Biomedical research literature with respect to the effects of Conducted Energy Weapons

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Aug 1, 2010

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Executive Summary

The objectives of this Literature Review (as set out in the Statement of Work) are to review the existing CEW literature in order to: 1) identify those studies that examine the medical / physiological impact of CEWs; 2) review the medical/physiological studies to identify a subset of studies that are the most current, peer-reviewed, and free of any perceived biases; and, 3) summarize this subset of reviewed research studies into a final report.

This document reviews and summarizes biomedical scientific literature relevant to the physiological effects of CEWs. One hundred thirty five published and peer-reviewed contributions to scientific journals were identified; fifty three articles were reviewed in detail. The scientific literature on the effects of CEWs is relatively broad, and has seen significant contributions in the last few years. A small group of well regarded authors has performed most of the work. A significant fraction of the original research is affiliated with Taser International in some way (by funding of the studies or by the relationship to the authors). This affiliated work is of good scientific quality and shows no other evident bias.

The main experimental research techniques involve prospective experiments on anaesthetized animals (mostly pigs) and on healthy humans volunteers. As well, retrospective analysis of reports from police, coroners, medical case reports and research on computer models of the body were included in the scope of this review.

Summary of findings: Overall, the literature indicates that risks are low to healthy subjects from short duration CEW pulses of the standard stimulation strength of in-use devices. In general, either stronger or significantly longer electrical stimulation, or simulation close to the heart was required to induce clinically significant effects to cardiac or respiratory function or blood chemistry. Studies of case reports show that the injury profile of CEWs is similar or favourable in comparison to other less-lethal force options (such as physical restraint or pepper spray). Specific risks were identified which we classify as:

Ventricular fibrillation (VF): CEWs stimulate the heart, but did not cause VF unless multiple or stronger stimulations, placement very close to the heart or chemical stimulants were given. One case report shows VF in a healthy subject.

Systemic physiological interactions: For longer or multiple stimulations, CEWs were shown to have physiological effects on cardiac, respiratory and blood chemical function, which lead to death in some animals. Such effects could interact with events during an arrest (stress, intoxicants, restraint, blood loss).

Specific subject groups: Groups such as the elderly, children, pregnant women, and cardiac device users may have higher risks.

CEW injuries: Case reports indicate risks to due the electrode barbs to vulnerable organs (such as the head) and due to falls consequent to incapacitation.

Limitations: While the literature is relatively complete, two limitations were noted: use of healthy subjects and experimental size. Experimental research has focused on healthy (and largely unstressed) pigs and human volunteers, while deaths proximal to CEW use are most likely in unhealthy, intoxicated, and highly stressed subjects, including those with excited delerium. Several hundred healthy subjects have been reported in experiments; however, CEW-associated deaths have occurred in less than one in a thousand weapon usages, and computer models estimate similarly low risk levels. To reliably investigate such rare events, much larger studies are required.

Introduction

The purpose of this report is to review the salient details, abstract the findings and articulate themes in a selected number of biomedical research reports which address the biomedical and physiological effects of Taser discharge on human beings. This report fulfils the contract (PO #7155860) between Carleton University and Public Safety Canada.

The detailed objectives of this work (as set out in the Statement of Work) are to review the existing CEW literature in order to:

- identify those studies that examine the medical/physiological impact of CEWs;
- review the medical/physiological studies to identify a subset of studies that are the most current, peer-reviewed, and free of any perceived biases; and,
- summarize this subset of reviewed research studies into a final report

One hundred thirty five published and peer-reviewed contributions to scientific journals were identified. These articles are cited with references in Appendix A. Of this number, fifty three articles were reviewed in detail; these detailed reviews are found in Appendices B and C. All of the identified studies fall in five general categories:

- Case reports of humans exposed to Conducted Energy Weapon (CEW) discharges
- Analyses of police and forensic records of incidents associated with Taser use.
- Studies of medical and physiological effects of CEW discharges on healthy humans
- Animal studies in which animals (primarily pigs) were exposed to CEW discharges
- Computer modelling of physiological effects of CEW discharges on humans

There is considerable recent work published or in-press with respect to the physiological effects of CEW emissions on humans. Much of the expertise is concentrated in a cluster of medical researchers who have written several articles on electrophysiology in addition to their specific contributions to the literature on the effects of CEW emissions. Several of the key authors of relevant literature have connections to Taser International, via owning shares, board or consultant relationships or funding for studies. We chose to review these papers since the work was clearly relevant and met scientific criteria for peer reviewed acceptance. In order to clarify this disclosed interest, we place these articles in a separate appendix (C), while noting the interest when they are discussed.

Most of the academic and medical research that we identified and reviewed originates in the United States, with smaller contributions from Canadian and European researchers. The most recent and reliable work is centered in universities and hospitals which have stellar reputations in electrophysiology and emergency medicine that pre-date work they have done with CEWs (see appendix E for a partial list of these institutions). There are some European sources such as the Bi-annual Symposium on Less Lethal Weapons, but, in general, the scientific work on CEWs in Europe lags North American studies.

METHODOLOGY:

There are two levels of peer-reviewed and published work in this report- "identified" and "reviewed". We have identified 153 articles which are cited in Appendix A. From this aggregation of literature we selected 53 for a more detailed review based on an analysis of the pertinence, scope and impact of the work. These detailed reviews are found in Appendices B and C.

We identified original studies of the physiological effects of CEW emissions, with particular emphasis on cardiac and respiratory function. A small collection of case reports discussing injuries to the eye, thoracic compression fractures and neurological effects was identified. Papers were identified based on the index functions of publishers such as PubMed, individual research publications and Google Scholar. To this list, we added a small number of with which titles we or our colleagues were familiar that were not identified by the automated search. Search terms included: biomedical effects of conducted energy weapons, conducted energy weapons, ventricular fibrillation from electrical stimulation, effects of pulsed emissions on the human body, cardiac effects from electrical stimulus, risk of Taser use. We identified original Canadian work. Some letters to the editor of learned journals were included because they were significant Canadian sources which indicated a need for greater medical involvement in research on the effects of CEW discharges. We identified a sampling of Case Reports involving CEW discharges because Case Reports constitute the only peer-reviewed and published scientific reports of physiological effects on vulnerable groups such as the aged, pregnant women, and children. The findings in Case Reports document biophysical and physiological effects of CEW emissions from situations that would never be authorized for experimental research.

We selected 53 articles for a detailed review (Appendicies B and C) based on the significance and relevance of the work, because the topics related directly to the physiological effects of CEW emissions and because the authors have published a larger number of peer-reviewed articles. We reviewed in greater detail also those studies cited by other authors and researchers. Where an author republished results of a study in another forum or a re-analysis of a particular experiment, we did not review the subsequent publication, unless it forms a significant new contribution.

In all cases of a detailed summary review, we noted the declared interests of the authors. There are 11 of these articles with a disclosed interest in Appendix C. We reviewed three chapters from the book <u>Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law</u>. Springer Press, 2009. These chapters were directly relevant to the effects of CEW discharge on human physiology and have been reviewed by an editorial board of scientists and medical personnel. We identified and reviewed some fundamental scientific literature which describes how the body (and parts such as the heart, skin, muscle and nerve fibres) behaves in the presence of pulsed electrical emissions. These are found in Appendix B.

In addition to the peer reviewed literature, there exist several contracted scientific works on Conducted Energy Weapons such as the report *Biological Effects of Directed Energy* authored by Beason et al and performed for the US Air Force Research Laboratory. Despite the quality of the contracted work, we did not review them in this document, since these works have not been peer-reviewed outside the organization which commissioned them. They are, however, worthy of consideration. Other international organizations which do not have a biomedical focus such as the Bioelectromagnetics Society have been involved in writing papers on the biophysical effects of CEWs. We have not identified or reviewed submissions to these fora unless the papers were submitted to scientific journals.

Definitions and Terminology:

Conducted Energy Weapon (CEW): Different authors refer to a Conducted Energy Weapon by different names. This is apparent in the Author's Abstract section of the summaries wherein we have not altered the words of the author(s). However, in all other sections of the detailed summaries we have tried to standardize our references to the weapon as CEW. Consequently ECD (Electronic Charge Devices), CED (Conducted Energy Devices), NID (Neuromuscular Incapaciting Devices), Taser, and Stun guns all mean the same thing, except where the research refers to a specific weapon used in tests.

Disclosed Interest: Journals use different terms to denote the affiliations of an author which may potentially colour his or her findings. The term used in the Statement of Work for this review is "perceived bias". Because various levels on interest exist (from partial funding of a study to a management position at the equipment vendor) which do not necessarily lead to perceived bias, scientific journals typically choose more neutral terms such as: Competing Interests, Disclosed Interest, Reported Interest, or Conflict of Interest. We use the term "disclosed interest", and indicate it in all situations in which we are aware of it.

Sources of biomedical research work:

Of these 153 articles, editorials, letters to the editor and case reports identified, we reviewed 53 of them in detail because they were directly relevant to biophysical effects of CEW emissions and, for the most part, featured original research, research on healthy humans, case reports on humans and analysis of data derived from original reports. Summaries and authors' abstracts are found in Appendices B and C. We have summarized each paper systematically and presented the summaries without reproducing the papers. The final segment in our summary of each paper is the verbatim words of the author – an abstract or a direct quotation of relevant text when no abstract was available. Every reviewed paper is available in its entirety but is not included in this report because of copyright and length.

The reviewed articles have been separated into groups: no disclosed interest and disclosed interest. Of these 53 articles, 38 of them did not have any disclosed interest. The summaries of these full studies are found in Appendix B. Another four published Case Reports and Editorials do not have any disclosed interest. These summaries are found in Appendix D. Eleven of the 53 articles which we reviewed in detail contain a disclosed interest in Taser International (TI). The nature of these links varies from funding for a study, share ownership in TI, or consultant or employment with TI. It was not appropriate to set aside all research associated in any way with TI, due to the significance of these papers and the academic and research stature of the authors. Instead we identify the authors as having a Disclosed Interest as we derived from other sources even though it may not be disclosed in each paper. This identification is then maintained in our review of the work. Two of these experiments were funded by Taser International (Lakkireddy et al, 2006 and 2007). Five of these eleven articles were written by JD Ho who has published widely on electrophysiology.

The articles we reviewed were found in the following publications:

Academic Emergency Medicine
American Journal of Cardiology
American Journal of Emergency Medicine
American Journal of Forensic Medicine and Pathology
American Surgeon
Annals of Emergency Medicine
Canadian Journal of Emergency Medicine
Canadian Journal of Emergency Medicine
Canadian Medical Association Journal
Europace
Forensic Science and Medical Pathology
Humana Press
Forensic Science International
Heart Rhythm
IEEE Engineering Medicine Biological Society
IEEE Transactions in Bio-Medical Engineering
Journal of Cardiovascular Electrophysiology
Journal of Emergency Medicine
Journal of Forensic Science
Journal of the American College of Cardiology
Journal of Trauma-Injury and Critical Care
Journal of Surgical Research
Journal of Forensic Medicine and Pathology
Law Enforcement Executive Forum
Pacing and Clinical Electrophysiology
Perspectives in Psychiatric Care
Physics in Medicine and Biology
Prehospital Emergency Care
Springer Press
The Internet Journal of Rescue and Disaster Medicine
The Journal of Trauma Injury, Infection and Critical Care
University of Wisconsin Press

FINDINGS:

In this section we classify and summarize the reviewed research reports, while in the "Summary" section we identify the general themes, conclusions and limitations of the research. Research has been motivated by several hypotheses as to the mechanisms by which CEWs may contribute to harm or death. We classify these hypotheses under four groups, and briefly summarize the relevant studies associated with each mechanism (Authors noted by an asterisk (*) have disclosed interest).

1) Electrocution by induction of ventricular fibrillation (VF)

One key concern is the possibility CEWs may induce VF, a rapid, uncoordinated and inefficient heart rhythm, which, if prolonged, leads to death because the body doesn't receive adequate blood supply. Stimulation at the most sensitive interval during the cardiac cycle is the main mechanism considered. Effects due to electrocution by VF would be most likely to occur soon (minutes) after simulation by the CEW.

Relevant studies show that long CEW discharges in anesthetized pigs resulted in cardiac and blood chemical changes; in 2 of 11 pigs, VF lead to death (Dennis et al, 2007). However, electrophysiological arguments show VF is unlikely in a normal adult (Ideker and Dosdall, 2007). Neither does the current density from the Taser waveform cause VF in isolated guinea pig hearts (Holden et al, 2007). A Canadian study showed that thoracic shots simulate the heart (Nanthakumar et al, 2006), and of six pigs (receiving 150 CEW shots and a dose of epinephrine) one showed VF (Nanthakumar et al, 2008). While epinephrine appears to increase susceptibility to VF, cocaine use has been shown to reduce the vulnerability of pigs (Lakkireddy et al, 2006*)

VF can be induced in pigs by significantly longer than normal stimulation (Dennis et al, 2007) or high intensity CEW shock (Lakkireddy et al, 2008*). In addition, placing the darts close to the pig heart will induce VF in certain circumstances. The darts-to-heart distance to cause VF in pigs is 17 mm (Wu et al, 2007) or 2-8mm (in a revised study by the same authors: Wu et al, 2008). These data are used to estimate the probability of VF using computer models of the body and its electrical properties. Sun (2007) calculated the probability of VF to be less than 0.1%; while a different computer model shows nerves are stimulated up to 19 cm from darts (Sun and Webster, 2007). At larger distances from the heart (on the body surface) it requires more energy than the standard Taser X26 pulse to cause VF (Lakkireddy et al, 2008*).

