauma. 2010;68:1239–46.
144. Martin B, Wright S. Looming struggles over technology for border control. OTSC. 2006;3:95–107.
145. Cusac A-M. Shocked and stunned: the growing use of tasers. In: Herivel T, Wright P, editors. Prison profiteers: who makes money from mass incarceration. New York: The New Press; 2007. p. 250–64.
146. Haberland BB. Certain controversies concerning non-lethal weapons. NZ Armed Forces Law Rev. 2006;6:20–45.
147. Moreau de Bellaing CM. Can electricity sooth the savage beast? What tasers do to police use of force. In: Ann Meeting Society Social Stud Sci European Ass Study of Sci Tech. Copenhagen, Denmark; 17–20 Oct 2012.
148. Parent R. Crisis intervention: the police response to vulnerable individuals. Police J. 2007;80:109–16.
149. City of Houston. Conducted energy device program performance audit. Office of the City Controller, City of Houston, Texas. 8 Sep 2008. www.houstontx.gov/controller/audit/2009-09.pdf. Accessed 20 Nov 2014.
150. Ijames S. TASER dos and don'ts. Tactical Response. 2009;3(5). http://www.hendonpub.com/resources/article_archive/results/details?id=2213. Accessed 22 Dec 2014.
151. Pinizzotto AJ, Davis EF, Bohrer SB, Infanti BJ. Law enforcement restraint in the use of deadly force within the context of 'the deadly mix'. Policing. 2012;14:285–98.
152. Hall C, Votova K. Prospective analysis of police use of force in four Canadian cities: nature of events and their outcomes. Contractor report no. DRDC CR 2013-011. Ottawa, Ontario, Canada: Defence Research and Development Canada—Centre for Security Science; 2013.
153. Scott KB. Evaluation of extended deployment of taser by Strathclyde police. In: Scottish Institute for Policing Research. Annual report 2012. Dundee, Scotland: University of Dundee; 2013. p. 36–7.
154. Ho JD, Dawes DM, Johnson MA, Lundin EJ, Miner JR. Impact of conducted electrical weapons in a mentally ill population: a brief report. Am J Emerg Med. 2007;25:780–5.
155. Martinelli R, Staton J. The Forensic Force® series: psychophysiological responses to TASER®-ECD influence. Law Enforc Exec Forum. 2010;10(4):101–12.
156. Kleinig J. Ethical constraints on taser use by police. Policing J Policy Pract. 2007;1:284–92.
157. Winslow JE, Bozeman WP, Fortner MC, Alson RL. Thoracic compression fractures as a result of shock from a conducted energy weapon: a case report. Ann Emerg Med. 2007;50:584–6.
158. Sloane CM, Chan TC, Vilke GM. Thoracic spine compression fracture after TASER activation. J Emerg Med. 2008;34:283–5.
159. Sinha A, Dholakia M. Thoracic compression fracture caused by TASER-induced injury: a case report. Phys Med Rehabil. 2011;3(10 Suppl 1):S220.
160. Coad F, Maw G. TASERed during training: an unusual scapular fracture. Emerg Med Australas. 2014;26:206–7.
161. Kimmick E. Deputy's arms, shoulders injured in Taser training. Muscles convulsed severely enough to fracture several bones. The Billings Gazette (Montana). 19 May 2010.
162. Stone N 3rd, Karamitopoulos M, Edelstein D, Hashem J, Tucci J. Bilateral distal radius fractures in a 12-year-old boy after household electrical shock: case report and literature summary. Case Rep Med. 2014;2014:235756.
163. Anonymous. Ontario woman, 80, fractures hip after being struck with police taser. Toronto: The Canadian Press; 2013.