When 105 healthy human volunteers received a short 3 second burst of CEW energy, they showed increased heart rates, but no other problems such as VF (Levine et al, 2007). Twenty-five exhausted human volunteers who were otherwise healthy did not show any cardiac dysrhythmias after 15 second exposures to CEW emissions. (Ho et al, 2009*). Similarly, 66 resting volunteers did not show dangerous cardiac or blood chemical effects from 5 second bursts of a CEW (Ho et al, 2006*). One case report of a teenager who received a CEW shock went into VF; he was successfully defibrillated by paramedics (Kim and Franklin, 2005).

2) Physiological interaction of the effects of the CEW and arrest events

CEWs were shown to have physiological effects on cardiac, respiratory and blood chemical function which increase with duration of exposure, and such effects could plausibly interact with events during an arrest (stress, intoxicants, restraint, blood loss). Several blood chemical and cardiovascular effects of the CEW have been studied which can plausibly contribute in such an interaction of factors. Blood chemical changes studied are the concentrations of lactate, ions, stress hormones, and chemical markers of muscle damage. The cardiovascular effects studied are in changes in heart rhythm (via the ECG) and blood pressure.

Based on these changes, the hypothesized interactions may work in the following way: an increase in heart rate and blood pressure results from events associated with the arrest. At the same time, CEW induced peripheral muscle tetanus constricts systemic arteries. The changes in blood chemistry make the heart muscle less efficient, even while a large cardiac output into the higher resistance vasculature is required. One especial concern is when the CEW stimulation is stopped and the arrest is complete; the afterload on the heart will rapidly decrease, potentially resulting in a precipitous drop in blood pressure and possible cardiovascular decompensation. Effects due to this mechanism would be most likely to occur several minutes to hours after simulation with the CEW.

Relevant studies show a range of cardiovascular effects such as an increase in heart rate (Cao et al, 2007; Vilke et al 2007, 2008), significant changes in blood chemistry resulted from 30 and 60 seconds exposures to CEW emissions. (Jauchem et al, 2009; Jauchem et al 2008) . Three minute exposures caused significant mortality (6/10) in this experiment. On the other hand, healthy anesthetized pigs do not show serious adverse effects of emissions from the Stinger S-400 CEW (Esquivel et al, 2007). One hundred eighteen human volunteers showed no changes in muscles or heart rhythm (VanMeenen et al, 2010) after 2, 3 and 5 second CEW discharges and 32 volunteers showed increases in heart rate but no dysrhythmia and no clinically significant changes in respiratory or blood chemical status (Vilke et al, 2007 and 2008). Markers in the blood can indicate whether heart muscle has been damaged as a result of stimulation. In one study, healthy volunteers showed no blood chemical signs of heart damage (Sloane, 2008).

Deaths proximal to CEW use are in similar situations to other police restraint-related deaths. (Strote et al, 2005). In a study involving 53 volunteers, it was found that the stress response is lower for CEW stimulation than OC spray or physical exertion (Dawes et al, 2009*). Such comparisons are relevant because this mechanism of possible CEW related harm is related to the interactions between factors during police use of force. Risk factors have been analysed in 18 deaths after forceful restraint. Six risk factors have been identified and ranked by Stratton et al, 2001. These factors are stimulant use (78%), disease states (56%), obesity (56%), capsicum spray (33%), Taser (28%). In 22 alcohol-intoxicated volunteers, there were no clinically significant effects of 15 second CEW discharges. (Moscati et al, 2010*).

3) Vulnerable populations

Several groups are thought to be more vulnerable to the effects of the CEW: children, elderly, pregnant women and certain patients such as those with preexisting heart conditions. Pregnant subjects may have a risk of miscarriage. One Case Report indicated that an early miscarriage occurred after CEW exposure to abdomen (Meh, 1992). Patients with pacemakers or implantable cardioverter-defibrillators (ICDs) have wires near the heart which may conduct CEW stimulation to the heart. ICDs may misinterpret CEW simulation as VF and shock the heart. An ICD interpreted CEW as transient VF (Haegeli et al, 2006). On the other hand, Lakireddy et al* (2007) concluded that pacemakers and ICDs are not affected by CEW emissions. Unfortunately, little systematic work has been done to understand many of these vulnerable groups. For example, the concern for children is mostly due to the increased current density from the CEW in a smaller body; it should be relatively straightforward to build animal or computer models of this group, but we are not aware of any studies.

4) Injuries due to the CEW barbs or consequent to incapacitation.

CEW barbs pose obvious dangers to the eyes, head and genitals. Additionally, the incapacitation produced typically brings the subject to the ground, and may involve trauma due to this fall. Most (99%) of subjects do not experience significant injuries (Bozeman et al, 2009). One Canadian case report detailed the physiological effect (seizure, disorientation) and continued neurological distress following a CEW discharge (via barb) to the head (Bui et al, 2009). There have been Case Reports of falls, lacerations, and skull fracture after CEW discharge (Mangus et al, 2008) as well as penetrating eye injuries from CEW barbs. (Han et al, 2009; Ng and Chehade, 2005). Sloane et al (2008) reported a spinal compression fracture after CEW exposure.

Summary:

The literature generally supports the view that the risks to healthy subjects from standard CEW discharges for short duration stimulation are low. In general, in order to provoke clinically significant effects in animals or human volunteers there is a requirement for either for longer or multiple discharges, or for larger simulation pulses than the standard weapons give. Thus, while cardiac function (ECG) and blood chemistry (lactates and pH) are affected by standard CEW discharges, these changes were not clinically significant and returned to baseline levels within minutes to hours (ie. Vilke et al, 2008; Van Meenan et al, 2010). These findings are consistent across a wide range of reports. This finding of low risk also applies to physically exhaused and to inebriated (with alcohol) volunteers. Other findings which support the view of CEWs as low risk are those that show that the injury profile of CEWs is similar or favourable in comparison to other less-lethal force options such as physical restraint or pepper spray (Dawes et al, 2009*) and that deaths proximal to CEW use are in similar situations to other police-restraint related deaths (Strote et al, 2005).

While the evidence is consistent for the low risk nature of CEWs in healthy subjects, the literature suggests a few areas of increased risk, and leaves many open question questions. We classify the areas of increased risk as: increased duration CEW exposure, vulnerable populations and CEW injuries. *Increased duration CEW exposure* resulted in clinically important effects in animal subjects and lead to death by VF (Nanthakumar et al, 2008) or by respiratory arrest (Jauchem, 2010). Furthermore, the effects of longer CEW exposure can be understood to support other physiological effects such as stress, intoxicants or blood loss during an arrest. *Vulnerable Populations* include children, elderly, pregnant women, patients preexisting heart conditions or with pacemakers or cardiac devices, and psychologically affected subjects (especially the group referred to as excited delirium). There is essentially no experimental research considering these vulnerable groups, with the exception of a study of pacemakers and cardiac devices (Lakireddy et al, 2007*). However, in each case there are reasonable grounds to suspect that such vulnerable groups may be especially vulnerable to CEWs. *CEW injuries* are due to the electrode barbs on vulnerable tissue, or due to trauma from a fall during CEW stimulation. Numerous case reports (ie. Mangus et al, 2008) have discuss these injuries.

We identify several limitations in the published research, related to vulnerable groups and experimental sample size. While experimental research has focused on healthy (and largely unstressed) pigs and human volunteers, deaths proximal to CEW use are most likely vulnerable groups, and specifically in unhealthy, intoxicated, stressed subjects. We did not identify any experimental work on the effects of CEW emissions on the elderly, pregnant women or children. This lack of experimental study is also true of the characteristics of subjects on which CEWs are most commonly used. Specifically, although a clinical definition of excited delirium has been developed and adopted by the American College of Emergency Physicians, no experimental model has been developed for research purposes. While many and useful CEW studies on animals (primarily anesthetized pigs) have been performed, the translation of results from animal studies to the human physiology is subject to some uncertainty. There is no adequate animal model of the details of the high-risk and arrest scenario and although pigs are a reasonable physical proxy to the human anatomy (Jauchem 2010), the pig does not provide a model for pain, muscle damage or neurological impairment.

A second limitation in the published studies that of experimental size. In total, several hundred healthy subjects (pigs and human volunteers) have been reported in experiments. However, based on data from CEW usage in USA, CEW-associated deaths have occurred in less than one in a thousand weapon usages, and computer models estimate similarly low risk levels. To reliably investigate such rare events, much larger studies are required.

In summary: the literature on biomedical effects of CEWs is relatively complete and has seen a large level of important recent contributions; the general consensus is that standard CEW stimulations represent a low risk to healthy subjects; and, there is remaining uncertainly about the effects of prolonged stimulation and in vulnerable populations.

Appendix A: Articles identified as relevant to the physiological effects of CEW emissions.

Table headings indicate: **Rev =** reviewed in this work; **Pg** = page number of this report; **Ed** = editorial or letter to the editor; **DI** = Disclosed Interest; **CR** = case report

Author and Reference	Rev	DI	Ed	CR	pg
Al-Jarabah M J, Coulston, and Hewin D. *Pharyngeal Perforation Secondary to Electrical Shock From a Taser Gun*. Emergency Medicine Journal, 2008; 25(6):378	No				
Angelidis M, Basta A, Walsh M, Hutson R., Strote J. *Injuries associated with law enforcement use of conducted electrical weapons*. Acad Emerg Med. 2009; 16(suppl. 1):S229.	No				
Barnes DG, Winslow JE, Alson RL, Johnson J, Bozeman WP. *Cardiac Effects of the Taser Conducted Energy Weapon*, Annals of Emergency Medicine, 2006; 48(4): 102.	No				
Beason CW, Jauchem JR, Clark CD, Parker JE, Fines DA. *Pulse variations of a conducted energy weapon (similar to the TASER X26 device): effects on muscle contraction and threshold for ventricular fibrillation*.J Forensic Sci. 2009; 54(5):1113-8.	Yes	No			24
Bozeman WP, Barnes DG, Winslow JE III, Johnson JC, Phillips CH, Alson R. *Immediate cardiovascular effects of the Taser X26 conducted electrical weapon*. Emerg. Med. J. 2009; 26(8): 567-570.	No				
Bozeman WP, Hauda WE 2nd, Heck JJ, Graham DD Jr, Martin BP, Winslow JE. *Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects*. Annals of Emergency Medicine, 2009; 53(4): 480-489.	Yes	No			25
Bozeman WP. *Withdrawal of Taser Electroshock Devices: Too much, Too soon*. Annals of Emergency Medicine, 2005; 46(3): 300-301.	No				
Bozeman WP, Winslow JE III, Graham D, Martin B, Hauda WE, Heck JJ. *Injury Profile of Electrical Conducted Energy Weapons.* Annals of Emergency Medicine, 2007; 50(3);S65	No				
Bozeman WP, Winslow JE. *Medical Aspects of Less Lethal Weapons*. The Internet Journal of Rescue and Disaster Medicine, 2005: 5(1):1531-2992.	No				
Bui ET, Sourkes M, and Wennberg R. *Generalized Tonic-clonic Seizure After a Taser Shot to the Head*. Canadian Medical Association Journal, 2009; 180(6): 625-626.	Yes	No		Yes	26

Author and Reference	Rev	DI	Ed	CR	pg
Butler C, Hall C. *Police/Public Interaction: Arrests, Use of Force by Police, and Resulting Injuries to Subjects and Officers. A Description of Risk in One Major Canadian City*. Law Enforcement Executive Forum, 2008; **8**(6): 141-157.	No				
Cao, M. *Taser-induced rapid ventricular myocardial captures demonstrated by pacekmaker intracardiac electrograms*. J Cardiovas Electrophysiol. 2007; 18(8):876-9.	Yes	No			27
Cao M, Shinbane JS, Gillberg JM, Saxon LA, Swerdlow CD. *A Very Interesting Case Study Involving a TASER Conducted Electrical Weapon (CEW) Used On a Patient With a Pacemaker* - Author Reply. Journal of Cardiovascular Electrophysiology, 2007; 18(12):E31.	No				
Cao M, Shinbane JS, Gillberg JM, Saxon LA. *Taser-induced Rapid Ventricular Myocardial Capture Demonstrated by Pacemaker Intracardiac Electrograms.* Journal of Cardiovascular Electrophysiology, 2007; 18(8): 876-879	No				
Chen SL, Richard CK, Murthy RC, Lauer AK. *Perforating Ocular Injury by Taser.* Clinical & Experimental Ophthalmology, 2006; 34(4): 378-380.	No				
David E, Fretz A, Reissenweber J, Witten, D. *Taser and Health Risk* Proc. 4th European Symposium on Non-Lethal Weapons. 2007; Ettlingen, Germany	No				
Dawes DM, Ho J, Miner J *The Neuroendocrine Effects of the TASER X26: A Brief Report*. Forensic Science International, 2009; 183(1-3): 14-19.	Yes	Yes			65
Dawes DM, Ho JD, Cole JB, Reardon RF, Lundin, EJ, Terwey KS, Falvey DG, Miner JR. *Effect of an Electronic Control Device Exposure on a Methamphetamine-intoxicated Animal Model.* Academic Emergency Medicine, 2010; 17(4):436 – 443	No				
Dawes DM, Ho JD, *Fortuitous Effect of TASER Shock Misleading.* Annals of Emergency Medicine, 2009; 53(2):286-287.	No				
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.	No				
Dearing M, Lewis TJ, *Foreign Body Lodged in Distal Phalanx of Left Index Finger-taser Dart*. Emergency Radiology, 2005; 11(6): 364-365.	No				

Author and Reference	Rev	DI	Ed	CR	pg
Dennis AJ, Valentino DJ, Walter RJ, Nagy KK, WinnersJ, Bokhari F, Wiley DE, Joseph KT, Roberts RR. *Acute Effects of TASER X26 Discharges in a Swine Model.* Journal of Trauma Injury, Infection & Critical Care, 2007; 63(3): 581-590.	Yes	No			28
Dorian P, Nanthakumar K. *Electronic Control Devices and the Clinical Milieu* - In Reply. Journal of the American Colloege of Cardiology, 2007; 49(6): 732-733.	No				
Dosdall DJ, Ideker RE. *Cardiac Arrhythmias*. Taser Conducted Energy Weapons: Physiology, Pathology, and Law. Chapter 9. Springer, 2009.	Yes	No			30
Eastman AL, Metzger JC, Pepe PE, Benitez FL, Decker J, Rinnert KJ, Field CA, Friese RS. *Conductive Electrical Devices: A Prospective, Population-Based Study of the Medical Safety of Law Enforcement Use*. Journal of Trauma, Injury Infection and Critical Care, 2008. 64(6):1567-1572	No				
Efimov IR, Kroll MW, Panescu D, Sweeney JD. *Finite Element Modeling of Electric Field Effects of TASER Devices on Nerve and Muscle*. Eng Med Biol Soc. 2006; 1(1):1277-1279.	Yes	No			
Esquivel AO, Dawe EJ, Sala-Mercado JA, Hammond RL, Bir CA. *The physiologic effects of a conducted electrical weapon in swine*. Ann Emerg Med. 2007; 50;576-83	Yes	No			31
Fish RM, Geddes LA. *Effects of stun guns and tasers* Lancet, 2001; 358:687-8	Yes	No			32
Gowrishankar TR, Esser AT, Smith KC, Burns SK, Weaver JC. *In silico estimates of cellelectroporation by electrical incapacitation waveforms*. Proc. Conf. Engineering in Medicine and Biology Society, 2009. EMBC 2009.	No				
Haegeli LM, Sterns LD, Adam DC, Leather RA. *Effect of a Taser Shot to the Chest of a Patient with an Implantable Defibrillator*. Heart Rhythm, 2006. 3(3):339-341.	Yes	No			33
Hall CA, Public Risk From Tasers: *Unacceptably High or Low Enough to Accept?* Canadian Journal of Emergency Medicine, 2009; 11(1): 84-86.	Yes	No	Yes		78
Han JS, Chopra A, Carr D. *Ophthalmic Injuries From a TASER*. Canadian Journal of Emergency Medicine, 2009; 11(1):90-93.	Yes	No			34
Hinchey PR, Subramaniam, G. *Pneumothorax as a Complication After TASER Activation.* Prehospital Emergency Care, 2009; 13(4):532-535	No				

Author and Reference	Rev	DI	Ed	CR	pg
Ho JD, Dawes DM, Heegaard WG, Calkins HG, Moscati RM, Miner JR, *Absence of electrocardiographic change after prolonged application of a conducted electrical weapon in physically exhausted adults*. Journal of Emergency Medicine. *In Press:* 2009.03.023.	Yes	Yes			67
Ho J, Lapine A, Joing S, Reardon R, Dawes D. *Confirmation of Respiration during Trapezial Conducted Electrical Weapon Application*. Academic Emergency Medicine, 2008: 15(4):398–398	No				
Ho JD, Dawes DM, Johnson MA, Lundin EJ, Miner JR. *Impact of conducted electrical weapons in a mentally ill population: a brief report*. American Journal of Emergency Medicine, 2007; 25(7):780-785.	No				
Ho JD, Dawes DM, Bultman LL, Thacker JL, Skinner LD, Bahr JM, Johnson MA, Miner JR. *Respiratory Effect of Prolonged Electrical Weapon Application on Human Volunteers*. Academic Emergency Medicine, 2007; 14(3): 197-201	No				
Ho JD, Dawes DM. *Research Update on the Taser® Electronic Control Device*. Proc. 5th European Symposium on Non- Lethal Weapons, 2009; Ettlingen, Germany.	No				
Ho JD, Johnson MA, Dawes DM. *The State of Current Human Research and Electronic Control Devices (ECDs*). Proc. 4th European Symposium on Non- Lethal Weapons, 2007; Ettlingen, Germany.	Yes	Yes			71
Ho JD, Dawes DM, Reardon RF, Lapine AL, Dolan BJ, Lundin EJ, Miner JR. *Echocardiographic Evaluation of a TASER-X26 Application in the Ideal Human Cardiac Axis*. Academic Emergency Medicine, 2008; 15:838–844	No				
Ho JD, Miner JR, Lakireddy DR, Bultman LL, Heegaard WG. *Cardiovascular and physiologic effects of conducted electrical weapon discharge in resting adults*. Acad Emerg Medicine, 2006; 13:589–95.	Yes	Yes			68
Ho JD, Dawes DM, Bultman LL, Moscati RM, Janchar TA, Miner JR. *Prolonged TASER use on exhausted humans does not worsen markers of acidosis*. American Journal of Emergency Medicine, 2009; 27(4): 413-418	No				
Ho JD. *Electrocardiographic Effects of the CEW*. Taser®Conducted Electrical Weapons: Physiology, Pathology and the Law. Chapter 10. Springer Press. 2009.	Yes	Yes			70
Ho JD, Dawes DM, Cole JB, Hottinger JC, Overton KG, Miner JR *Lactate and pH evaluation in exhausted humans with prolonged TASER X26 exposure or continued exertion*. Forensic Science International, 2010; 195(1):169	No				

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Holden SJ, Sheridan RD, Coffey TJ, Scaramuzza RA, Diamantopoulos P. *Electromagnetic Modelling of Current Flow in the Heart from TASER Devices and the Risk of Cardiac Dysrhythmias*. Physics In Medicine and Biology, 2007; 52 (24): 7193–7209.	Yes	No			35
Hoffman, L. *ACEP Recognizes Excited Delirium Syndrome*. Emergency Medicine News. 2009. 31(10):5	No	No			
Ideker RE, Dosdall DJ. *Can the Direct Cardiac Effects of the Electric Pulses Generated by the TASER X26 Cause Immediate or Delayed Sudden Cardiac Arrest in Normal Adults*? American Journal of Forensic Medicine and Pathology, 2007; 28(3): 195-201.	Yes	No			36
Irnich W. *The fundamental law of electorstiumlation and its application to defibrillation.* Pacing Clin Electrophysiol, 1990; 13:1433-1447.	No				
Jauchem JR, Cook MC, Beason CW. *Blood factors of Sus scrofa following a series of three TASER® electronic control device exposures*. Forensic Science International, 2008; 175(2-3): 166-170	Yes	No			37
Jauchem JR. Re: *Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of Sus scrofa following repeated TASER® exposures,* Forensic Science International, 2007; 168(1): e19.	No				
Jauchem J, Beason CW, Cook MC. *Acute effects of an alternative electronic-control-device waveform in swine*. Forensic Sci Med Pathol, 2009; 5:2-10	Yes	No			38
Jauchem JR. *Repeated or long-duration Taser electronic control device exposures: acidemia and lack of respiration*. Forensic Sci Med Pathol, 2010; 6:46–53	Yes	No			39
Jauchem JR. *An animal model to investigate effectiveness and safety of conducted energy weapons (including TASER devices*). J Forensic Sci, 2010; 55(2):521-6.	Yes	No			40
Jauchem JR, Seaman RL, Klages CM. *Physiological effects of the TASER ((R)) C2 conducted energy weapon.* Forensic Sci Med Pathol, 2009; 5(3): 189-198.	No				
Jauchem, JR. *Deaths in custody: Are some due to electronic control devices (including TASER® devices) or excited delirium?* Journal of Forensic and Legal Medicine, 2010; 17(1): 1-7.	No				
Kiedrowski J, Petrunik M, Melchers R. *An independent review of the adoption and use of conducted energy weapons by the Royal Canadian Mounted Police. Ottawa (ON*): Royal Canadian Mounted Police; 2008.	No				
Kim PJ, Franklin WH. *Ventricular Fibrillation After Stun-Gun Discharge*. New England Journal of Medicine, 2005; 353(9): 958-959.	Yes	No			41

Author and Reference	Rev	DI	Ed	CR	pg
Koscove EM, *Physiological Effects of the Taser*. Annals of Emergency Medicine, 2008; 52(1): 85.	Yes	No			79
Kroll MW, Calkins H, Luceri RM, Graham MA, Heegaard WG. *TASER safety*. Canadian Medical Association Journal, 2008; 179(7): 677-678.	No				
Kroll MW. *Physiology and pathology of TASER® electronic control devices.* Journal of Forensic and Legal Medicine, 2009; 16(4): 173-177.	No				
Kroll, MW, Ho JD. *Eds.* <u>Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law</u>. Springer, 2009.	No				
Kroll MW, Luceri RM, Calkins H. *A Very Interesting Case Study Involving a TASER Conducted Electrical Weapon (CEW) Used on a Patient With a Pacemaker*. Journal of Cardiovascular Electrophysiology, 2007; 18(12): E29-30	No				
Lakkireddy D, Wallick D, Ryschon K, Chung MK, Butany J, Martin D, Saliba W, Kowalewski W, Natale A, Tchou PJ. *Effects of Cocaine Intoxication on the threshold for Stun Gun Induction of Ventircular Fibrillation*. Journal of American College of Cardiology, 2006; 48(4); 805-811.	Yes	Yes			73
Lakkireddy D, Wallick D, Verma A, Rytschon K, Kowalewski W, Wazni O, Butany J, Martin D, Tchou P. *Cardiac effects of electrical stun guns: does position of barbs contact make a difference*? Pacing and Clinical Electrophysiology, 2008; 31(4): 398-408	Yes	Yes			74
Lakkireddy D, Khasnis A, Antenacci J, Ryshcon K, Chung MK, Wallick D, Kowalewski W, Patel D, Mlcochova H, Kondur A, Vacek J, Martin D, Natale A, Tchou P. *Do Electrical Stun Guns (TASER-X26®) Affect the Functional Integrity of Implantable Pacemakers and Defibrillators?* Europace, 2007; 9(7): 551-556.	Yes	Yes			72
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*. American Journal of Cardiology, 2009; 103(6): 877-880	No				
Levine SD, Sloane CM, Chan TC, Dunford JV, Vilke GM. *Cardiac Monitoring of Human Subjects Exposed to the Taser.* Journal of Emergency Medicine, 2007; 33(2):113-117.	Yes	No			42
Lim EC-H, Seet R.C.-S., *Taser Usage and Neurological Sequelae*. Journal of Emergency Medicine, 2008. 37(2):170-171	No				

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Link MS, Estes NAM. *Cardiac Safety of Electrical Stun Guns: Letting Science and Reason Advance the Debate. Pacing and Clinical Electrophysiology*, 2008; 31(4):395-397.	No				
MacDonald JM, Kaminski RJ, Smith MR. *The Effect of Less-Lethal Weapons on Injuries in Police Use-of-Force Events.* American Journal of Public Health, 2009; 99(12): 2268-2274.	No				
Mangus BE, Shen LY, Helmer SD, Maher J, Smith, RS, *Taser and Taser Associated Injuries: A Case Series*. American Surgeon, 2008; 74(9):862-865.	Yes	No			43
McDaniel WC, Stratbucker RA, Nerrheim M. *Cardiac safety of neuromuscular incapacitating defensive devices*. Pacing Clin Electrophysiol, 2005; 28(Suppl 1):5284-287	No				
Meh LE. *Electrical injury from tasering and miscarriage.* Acta Obstetricia et Gynecologica Scandinavica, 1992; 71(2):118-123	No				
Miller CD. *Acidosis, Lactate, Electrolytes, Muscle Enzymes, and Other Factors in the Blood of Sus Scrofa Following Repeated TASER® Exposures*. Forensic Science International, 2007; 168(1): E17–18.	No				
Moscati R, Cloud S. *Rhabdomyolysis*. . Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law. Chapter 13. Springer, 2009.	Yes	Yes			76
Moscati R, Ho JD, Dawes DM, Miner JR. *Physiologic Effects of Prolonged Conducted Electrical Weapon Discharge in Ethanol Intoxicated Adults.* Amer J Emerg Med, 2010; 28(5):582-587	Yes	Yes			75
Mukherjee, A., *Tasers*. Canadian Medical Association Journal, 2008; 179(4): 342.	No				
Munetz MR, Fitzgerald A, Woody M. *Police Use of the Taser With People With Mental Illness in Crisis*. Psychiatric Services, 2006; 57(6): 883	No				
Nanthakumar K, Billingsly IM, Masse S, Dorian P, Cameron D, Chauhan, VS, Dowrar E, Sevaptsidis E. *Cardiac Electrophysiological Consequences of Neuromuscular Incapacitating Device Discharges*. J. American College of Cardiology, 2006; 48(4): 798-804.	Yes	No			44
Nanthakumar K, Masse S, Umapathy K, Dorian P, Sevaptsidis E, Waxman M. *Cardiac Stimulation With High Voltage Discharge from Stun Guns.* Canadian Medical Association Journal, 2008; 178(11): 1451-1457.	Yes	No			45
Ng W, Chehade M. *Taser Penetrating Ocular Injury*. American Journal of Ophthalmology, 2005; 139(4): 713-715.	Yes	No			46

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Nimunkar AJ, Webster JG. *Safety of pulsed electric devices*. Physiol Meas, 2009; 30(1):101-14.	No				
O'Brien DJ. *Electronic weaponry — A question of safety*. Annals of Emergency Medicine, 1991; 20(5): 583-587.	No				
O'Brien J, McKenna BG. *Concerns About the Use of TASERs® On People with Mental Illness in New Zealand* Journal of Forensic Nursing. 2008; 3(2): 89-92	No				
Panescu D, Stratbucker RA. *Current Flow in the Human Body*. Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law. Chapter 6. Springer 2009.	No				
Panescu D, Kroll MW, Efimov IR, Sweeney JD. *Finite Element Modeling of Electric Field Effects of Taser Devices on Nerve and Muscle*. in Proc. Conf. 28th IEEE Engineering Medicine Biological Society, 2006; New York	No				
Panescu D, Kroll MW, Stratbucker RA. *Theoretical Possibility of Ventricular Fibrillation During Use of TASER Neuromuscular Incapacitation Devices*. in Proc. Conf. 30th IEEE Engineering Medicine Biological Society, 2008; Vancouver.	No				
Paquette M. *Excited delirium: Does it exist?* Perspectives in Psychiatric Care, 2003; 39:93–94.	No				
Pippin, JJ., *Taser Research in Pigs Not Helpful*. Journal of the American Colloege of Cardiology, 2007. 49(6): 731-732.	No				
Pearce JA, Bourland JD Neilsen W. *Myocardial stimulation with ultrashort duration current pulses*. Pacing Clin Electrophysiol, 1982; 5(1):52-58	No				
Rehman T-U, Yonas H, Marinaro J. *Intracranial Penetration of a TASER Dart*. American Journal of Emergency Medicine, 2007; 25(6):733	No				
Reilly JP, Diamant AM, Comeaux J. *Dosimetry considerations for electrical stun devices*. Physics in Medicine and Biology, 2009; 54:1319–1335	Yes	No			47
Richards KA, Kleusser PL, Kluger J. *Fortuitous Therapeutic Effect of Taser Shock for a Patient in Atrial Fibrillation*. Annals of Emergency Medicine , 2008; 52(6):686-688	Yes	No		Yes	48
Robb M, Close B, Furyk J, Aitken P. *Review article: Emergency Department implications of the TASER*. Emerg Med Australas, 2009; 21(4):250-258	No				
Roberts JR. *The Medical Effects of TASERs*. Emergency Medicine News: 2008. 30(2); p 11-14	No				

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Sanford JM, Jacobs GJ, Roe EJ, Terndrup TE. *Two Patients Subdued with a Taser® Device: Cases and Review of Complications* Journal of Emergency Medicine, In Press., 2009	No				
Schmiederer B, Du Chesne A, Schmidt PF, Brinkmann B. *Specific Traces in Stun Gun Deployment*. International Journal of Legal Medicine, 2005; 119(4): 207-212.	Yes	No			49
Schwarz ES. *Successful resuscitation of a patient in asystole after a TASER injury using a hypothermia protocol*. American Journal of Emergency Medicine, 2009; 27(4):511-515	No				
Seth RK, Abedi G, Daccache AJ, Tsai JC. *Cataract Secondary to Electrical Shock From a Taser Gun.* Journal of Cataract and Refractive Surgery, 2007; 33(9): 1664-1665.	No				
Sharma A, Theivacumar NS, Souka HM. *Tasers--less than lethal!* Ann R Coll Surg Engl, 2009; 91(4): W20.	No				
Sloane CM, Chan TC, Vilke GM. *A Medical Review of the Physiological Effects of Conducted Energy Devices (CED*). Report prepared for the City of Houston Police Department.	Yes	No			81
Sloane CM, Chan TC, Levine SD, Dunford JV, Neuman T, Vilke GM. *Serum Troponin I Measurement of Subjects Exposed to the Taser X-26*. Journal of Emergency Medicine, 2008; 35(1):29-32.	Yes	No			52
Sloane CM, Chan TC, Vilke GM. *Thoracic Spine Compression Fracture After TASER Activation.* Journal of Emergency Medicine, 2008; 34(3): 283-285.	Yes	No			50
Stanbrook, M.B., *Tasers in Medicine: An Irreverent Call for Proposals*. Canadian Medical Association Journal, 2008. 178(11):1401-1402.	Yes	No	Yes		80
Stratton SJ, Rogers C, Brickett K, Ginger Gruzinsk G. *Factors associated with sudden death of individuals requiring restraint for excited delirium,* Am J Emerg Med, 2001; 19(3):187–191.	Yes	No			51
Strote J, Hutson HR. *Taser Safety Remains Unclear*. Annals of Emergency Medicine, 2008; 52(1): 84-85.	No				
Strote J, Campbell R, Pease J, Hamman MS, Hutson R. *The role of tasers in police restraint-related deaths*, *Annals of Emergency Medicine*, 2005; 46(3): S85	Yes	No			52
Strote J, Hutson HR, *TASER Use in Restraint-Related Deaths*. Prehospital Emergency Care, 2006; 10(4):447-450.	Yes	No			53

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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(5):1239-46.	No		No		
Strote J, Verzemnieks E, Walsh M, Hutson HR. *Use of Force by Law Enforcement: An Evaluation of Safety and Injury.* J Trauma. *In Press:* 2010 Feb 2.	No				
Strote J, Hutson HR. *TASER study results do not reflect real-life restraint situations*. Am J Emerg Med, 2009; 27(6):747	No				
Strote J, Hutson HR. *Conducted electrical weapon injuries must be more broadly considered.* Ann Emerg Med. 2009; 54(2):310-1; author reply 311-2	No				
Sweeney JD *Skeletal muscle response to electrical stimulation*. In Reilly JP ed. Electrical Stimulation and Electropathology. New York NY. Cambridge University Press 1992: 285-327.	No				
Sweeney, J. *Transcutaneous Muscle Stimulation*. Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law. Chapter 5. Springer, 2009.	Yes	Yes			77
Swerdflow C, Kroll M, Williams H. *Presenting rhythm in sudden custodial deats after use of TASER electronic control device*. Heart Rhythm, 2008; 5(5):S44	No				
Sun H, Webster JG. *Estimating neuromuscular stimulation within the human torso with Taser stimulus*. Physics In Medicine and Biology, 2007; 52(21):6401-6411.	Yes	No			57
Sun H. *Models of Ventricular Fibrillation Probability and Neuromuscular Stimulation After Taser® Use in Humans*, in Electrical Engineering. 2007, University of Wisconsin: Madison, WI. Ph.D thesis	Yes	No			55
Tchou PJ. *Electronic Control Devices and the Clinical Milieu - In Reply II*. Journal of the American Colloege of Cardiology, 2007; 49(6):733.	No				
Tchou PJ. *CEW Effects with Illegal Stimulant Intoxication.* Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law. Chapter 18. Springer 2009.	No				
Valentino DJ, Walter RJ, Dennis AJ, Margeta B, Starr F, Nagy KK, Bokhari F, Wiley DE, Joseph KT, Roberts RR. *Taser X26 Discharges in Swine: Ventricular Rhythm Capture is Dependent on Discharge Vector*. J. Trauma-Injury Infection & Critical Care, 2008; 65(6):1478-1487	No				
Valentino DJ, Walter RJ, Dennis AJ, Nagy K, Loor MM, Winners J, Bokhari F,Wiley D, Merchant A, Joseph K, Roberts R. *Neuromuscular Effects of Stun Device Discharges.* Journal of Surgical Research, 2007; 143:78–87	No				

Author and Reference	Rev	DI	Ed	CR	pg
Valentino DJ, Walter RJ, Nagy K, Dennis AJ, Winners J, Bokhari F, Wiley D, Joseph KT, Roberts R. *Repeated Thoracic Discharges From a Stun Device.* J. Trauma: Injury, Infection, and Critical Care, 2007; 62(5); 1134-1142.	No				
VanMeenan K, Cherniak NS, Bergen MT, Gleason LA, Teichman R, Servatius RJ. *Cadiovascular Evaluation of Electronic Device Exposurein Law Enforcement Trainees: a Multi-site Study*. Journal of Emergency Medicine, 2010; 52:197.	Yes	No			58
Vanga SR, Krol MW, CarverM, Swerdlow L, Lakkireddy D. *Cardiac capture and fibrillation by CEW: An electrophysiologist's perspective,* Proc. Conf. IEEE Eng. Med. Biol. Soc., 2009.	No				
Vilke GM, Sloane CM, Bouton KD. *Physiological Effects of a Conducted Electrical Weapon on Human Subjects*. Annals of Emergency Medicine, 2007; 50(5):569-575.	Yes	No			61
Vilke GM, Neuman T, Castillo EM, Chan TC, Kolkhorst F. *Physiological Effects of the Taser - In Reply*. Annals of Emergency Medicine, 2008; 52(1): 85-86.	No				
Vilke GM, Sloane CM, Suffecool A, Kolkhorst FW, Neuman TS, Castillo EM, ChanTC. *Physiologic Effects of the TASER After Exercise.* Acad Emerg Med, 2009; 16(8): 704-710.	No				
Vilke GM. *Less Lethal Technology: Medical Issues,* Policing: International Journal of Police Strategies and Management, 2007; 30(3):341-357.	Yes	No			59
Vilke GM. *Cardiovascular and Metabolic Effects of the TASER on Human Subjects.* Annals of Emergency Medicine**, 2007**; 50(5): 569-575.	No				
Vilke GM, Sloane C, Levine S, Neuman T, Castillo C, Chan TC. *Twelve-lead Electrocardiogram Monitoring of Subjects Before and After Voluntary Exposure to the Taser X26*. American Journal of Emergency Medicine, 2008; 26(1): 1-4.	Yes	No			60
Walter RJ, Dennis AJ, Valentino DJ, Margeta G, Nagy KK, Bokhari F, Wiley DE, Joseph KT, Roberts RR. *TASER X26 discharges in swine produce potentially fatal ventricular arrhythmias*. Acad Emerg Med, 2008; 15(1):66.	No				
Whitehead, S.*, After Shock - A Rational Response to Taser Strikes.* Journal of Emergency Medical Services, 2005; 30(5): 56-66.	No				

Author and Reference	Rev	DI	Ed	CR	pg
Winslow JE, Bozeman WP, Fortner MC, Alson RL. *Thoracic Compression Fractures as a Result of Shock From a Conducted Energy Weapon: A Case Report*. Annals of Emergency Medicine, 2007; 50(5):584-586.	No				
Wu JY, Sun H, O'Rourke AP, Huebner S, Rahko PS, Will JA, Webster JG. *Taser Blunt Probe Dart-to-Heart Distance Causing Ventricular Fibrillation in Pigs*. IEEE Transactions on Bio-medical Engineering, 2008; 55(12): 2768-2771.	Yes	No			62
Wu JY, Sun H, O'Rourke AP, Huebner S, Rahko PS, Will JA, Webster JG. *Taser Dart-to-Heart Distance That Causes Ventricular Fibrillation in Pigs.* IEEE Transactions in Bio-Medical Engineering, 2007; 54(3):503-508.	Yes	No			63

Appendix B: Individual papers with no disclosed interest

<table>
<tr><td colspan="3">REFERENCE:

Beason CW, Jauchem JR, Clark CD, Parker JE, Fines DA. Pulse variations of a conducted energy weapon (similar to the TASER X26 device): effects on muscle contraction and threshold for ventricular fibrillation. J Forensic Sci. 2009; 54(5):1113-8.</td><td>DISCLOSED INTEREST
none</td></tr>
<tr><td>STIMULATION:
X26 and custom built modifiable electronic stimulator (MES), 20 Hz pulse rate for 5 s</td><td>SUBJECT:
10 anaesthetized pigs</td><td colspan="2">MEASUREMENT:
Muscle force (strain guages) and VF</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

Muscle contraction force increases with increases in dart spacing (to 20 cm), pulse charge and pulse repetition rate.</td></tr>
<tr><td colspan="4">SUMMARY:

Muscle contraction force was measured in pigs receiving an average of 33 shocks of varying amplitudes and pulse rates. No differences in muscle reaction were seen if precursor pulse (plasma arc) was deleted. Muscle contraction force increased linearly as pulse repetition rate increased to 40 Hz and charge was increased to 400 μC. No VF was noted during the ninety one X26 pulses but 10 instances of VF occurred at higher levels of stimulation during the 208 exposures from the MES.</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:
none</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

Conducted energy weapons (such as the Advanced TASER X26 model produced by TASER International), incapacitate individuals by causing muscle contractions. To provide information relevant to development of future potential devices, a “Modifiable Electronic Stimulator” was used to evaluate the effects of changing various parameters of the stimulating pulse. Muscle contraction was affected by pulse power, net/gross charge, pulse duration, and pulse repetition frequency. The contraction force increased linearly as each of these factors was increased. Elimination of a precursor pulse from X26-like pulses did not have a significant effect on the normalized force measured. Muscle-contraction force increased as the spacing increased from 5 to 20 cm, with no further change in force above 20 cm of spacing. Therefore, it is suggested that any future developments of new conducted energy weapons should include placement of electrodes a minimum of 20 cm apart so that efficiency of the system is not degraded. In the current study, the 50% probability of fibrillation level of X26-like pulses ranged from 4 to 5 times higher than the X26 itself. Relatively large variations about the X26 operating level were found not to result in fibrillation or asystole. Therefore, it should be possible to design and build an X26-type device that operates efficiently at levels higher than the X26.</td></tr>
</table>

REFERENCE:			DISCLOSED INTEREST
Bozeman WP, Hauda WE 2nd, Heck JJ, Graham DD Jr, Martin BP. *Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects.* Annals of Emergency Medicine, 2009; 53(4): 480-489.			None
STIMULATION: Conducted electrical weapons (CED), Taser	**SUBJECT:** 1,201 human subjects (94% male)	**MEASUREMENT:** Review of police and medical records	

FINDINGS (IN OUR WORDS):

More than 99% of subjects do not experience significant injuries after CED use.

SUMMARY:

The safety and injury profile of CEWs was measured by a review of police and medical records describing the incidence and severity of injuries associated with CEW use. All CEW uses against 1,201 cri minal suspects at 6 US law enforcement agencies during 36 months (2005-2008) were reviewed and were classified as: 1) Mild or no injuries (99.75%) or 2) Significant injuries (3 subjects or 0.25%). For mild injuries, 83% were superficial puncture wounds from weapon probes. Severe injuries were 2 intracranial injuries from falls and 1 case of rhabdomyolysis). Two subjects died in police custody and not found related to CED use.

COMMENTS + LIMITATIONS:

alcohol or drug levels was based on officer reports, rather than toxicologic testing

"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."

AUTHORS ABSTRACT:

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.

REFERENCE:			**DISCLOSED INTEREST**
Bui, ET, Sourkes M, and Wennberg R. *Generalized Tonic-clonic Seizure After a Taser Shot to the Head*. Canadian Medical Association Journal, 2009; 180(6): 625-626.			none

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
X26 shot from barbs	One healthy police officer	Blood chemistry, MRI, EEG

FINDINGS (IN OUR WORDS):

A case report of Taser shot to head, resulting in immediate seizure and persistent neurological distress**.**

SUMMARY:

One healthy police officer was shot in the back of the head by a Taser during a foot pursuit and had an immediate seizure with persistent neurological distress for more than a year after the incident. Blood chemistry findings were similar to research findings involving healthy adults but the lack of definitive indicators (MRI, EEG) underline the absence of data and research into neurological effects of Taser emissions.

Persistent anxiety, irritability, dizziness and headaches have lingered more than a year following the incident.

COMMENTS + LIMITATIONS:

AUTHORS ABSTRACT:

During a police chase on foot, a previously well police officer was hit mistakenly by a taser shot meant for the suspect. The taser gun had been fired once, sending 2 barbed darts into his upper back and occiput. Within seconds, the officer collapsed and experienced a generalized tonic-clonic seizure with loss of consciousness and postictal confusion. Subsequent magnetic resonance imaging scans of the head and electroencephalograms were normal. The patient has experienced no recurrence of seizure over more than a year of follow-up. This report shows that a taser shot to the head may result in a brain-specific complication such as generalized tonic-clonic seizure. It also suggests that seizure should be considered an adverse event related to taser use.

REFERENCE: Cao M, Shinbane JS, Gillberg JM, Saxon LA, Swerdlow CD. *Taser-induced rapid ventricular myocardial capture demonstrated by pacemaker intracardiac electrograms*, J Cardiovascular Electrophysiol, 2007; 18(8):876-879.			**DISCLOSED INTEREST** None
STIMULATION: Taser X26	**SUBJECT:** 53-year-old man	**MEASUREMENT:** dual-chamber pacemaker	

FINDINGS (IN OUR WORDS):

Case report of subject with a pacemaker which recorded activity during Taser exposure. Heart rate increased during exposure.

SUMMARY:

A 53-year-old male with a dual-chamber pacemaker implanted on the left chest received a Taser shot while running to avoid capture. The Taser shot struck the right chest with no immediate observable adverse effects. One week later, he was brought back for a medical evaluation due to nonspecific chest pain. Stored event data of the pacemaker revealed two high ventricular rate episodes corresponding to the exact time of the Taser application. The first tachycardia (high ventricular rate) episode lasted for 5 seconds, while the second lasted for 281–290 msec. The Taser discharge can potentially conduct directly to the leads or via the pacemaker through the leads and then to the heart.

COMMENTS + LIMITATIONS:
A first case of ventricular myocardial capture from Taser application on a single person.

AUTHORS ABSTRACT:

Introduction: A Taser weapon is designed to incapacitate violent individuals by causing temporary neuromuscular paralysis due to current application. We report the first case of a Taser application in a person with a dual-chamber pacemaker demonstrating evidence of Taser-induced myocardial capture.
Methods and Results: Device interrogation was performed in a 53-year-old man with a dual-chamber pacemaker who had received a Taser shot consisting of two barbs delivered simultaneously. Assessment of pacemaker function after Taser application demonstrated normal sensing, pacing thresholds, and lead impedances. Stored event data revealed two high ventricular rate episodes corresponding to the exact time of the Taser application.
Conclusions: This report describes the first human case of ventricular myocardial capture at a rapid rate resulting from a Taser application. This raises the issue as to whether conducted energy devices can cause primary myocardial capture or capture only in association with cardiac devices providing a preferential pathway of conduction to the myocardium.

REFERENCE:	DISCLOSED INTEREST
Dennis AJ, Valentino DJ, Walter RJ, Nagy KK, WinnersJ, Bokhari F, Wiley DE, Joseph KT, Roberts RR. *Acute Effects of TASER X26 Discharges in a Swine Model.* Journal of Trauma-Injury Infection & Critical Care, 2007; 63(3): 581-590.	none

STIMULATION:	SUBJECT:	MEASUREMENT:
Two 40 second discharges from X26	11 pigs	ECG, Blood chemistry, blood pressure

FINDINGS (IN OUR WORDS):

Long (40 s) CEW discharges resulted in significant cardiovascular and blood chemical changes. In two pigs, VF led to death.

SUMMARY:

11 pigs (6 experimental animals, 5 controls) were anesthetized and CEW applied on the chest along the cardiac axis with two 40 second X26 emissions. The pigs were artificially ventilated except during the discharges. Significant blood chemistry changes and cardiovascular effects were seen. Two animals died from VF immediately after CEW exposure.

COMMENTS + LIMITATIONS:

This is a significant study which shows possibly serious effects of longer discharges.

AUTHORS ABSTRACT:

Background: Very little objective laboratory data are available describing the physiologic effects of stun guns or electromuscular incapacitation devices (EIDs). Unfortunately, there have been several hundred in-custody deaths, which have been temporally associated with the deployment of these devices. Most of the deaths have been attributed to specific cardiac and metabolic effects. We hypothesized that prolonged EID exposure in a model animal system would induce clinically significant metabolic acidosis and cardiovascular disturbances. Methods: Using an Institutional Animal Care and Use Committee-approved protocol, 11 standard pigs (6 experimentals and 5 sham controls) were anesthetized with ketamine and xylazine. The experimentals were exposed to two 40-second discharges from an EID (TASER X26, TASER Intl., Scottsdale, AZ) across the torso. Electrocardiograms, blood pressure, troponin I, blood gases, and electrolyte levels were obtained pre-exposure and at 5, 15, 30, and 60 minutes and 24, 48, and 72 hours postdischarge. p values <0.05 were considered significant. Results: Two deaths were observed immediately after TASER exposure from acute onset ventricular fibrillation (VF). In surviving animals, heart rate was significantly increased and significant hypotension was noted. Acid-base status was dramatically affected by the TASER discharge at the 5-minute time point and throughout the 60-minute monitoring period. Five minutes postdischarge, central venous blood pH (6.86± 0.07) decreased from baseline (7.45 ± 0.02; p ± 0.0004). PCO2 (94.5 mm Hg ± 14.8 mm Hg) was significantly increased from baseline (45.3 mm Hg ± 2.6 mm Hg) and bicarbonate levels significantly decreased (15.7 mmol/L± 1.04 mmol/L) from baseline (30.4 mmol/L ± 0.7 mmol/L). A large, significant increase in lactate occurred postdischarge (22.1 mmol/L ± 1.5 mmol/L) from baseline (1.5 mmol/L± 0.3 mmol/L). All values returned to normal by 24 hours postdischarge in surviving animals. A minor, nonsignificant increase in troponin I was seen at 24 hours postdischarge (0.052 ng/mL ± 0.030 ng/mL, mean ± SEM).

Conclusions: Immediately after the discharge, two deaths occurred because of ventricular fibrillation. In this model of prolonged EID exposure, clinically significant acid-base and cardiovascular disturbances were clearly seen. The severe metabolic and respiratory acidosis seen here suggests the involvement of a primary cardiovascular mechanism.

REFERENCE:			DISCLOSED INTEREST
Dosdall DJ, Ideker RE. *Cardiac Arrhythmias*. Taser Conducted Energy Weapons: Physiology, Pathology, and Law. Chapter 9. Springer, 2009			none
STIMULATION: n/a	**SUBJECT:** 136 human deaths	**MEASUREMENT:** n/a	

FINDINGS (IN OUR WORDS):

Authors conclude it is unlikely that X-26 discharge can cause VF.

SUMMARY:

Authors perform a review of mechanisms of shock induced VF. 0.4% of people would develop ectopic beats if X26 electrodes were placed optimally on the chest. Taser pulses are 15x the time constant of cardiac muscle. Thus skeletal muscle responds to the pulses while cardiac muscles do not. Pulses 2.3 times stronger than Taser pulses are needed to cause an ectopic beat of the heart. 95% of sudden deaths due to excited delirium and or cusotdy) are characterized by brachycardia, PEA, or asystole. Ventricular fibrillation is uncommon. The time constant for dogs is 2.6 and 4.6 ms in 2 studies. The time constant for motor neurons is very much less than for cardiac cells. Electrodes placed on the chest deliver 4-10% of the current to the heart. VT leads to VF but healthy hearts recover sinus rhythm quickly. The Fundamental Law of Electrostimulation sets out strength-duration relationships and notes that a square wave of certain average amplitude can approximate the effects of complex waveshapes. Blair's model predicts that an X26 pulse changes the transmembrane potential in a motor neuron more than 12 times as much as a cardiac cell.

COMMENTS + LIMITATIONS:

The "fundamental law of electrostimulation" is not uniformly accepted by electrophysiologists as the only way to compare strength / duration curves for this application.

AUTHORS' SELECTED TEXT:

Conclusion: A review of relevant research into the mechanisms of shock-induced VF and the application of the Fundamental Law of Electrostimulation indicate that TASER X26 pulses do not reach the threshold for causing immediate or delayed onset VF. This conclusion is based on the accuracy of the Fundamental Law of Stimulation at small pulse widths (0.1 millisecond) and the accuracy of the depiction of the TASER X26 pulse in the paper of McDaniel et al [5]. Unless these assumptions are grossly in error, the safety factors associated with each of the mechanisms for VF discussed make it unlikely that the TASER X26 can cause VFD directly due to the electrical effects of the device.

REFERENCE:

Esquivel AO, Dawe EJ, Sala-Mercado JA, Hammond RL, Bir CA. *The physiologic effects of a conducted electrical weapon in swine*. Ann Emerg Med, 2007; 50:576–83.

DISCLOSED INTEREST
None

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
Stinger S-400	10 healthy anesthetised pigs	ECG, blood types and cardiac output

FINDINGS (IN OUR WORDS):

Healthy anesthetized pigs exposed to Stinger S-400 do not show serious adverse physiologic effects.

SUMMARY:

The authors investigated the physiological and health effects of repeated exposures to the Stinger S-400. 10 anesthetized pigs were exposed for 20 times in 31 minutes (4 sets of 5 exposures 5 minutes apart). The authors evaluated key physiologic characteristics: pH, PCO2, PO2, blood lactate level, cardiac output, ECG, pulse rate, mean arterial pressure, central venous pressure, pulmonary artery pressure and airway pressure. Exposure to Stinger S-400 results in respiratory acidosis, metabolic vasodilation, and an increase in blood lactate level. The authors also observed three isolated premature ventricular contractions in one pig after the first exposure, but they did not observe contractions in subsequent tests. They concluded that these effects were transient that all fully recovered after 4 hours, which suggested that the Stinger S-400 does not have serious adverse physiologic effects on healthy, anesthetized swine.

COMMENTS + LIMITATIONS:

AUTHORS ABSTRACT:

Study objective: By using an animal model, we determine whether repeated exposures to a conducted electrical weapon could have physiologic consequences. Methods: Exposures to the Stinger S-400 conducted electrical weapon were applied to 10 healthy, anesthetized, Yorkshire-cross, male swine by attaching probes from the cartridge to the sternal notch and anterolateral thorax at a distance of 21.5 cm. The standard pulse generated by the Stinger S-400 during the normal application was applied 20 times during 31 minutes. To evaluate the health effects of the exposures, key physiologic characteristics were evaluated, including arterial pH, PCO2, PO2, blood lactate, cardiac output, ECG, pulse rate, mean arterial pressure, central venous pressure, pulmonary artery pressure and airway pressure, and the cardiac marker troponin I. Results: There were notable changes in pH, PCO2, blood lactate, cardiac output, and mean arterial pressure after 1 or more sets of exposures, all of which normalized during the next few hours. Troponin I, PO2, pulse rate, mean arterial pressure, central venous pressure, pulmonary artery pressure, and airway pressure did not change markedly during or after the shocks. Three premature ventricular contractions occurred in one animal; all other ECG results were normal. Conclusion: Repeated exposures to a conducted electrical weapon result in respiratory acidosis, metabolic vasodilation, and an increase in blood lactate level. These effects were transient in this study, with full recovery by 4 hours postexposure. The Stinger S-400 appears to have no serious adverse physiologic effects on healthy, anesthetized swine.

REFERENCE: Fish RM, Geddes LA. (2001). *Effects of stun guns and tasers***.** Lancet, 358:687.			**DISCLOSED INTEREST** None
STIMULATION: Review paper	**SUBJECT:** n/a	**MEASUREMENT:** n/a	
FINDINGS (IN OUR WORDS): Authors conclude that Taser has fewer side effects and is safer than ballistic weapons.			
SUMMARY: This review paper investigated effects of the stun guns and the Taser, and compared it with ballistic weapons. The effects of stun guns increase with the duration of application. They rejected the possibility of ventricular fibrillation in humans based on pig data, while suggesting further research on the effects of Taser on people with pacemakers. The possibility of Taser-related injuries was noted - eye or blood vessel injuries due to Taser dart penetration, secondary trauma from a fall, other injuries (contusions, abrasions, lacerations and testicular torsion). In comparison of Taser with ballistic weapons, none of the Taser subjects among 218 had long term serious effects, while 50% of subjects among 22 with bullet wounds did.			
COMMENTS + LIMITATIONS: That CEWs cause less serious effects than ballistic weapons would appear to be fairly obvious.			
AUTHORS ABSTRACT: n/a			

REFERENCE: Haegeli LM, Sterns LD, Adam DC, Leather RA. *Effect of a Taser shot to the chest of a patient with an implantable defibrillator.* Heart Rhythm, 2006; 3(3):339-41		**DISCLOSED INTEREST:** none
STIMULATION: Taser M26	**SUBJECT:** human (woman)	**MEASUREMENT**: ICD (Implantable cardioverter-defibrillator)

FINDINGS (IN OUR WORDS):

The case report of a subject in which the ICD misinterpreted CEW exposure as VF.

SUMMARY:

The paper reported first case of Ventricular Fibrillation on a patient with ICD (Implantable cardioverter-defibrillator) which recorded the signal. A woman with a single chamber ICD received a Taser exposure directly on her sternum for 5 seconds. Although no adverse problems were discovered after the Taser shock, the ICD misinterpreted the electrical pulses from the CEW as VF and prepared to inject a defibrillating pulse (which was not given to the subject, since the end of the CEW simulation ended the apparent VF).

COMMENTS + LIMITATIONS:

This paper illustrates a potentially serious possibility. If the ICD had chosen to "defibrillate" the heart, this extra shock could be harmful or even life-threatening.

AUTHORS SELECTED TEXT:

N/A

REFERENCE:	DISCLOSED INTEREST
Han JS, Chopra A, Carr D., *Ophthalmic injuries from a TASER*. Canadian Journal of Emergency Medicine, 2009; 11(1):90-3.	None

STIMULTAION:	SUBJECT:	MEASUREMENT:
Taser X26	1 healthy man (age 25)	CT scan

FINDINGS (IN OUR WORDS):

Review of one case of eye injury by Taser dart.

SUMMARY:

Authors investigated a case study of eye injuries sustained by a subject being impaled with a Taser dart and the delivered electrical current. They suggested safe approaches for removal of barbed Taser darts from the soft tissue, and the intervention.

Taser-related injuries can cause globe rupture and associated vitreous hemorrhage, retinal laceration and lid injury. They noted the potential of injuring vulnerable areas such as the eye, genitalia and large blood vessels in the neck, where most vulnerable is the ocular tissues that are prone to ischemia due to its particular low resistance to electric current.

COMMENTS + LIMITATIONS:
N/A

AUTHORS ABSTRACT:

The TASER (TASER International) is an energy-conducting weapon that is becoming more frequently used by law enforcement officials to subdue combative individuals. Though generally regarded as a safe alternative, the use of such weapons has been reported to cause serious injuries. We describe a case in which ocular injuries were sustained by impalement with a TASER dart. Emergency physicians should be aware of the potential for serious ophthalmic injuries from TASERs and how such injuries should be managed.

REFERENCE:		**DISCLOSED INTEREST**
Holden SJ, Sheridan RD, Coffey TJ, Scaramuzza RA, Diamantopoulos P, *Electromagnetic Modelling of Current Flow in the Heart from TASER Devices and the Risk of Cardiac Dysrhythmias.* Physics In Medicine and Biology, 2007; 52(24):7193–7209.		**None**
STIMULATION: M26 and X26 TASER waveforms	**SUBJECT**: Guinnea pig hearts	**MEASUREMENT:** Heart rate measurement

FINDINGS (IN OUR WORDS):

The current density from Taser waveforms does not cause VF in isolated guinnea pig hearts.

SUMMARY:

The authors used a numerical model of the human body and its internal organs to estimate current flow in the heart from activation of M26 and X26 TASER waveforms on the anterior chest wall. They characterized different dart distances and firing range in 6 different scenarios in their model for the M26 and X26 exposure.

The current densities derived from the model were then applied to isolated guinnea pig hearts placing the stimulation electrodes on the epicardial surface of ventricles. Results showed that the M26 and the X26 waveforms did not induce VF.

COMMENTS + LIMITATIONS:

In this study, tests were performed on isolated hearts, which may not be a sufficiently good model of the in-vivo conditions.

AUTHORS ABSTRACT:

Increasing use by law enforcement agencies of the M26 and X26 TASER electrical incapacitation devices has raised concerns about the arrhythmogenic potential of these weapons. Using a numerical phantom constructed from medical images of the human body in which the material properties of the tissues are represented, computational electromagnetic modelling has been used to predict the currents arising at the heart following injection of M26 and X26 waveforms at the anterior surface of the chest (with one TASER 'barb' directly overlying the ventricles). The modelling indicated that the peak absolute current densities at the ventricles were 0.66 and 0.11 mA/mm^2 for the M26 and X26 waveforms, respectively. When applied during the vulnerable period to the ventricular epicardial surface of guinea-pig isolated hearts, the M26 and X26 waveforms induced ectopic beats, but only at current densities greater than 60-fold those predicted by the modelling. When applied to the ventricles in trains designed to mimic the discharge patterns of the TASER devices, neither waveform induced ventricular fibrillation at peak currents >70-fold (for the M26 waveform) and >240-fold (for the X26) higher than the modelled current densities. This study provides evidence for a lack of arrhythmogenic action of the M26 and X26 TASER devices.

REFERENCE: Ideker RE, Dosdall DJ. *Can the direct cardiac effects of the electric pulses generated by the TASER X26 cause immediate or delayed sudden cardiac arrest in normal adults?* Am J Forensic Med Pathol, 2007; 28:195–201?			**DISCLOSED INTEREST** None
STIMULATION: n/a	**SUBJECT:** n/a	**MEASUREMENT:** n/a	

FINDINGS (IN OUR WORDS):

Authors conclude that the Taser X26 is unlikely induce immediate ventricular fibrillation on the normal adult heart.

SUMMARY:

The authors reviewed biologic and physical findings to examine the likelihood that the use of a Taser could lead to delayed or immediate sudden cardiac arrest after Taser use via the effect of the Taser generated electric field. Three main lines of argument are given: (i) Electrical stimulation of an ectopic heart beat, (ii) application of the fundamental law of electrostimulation to Taser X26 pulse, and (iii) electrical stimulation of immediate and delayed ventricular fibrillation. They conclude that 0.4% of individuals could experience an ectopically paced beat stimulated by a Taser X26 pulse if the Taser electrodes are in the most sensitive positions. The possibility of CEW induced immediate ventricular fibrillation on the normal adult heart is rejected.

COMMENTS + LIMITATIONS:

Their conclusions are partially based on several assumptions – regarding Taser X26 pulse, Blair's method and Fundamental Law of Electrostimulation. These assumptions are not universally accepted as the best model of electrical safety limits in the bioelectrical effects literature.

Only considered normal adult humans for this investigation

AUTHORS ABSTRACT:

There is only a small amount of experimental data about whether the TASER X26, a nonlethal weapon that delivers a series of brief electrical pulses to cause involuntary muscular contraction to temporarily incapacitate an individual, can initiate ventricular fibrillation to cause sudden cardiac arrest either immediately or sometime after its use. Therefore, this paper uses the fundamental law of electrostimulation and experimental data from the literature to estimate the likelihood of such events. Because of the short duration of the TASER pulses, the large duration of the cardiac cell membrane time constant, the small fraction of current from electrodes on the body surface that passes through the heart, and the resultant high pacing threshold from the body surface, the fundamental law of electrostimulation predicts that the TASER pulses will not stimulate an ectopic beat in the large majority of normal adults. Since the immediate initiation of ventricular fibrillation in a normal heart requires a very premature stimulated ectopic beat and the threshold for such premature beats is higher than less premature beats, it is unlikely that TASER pulses can immediately initiate ventricular fibrillation in such individuals through the direct effect of the electric field generated through the heart by the TASER. In the absence of preexisting heart disease, the delayed development of ventricular fibrillation requires the electrical stimuli to cause electroporation or myocardial necrosis. However, the electrical thresholds for electroporation and necrosis are many times higher than that required to stimulate an ectopic beat. Therefore, it is highly unlikely that the TASER X26 can cause ventricular fibrillation minutes to hours after its use through direct cardiac effects of the electric field generated by the TASER.

REFERENCE:	**DISCLOSED INTEREST**
Jauchem J, Beason CW, Cook MC. *Acute effects of an alternative electronic-control-device waveform in swine*. Forensic Sci Med Pathol, 2009; 5:2-10.	None

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
30 s and 60 s exposure electronic stimulator similar to X26	10 pigs mean weight 59.3 kg	Blood chemical analysis

FINDINGS (IN OUR WORDS):

Longer CEW exposure causes decrease in blood pH and increase in Lactate. For very long exposure only 4/10 animals survived.

SUMMARY:

Ten pigs were exposed to 30 or 60 second applications of an electronic waveform similar to X26. Blood was then sampled to determine changes in blood chemistry. After exposure to CEW, Blood pH significantly decreased (and returned to baseline levels in minutes). Lactate was highly elevated with a slower return to baseline levels (hours). All animals survived. Changes in blood chemistry were more severe for the longer exposures than for 5 s CEW exposures.

Subsequently, during more extreme exposures of an X26 waveform (3 minutes 7 s on 3 s off), only four of ten animals survived.

COMMENTS + LIMITATIONS:
No monitoring during discharge was possible. Blood samples drawn before and after exposure to weapon's discharge.

AUTHORS ABSTRACT:

In previous studies, repeated 5-s exposures of anesthetized pigs to an electronic control device (TASER International's Advanced TASER_ X26 device) resulted in acidosis and increases in blood electrolytes. In the current study, experiments were performed to investigate the effects of longer continuous exposures to a different electroniccontrol device waveform. After intramuscular injection of tiletamine HCl and zolazepam HCl, anesthesia was maintained with propofol infusion. Ten pigs were exposed to either 30- or 60-s applications of an electronic waveform similar to the TASER-X26 device. Transient increases in potassium, and sodium were consistent with previous reports in the literature dealing with studies of muscle stimulation or exercise. Blood pH was significantly decreased after exposure, but subsequently returned to baseline levels. Lactate was highly elevated and remained somewhat increased even after three hrs. Serum myoglobin was increased after exposure and remained elevated for the 3-h follow-up period. Acidosis would appear to be one of the major concerns with long-duration (e.g., several min) exposures over a short period of time. Even with the extremely low pH immediately after exposure, all animals survived. On the basis of these results, further development of useful continuous-exposure electronic control devices is at least feasible, with the caveat that some medical monitoring of subjects may be required.

REFERENCE: Jauchem JR, Cook MC, Beason CW. *Blood factors of Sus scrofa following a series of three TASER electronic control device exposures***,** Forensic Sci Int, 2008; 175:166–70.	**DISCLOSED INTEREST** none

STIMULATION: Taser X26 (5s)	**SUBJECT:** 10 pigs	**MEASUREMENT:** blood chemistry tests

FINDINGS (IN OUR WORDS):

Three repeated TASER exposures on pigs had transient effects on blood chemistry which returned to normal levels before exposure.

SUMMARY:

Ten anaesthetized pigs (46 to 61 kg) were given repeated exposures to Taser and blood samples were taken for the following 3 hours. Mean heart rate was slightly increased after exposure and the mean respiration rate was slightly decreased. Lactate was significantly elevated immediately after and at 30 and 60 min after exposure. Blood pH decreased immediately following exposure, but all returned to pre-exposure levels. They concluded that three repeated Taser exposures had only transient effects on blood factors.

COMMENTS + LIMITATIONS:

n/a

AUTHORS ABSTRACT:

In a previous study, 18 repeated exposures of anaesthetized swine to an electro-muscular incapacitating device (TASER International's ADVANCED TASER1 X26 electronic control device) resulted in acidosis and increases in blood electrolytes. In the current study, experiments were performed to investigate effects of a more typical scenario of repeated exposures of the device on muscle contraction and changes in blood factors. Ten swine were exposed for 5 s, followed by a 5-s period of no exposure, three times. Selected blood factors were monitored for 3h following exposure. Transient increases in blood glucose, lactate, sodium, potassium, calcium, and pCO_2 were consistent with previous reports in the literature dealing with studies of muscle stimulation or exercise. Blood pH was decreased immediately following exposure, but subsequently returned toward a normal level. Oxygen saturation (measured by pulse oximetry) was not changed significantly. In conclusion, three repeated TASER device exposures had only transient effects on blood factors, which all returned to pre-exposure levels, with the exception of hematocrit (which remained elevated after 3 h). Since the increase in this factor was less than that which may occur after short periods of exercise, it is unlikely that this would be an indicator of any serious harm.

<table>
<tr><td colspan="2">REFERENCE:

Jauchem J. Repeated or long-duration Taser electronic control device exposures: acidemia and lack of respiration. Forensic Sci Med Pathol, 2010; 6:46–53</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
Taser X26</td><td>SUBJECT:
Pigs</td><td>MEASUREMENT:
Blood chemistry</td></tr>
<tr><td colspan="3">FINDINGS (IN OUR WORDS):

Where pigs have died from lengthy exposure to CEW discharges, it was not VF but respiratory arrest that caused the death.</td></tr>
<tr><td colspan="3">SUMMARY:

The paper analyses a number of studies of long (> 1 min) CEW exposure which resulted in the death in pigs. Decreased blood pH and ineffective respiration were common during and after CEW exposure. Papers that examined the effects of short term (5 s) exposure to humans were also considered. Acidemia and lack of effective respiration were common during or immediately after exposure to CEW's. Author cites another study that indicates that even a 5 s exposure resulted in significant increase in blood lactate in human subjects.</td></tr>
<tr><td colspan="3">COMMENTS + LIMITATIONS:

This is a significant result, and indicates a possible new mechanism for CEW-related death. Uses data from previous experiments (Jauchem 2006, 2008, 2009). It is not known if this mechanism applies to human subjects.</td></tr>
<tr><td colspan="3">AUTHORS ABSTRACT:

Conducted energy weapons (CEWs), such as TASER devices, may be applied to subjects in repeated or long-duration modes. Such applications may result in more potentially harmful effects (as reflected in blood factor changes) than shorter exposures. In this review, results from a number of studies of repeated and long-duration CEW exposures in an animal model are examined. Additionally, a few limited investigations of shorter CEW applications to human subjects are considered. Specifically, in anesthetized swine, increased blood acidity (acidemia) and lack of effective respiration were found to be common during or immediately after CEW exposure. The acidemia could have been due to both metabolic and respiratory acidosis. A relatively rapid recovery toward baseline pH levels occurred. The lack of effective respiration has not been verified in experiments of CEW applications to human subjects; however, in some incidents of human deaths after CEW exposures subjects have been reported to stop breathing immediately after the exposure. It is not known if all human subjects exposed to CEW applications in the field (often ''on drugs'' or ''in excited delirium'') would be able to maintain adequate breathing. Since a limited number of short CEW applications would be less likely to cause adverse effects, however, CEWs can still be a valuable tool for law enforcement activities.</td></tr>
</table>

<table>
<tr><td colspan="2">REFERENCE:

Jauchem JR. An animal model to investigate effectiveness and safety of conducted energy weapons (including TASER devices). J Forensic Sci, 2010; 55(2):521-6</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
n/a</td><td>SUBJECT:
n/a</td><td>MEASUREMENT:
n/a</td></tr>
<tr><td colspan="3">FINDINGS (IN OUR WORDS):

Concludes that pigs are an acceptable model for studying CEW effects on humans.</td></tr>
<tr><td colspan="3">SUMMARY:

In this paper, Jauchem suggests that pigs are an appropriate animal research model to investigate the effectiveness of CEW's based on anatomy, size, performance under certain anaesthetics, assisted breathing during sedation and position. However, the author notes that there are limitations to the model, specifically changes known to occur such as pain, muscle damage or neurological impairment.</td></tr>
<tr><td colspan="3">COMMENTS + LIMITATIONS:

This paper is a useful discussions of the advantages and limits of animal models. Jauchem has written extensively with respect to changes in blood chemistry following Taser emissions.</td></tr>
<tr><td colspan="3">AUTHORS ABSTRACT:

Conducted energy weapons (CEWs) are used by law-enforcement personnel to incapacitate individuals quickly and effectively, without causing lethality. CEWs have been deployed for relatively long or repeated exposures during law-enforcement operations. The purpose of this technical note is to describe, in detail, some aspects of an anesthetized swine model used in our laboratory and to answer specific questions related to the model. In particular, tiletamine/zolazepam-induced, propofol-maintained anesthesia appears to be a useful technique for studying effects of CEW applications on muscle contraction and blood factors such as muscle enzymes. Because effects of CEWs on breathing have not been fully elucidated, a spontaneously breathing model is preferable to one in which mechanical ventilation is supplied. Placement of the swine in a supine position may facilitate measurement of muscle contractions, without compromising other physiological parameters.</td></tr>
</table>

REFERENCE:		**DISCLOSED INTEREST**
Kim PJ, Franklin WH. *Ventricular Fibrillation After Stun-Gun Discharge*. New England Journal of Medicine, 2005; 353(9): 958-959.		None
STIMULATION: Taser	**SUBJECT:** 1 human	**MEASUREMENT:**

FINDINGS (IN OUR WORDS):

Taser caused ventricular fibrillation in a teenager who recovered in hospital after several days.

SUMMARY:

A case report that a Taser caused VF on a human subject. A teenager collapsed after CEW exposure which caused VF. After paramedics administered external defibrillation and medication, the subject teenager recovered in hospital after several days. The authors warned law-enforcement personnel to take extra caution as Taser caused ventricular fibrillation.

COMMENTS + LIMITATIONS:

This is a significant report which indicates that VF following Taser exposure is possible. Unfortunately, many details of the specific case were not given, so it is unclear what risk factors were present for this subject.

AUTHORS SELECTED TEST:

The question of the safety of the use of “stun guns” by law-enforcement agencies has been raised in the news. Deaths after discharges from such devices (Tasers) have been reported, although no definite causative link between death and the use of a stun gun has been made. An adolescent was subdued with a Taser stun gun and subsequently collapsed. Paramedics found the adolescent to be in ventricular fibrillation and began performing cardiopulmonary resuscitation within two minutes after the collapse. After four shocks and the administration of epinephrine, atropine, and lidocaine, a perfusing rhythm was restored. The adolescent made a nearly complete recovery and was discharged from the hospital several days later. This case of ventricular fibrillation after a discharge from a stun gun suggests that the availability of automated external defibrillators to law-enforcement personnel carrying stun guns should be considered.

REFERENCE:			DISCLOSED INTEREST
Levine SD, Sloane CM, Chan TC, Dunford JV, Vilke GM. *Cardiac Monitoring of Human Subjects Exposed to the Taser.* Journal of Emergency Medicine, 2007; 33(2): 113-117.			None
STIMULATION: Taser X26 (0.9-5 s and mean of 3 s)	**SUBJECT:** 105 resting, adult law enforcement officers	**MEASUREMENT:** Changes in cardiac rate, rhythm, ectopy, morphology and conduction intervals.	

FINDINGS (IN OUR WORDS):

Healthy volunteers developed significant increases in their heart rate but without any indications of potential cardiac problems or irregularities.

SUMMARY:

The authors evaluated heart rhythm changes subsequent to Taser exposure on human volunteers. 105 resting and healthy law enforcement officers received a shock to back. The authors measured the changes in cardiac rate, rhythm, ectopy, morphology and conduction intervals of those individuals after a short Taser exposure (0.9 - 5 s). Subjects developed significant increases in their heart rate but without any indications of potential cardiac problems or irregularities.

COMMENTS + LIMITATIONS:

Taser activation time was short (0.9-5 s and mean of 3 s)
Well trained, resting and adult law enforcement officers, where subjects have stress, and may consumed drugs and alcohol.

AUTHORS ABSTRACT:

The Taser® (TASER International, Scottsdale, AZ) is a high-voltage, low-amperage device used by many law enforcement agencies. Our objective in this study was to evaluate for rhythm changes utilizing cardiac monitoring during deployment of the Taser® on volunteers. A prospective, observational study evaluated law enforcement personnel who had continuous electrocardiographic monitoring immediately before, during, and after having a voluntary exposure to the Taser X-26®. Changes in cardiac rate, rhythm, ectopy, morphology, and conduction intervals were measured. A total of 105 subjects were evaluated. The mean shock duration was 3.0 s (range 0.9–5 s). Mean heart rate increased 15 beats/min (95% CI 12.6 –18.3), from 122 beats/min before shock to 137 beats/min immediately after shock. One subject had a single premature ventricular contraction both before and after the shock, but no other subject developed ectopy or dysrhythmia. Poor inter-rater agreement prevented determination of the overall effect of shock on conduction intervals. However, several interpretable tracings demonstrated change in QT duration—either shortening or prolongation after shock. Human subjects exposed to a brief shock from the Taser® developed significant increases in heart rate, but there were no cardiac dysrhythmias or morphologic changes. Alterations in the QT interval were observed in some subjects but their true incidence and clinical significance are unknown.

REFERENCE: Mangus BE, Shen LY, Helmer SD, Maher J, Smith, RS. *Taser and Taser Associated Injuries: A Case Series*. The American Surgeon, 2008; 74(9):862-865.		DISCLOSED INTEREST None
STIMULATION: Taser	**SUBJECT:** 4 patients	**MEASUREMENT:** Medical inspection

FINDINGS (IN OUR WORDS):

Four case reports of patients' injuries from Taser exposure ranging from mild to life-threating.

SUMMARY:

The authors present case reports of four patients injured due to Taser exposure: 1) forehead hematoma and laceration as a result of fall (after being subdued), 2) the Taser probes struck in the head and penetrated the scalp, 3) a concussion, nose laceration, nasal fracture, and orbital floor fracture due to falling down and hitting head, 4) a basilar skull fracture, right subarachnoid hemorrhage, and left-sided epidural hemorrhage from striking head on the pavement.

The authors conclude that Tasers are a mechanism for potential injury and warned trauma surgeons and law enforcement agencies to be aware of the potential danger of significant head injuries as a result of loss of neuromuscular control.

COMMENTS + LIMITATIONS:
n/a

AUTHORS ABSTRACT:

Taser devices were introduced in 1974 and are increasingly used by law enforcement agencies. Taser use theoretically reduces the risk of injury and death by decreasing the use of lethal force. We report a spectrum of injuries sustained by four patients subdued with Taser devices. Injuries identified in our review included: 1) a basilar skull fracture, right subarachnoid hemorrhage, and left-sided epidural hemorrhage necessitating craniotomy; 2) a concussion, facial laceration, comminuted nasal fracture, and orbital floor fracture; 3) penetration of the outer table and cortex of the cranium by a Taser probe with seizure-like activity reported by the officer when the Taser was activated; and 4) a forehead hematoma and laceration. The Taser operator's manual states that these devices are designed to incapacitate a target from a safe distance without causing death or permanent injury. However, individuals may be exposed to the potential for significant injury. These devices represent a new mechanism for potential injury. Trauma surgeons and law enforcement agencies should be aware of the potential danger of significant head injuries as a result of loss of neuronruscular control.

REFERENCE:	**DISCLOSED INTEREST**
Nanthakumar K, Billingsly IM, Masse S, Dorian P, Cameron D, Chauhan, VS, Dowrar E, Sevaptsidis E. *Cardiac Electrophysiological Consequences of Neuromuscular Incapacitating Device Discharges*. Journal of the American College of Cardiology, 2006; 48(4):798-804.	None

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
150 shots from X26. Duration 5 s and 15 s Epinephrine induced stress	6 pigs 45-55 kg	Intracardiac catheters Blood pressure transducers

FINDINGS (IN OUR WORDS):

Almost 80% of thoracic discharges stimulate the heart while non thoracic discharges do not. The X26 was more likely to stimulate the heart than the M26.

SUMMARY:

The authors sought to evaluate the cardiac consequences of CEW's in an experimental model (pigs). 74 of 94 thoracic discharges stimulated the myocardium. None of the 56 non-thoracic discharges stimulated the myocardium. One conclusion of this study suggests a particular risk for individuals with pre-existing heart disease. The authors also conclude that arrhythmias are not a cause of death when the vector of discharge was not across the heart.

COMMENTS + LIMITATIONS:

Authors such as Ho have urged caution in interpreting the results of this experiment because of the use of ephinephrine which by itself can stimulate the heart. Nanthakumal *et al* have concluded that the structural variation in the chest wall anatomy of pigs is a limitation in extrapolating their animal model to humans.

AUTHORS' ABSTRACT:

Objectives: The purpose of this study was to evaluate the cardiac consequences of neuromuscular incapacitating device (NID)/stun gun discharge in an experimental model. Background:The large-voltage electrical discharges from NIDs have been suggested to pose a risk for triggering cardiac arrhythmias. Methods: Intracardiac catheters and blood pressure transducers were inserted before the application of NID discharges in six anesthetized pigs. Two different commercially available models (NID-1 and NID-2), two different vectors of discharges (thoracic: parallel to the long axis of the heart on the chest wall, and nonthoracic: away from the chest, across the abdomen), and two different durations of discharge (5 and 15 s) were tested. The effect of simulated adrenergic stress using epinephrine was also evaluated. Results: We studied a total of 150 discharges to 6 pigs; 74 of these discharges resulted in stimulation of the myocardium, as documented by electrical capture (mean ventricular rate during stimulation and capture, 324 ± 66 beats/min). Of the 94 thoracic discharges, 74 stimulated the myocardium, compared with none from 56 nonthoracic discharges ($p < 0.0001$). During 16 discharges with epinephrine, there were 13 episodes of stimulation of the myocardium, of which 1 induced ventricular fibrillation and 1 caused ventricular tachycardia. Thoracic discharges from NID-1 were more likely to stimulate the myocardium than those from NID-2 (98% vs. 54%, $p < 0.0007$). CONCLUSIONS In an experimental model, NID discharges across the chest can produce cardiac stimulation at high rates. This study suggests that NIDs may have cardiac risks that require further investigation in humans.

REFERENCE: Nanthakumar K, Masse S, Umapathy K, Dorian P, Sevaptsidis E, Wasman M. *Cardiac Stimulation With High Voltage Discharge from Stun Guns*. Canadian Medical Association Journal, 2008; 178(11): 1451-1457		**DISCLOSED INTEREST** None
STIMULATION: 150 discharges of X26 and M26	**SUBJECT:** 6 pigs	**MEASUREMENT:** Intracardiac ECG

FINDINGS (IN OUR WORDS):

Taser discharges on the chest can cause heart stimulation while non-chest placement does not. With epinephrine, one case of VF was seen.

SUMMARY:

Six pigs were stimulated with 150 discharges from X26 and M26 Tasers while ECG measurements were made to determine changes in cardiac rhythm. Nearly 80% of the shocks to the chest stimulated the heart while no non-chest shots did so. An additional 13 discharges involved pigs under stimulation from large doses of epinephrine (to simulate adrenalin). The threshold of stimulation for the myocardium was 50 mA over 50 microseconds**.** The authors conclude that the longer the discharge, the greater the ability to stimulate the heart.

COMMENTS + LIMITATIONS:

This is one of two articles from the same experimental investigation. *Cardiac Electrophysiological Consequences of Neuromuscular Incapacitating Device Discharges*.(2005) Although the authors refer to the Lakkireddy and Dennis pig studies, they indicate that the lack of human studies limits their ability to determine how much energy it takes to stimulate the human heart**.**

AUTHORS ABSTRACT:

The ability of an electrical discharge to stimulate the heart depends on the duration of the pulse, the voltage and the current density that reaches the heart. Stun guns deliver very short electrical pulses with minimal amount of current at high voltages. We discuss external stimulation of the heart by high voltage discharges and review studies that have evaluated the potential of stun guns to stimulate cardiac muscle. Despite theoretical analyses and animal studies which suggest that stun guns cannot and do not affect the heart, 3 independent investigators have shown cardiac stimulation by stun guns. Additional research studies involving people are needed to resolve the conflicting theoretical and experimental findings and to aid in the design of stun guns that are unable to stimulate the heart.

REFERENCE: Ng W, Chehade M**.** *Taser Penetrating Ocular Injury*. American Journal of Ophthalmology, 2005; 139(4): 713-715.		**DISCLOSED INTEREST** None
STIMULATION: Taser X 26	**SUBJECT:** man (age 50)	**MEASUREMENT**: CT

FINDINGS (IN OUR WORDS):

A case report describing Taser barb penetrating ocular injury.

SUMMARY:

In this case report, authors investigated 50-year-old man who had ocular injury due to Taser barb penetration. After CT scan performed to show the location of the barb, patient had surgery under general anesthesia. One week after the injury, the eye felt comfortable. The suggested that the removal of the Taser should be performed in an operating theater under general anesthesia.

COMMENTS + LIMITATIONS:

One of several reports on Taser related eye injuries.

AUTHORS ABSTRACT:

Purpose: To describe the presentation and treatment of a Taser penetrating ocular injury.
Design: Case report. METHODS: A 50-year-old man with a Taser injury 1.5 cm below the right lower eyelid margin was admitted to the emergency department of a tertiary hospital. The case report describes the ophthalmic assessment, investigation, treatment, and outcome of the Taser barb penetrating ocular injury.
Results: The Taser has a fish hook barb that caused a full-thickness wound adequately large for vitreous to escape when the Taser was removed. Consequently, the scleral wound was repaired and cryopexy was performed. The affected eye made a satisfactory recovery, and the visual acuity was 6/9 with a pinhole 1 week after operation.
Conclusions: Any Taser injury around the orbits should raise the suspicion of a penetrating ocular injury. In likely cases, removal of the Taser should be performed in an operating theatre under general anaesthesia.

REFERENCE : Reilly JP, Diament A, Comeaux J. *Dosimetry considerations for electrical stun guns.* Phys. Med. Biol, 2009; 54:1319–1335		**DISCLOSED INTEREST** None
STIMULATION: M26, X26, Sticky Shocker, Taser Tron	**SUBJECT:** SENN nerve model	**MEASUREMENT:** Simulation model

FINDINGS (IN OUR WORDS):

The authors define a new factor, $F_{T,}$ which characterizes the stimulating capabilities of CEW's.

SUMMARY:

Authors develop a numerical model by which the stimulating capacities of weapons can be measured. Based on a nerve stimulation model, a parameter, F_T ,as a ratio of a weapon's stimulating ability is established. CEWs produce levels of energy well above the excitation threshold. (98.6 µC vs 0.9938 µC for a 400 Ω load. X26 is more effective than the M26 in stimulating nerve models. Waveforms from the M26, X26, Sticky Shocker and TaserTron were measured and tested against a reference. F_T relative values are similar to the charge within the largest phase of the current versus time.

COMMENTS + LIMITATIONS:

This may be a very useful way to compare the relative effects of differet CEW waveforms. Pain thresholds are 100 x less than the energy delivered by a Taser. This model only considers nerve and not muscle or cardiac fiber.

AUTHORS ABSTRACT:

Electrical dosimetry issues are discussed in relation to electrical stun devices (ESDs). A measure of effectiveness is based on a 'threshold factor,' FT, calculated with a myelinated nerve model that simulates stimulation of a reference-case neuron (20 µm diameter, 1 cm distant). Several ESDs were measured in the laboratory using resistive loads of 100–1000 Ω; some included air gaps bridged via an electric arc. Conducted current waveform parameters and the associated threshold factors depend on the resistance of the load. Thresholds were also determined for ideal monophasic and biphasic square wave stimuli, and compared with measured ESD waveforms. Although F_T is proposed as a metric of strength, an approximate surrogate is the charge within the largest phase of the current versus time waveform. The approximation is reasonably accurate for monophasic waveforms with phase durations below about 100 µs, and for charge-balanced biphasic square-wave stimuli with phase durations between about 40 and 100 µs.

<table>
<tr><td colspan="2">REFERENCE:

Richards KA, Kleuser PL, Kluger J. Fortuitous Therapeutic Effect of Taser Shock for a Patient in Atrial fibrillation. Annals of Emergency Medicine, 2008; 52(6):686-688.</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
X26 upper left chest drive stun</td><td>SUBJECT:
28 year old male</td><td>MEASUREMENT:
Urinary catheter</td></tr>
<tr><td colspan="3">FINDINGS (IN OUR WORDS):

Case report of patient where Taser stimulations resulted in defibrillation</td></tr>
<tr><td colspan="3">SUMMARY:

A patient was being treated for hypothermia and irregular heart rhythm in ER after 40 hours in a lake. He became upset and combative, ripped out the electrodes and went into atrial fibrillation. Security and the police were called to restrain the patient. A single shot in drive stun was applied to the upper left chest. A regular heartbeat was restored although at an elevated rate.</td></tr>
<tr><td colspan="3">COMMENTS + LIMITATIONS:
This is a case report of one patient, but it does suggest that the CEW stimulation is sufficiently strong to have a defibrillating effect on the heart.</td></tr>
<tr><td colspan="3">AUTHORS ABSTRACT:

Neuromuscular incapacitating devices are used by law enforcement and military forces worldwide. The most frequently used of these devices are from Taser International. Although they are regarded as a less than lethal alternative, there has been several case reports aimed at linking the potential causal relationship of a shock from a neuromuscular incapacitating device and sudden cardiac death caused by induced ventricular tachycardia or ventricular fibrillation. In this report, we describe the first known account in which a neuromuscular incapacitating device had a temporal relationship to a more positive therapeutic outcome for a patient.</td></tr>
</table>

REFERENCE:		**DISCLOSED INTEREST**
Schmiederer B, Du Chesne A, Schmidt PF, Brinkmann B. , *Specific Traces in Stun Gun Deployment.* International Journal of Legal Medicine, 2005; 119(4): 207-212.		none
STIMULATION: Electric shocking devices (ESD) / Stun guns - Power 200,	**SUBJECT:** human skin samples, as well as the clothing fabrics cotton, wool, silk, nylon, jeans material, and leather	**MEASUREMENT:** scanning electron microscopy (SEM) and energy dispersive X-ray spectrometer (EDS)

FINDINGS (IN OUR WORDS):

Forensic evidence is described on skin and clothing that can characterize the CEW weapon used.

SUMMARY:

The authors of the paper investigated the after-effects of firing a stun gun based on various factors such as time duration, distance from target, and bare skin vs clothing as target surface. They performed a serious of 250 tests on surfaces such as human skin samples, as well as the clothing fabrics cotton, wool, silk, nylon, jeans material, and leather.

The authors found the presence of metallic deposits corresponding to the electrodes of the device used based on the examination with SEM, the association of longer duration of firing with a larger number of metallic deposits, and the indication of the type of device used and its current status through elemental composition.

COMMENTS + LIMITATIONS:

AUTHORS ABSTRACT:

Stun guns are electric shocking devices that can be deployed as defensive or offensive weapons. The aim of this study was the identification of several types of trace evidence for corroborating deployment and providing clues to the weapon actually used. In a series of some 250 tests, the after-effects of firing a stun gun were studied under the differential influence of factors, such as time duration, distance from target, and bare skin vs clothing as target surface. Examination with scanning electron microscopy (SEM) and energy dispersive X-ray spectrometer (EDS) demonstrated the presence of metallic deposits corresponding to the electrodes of the device used. The observed differences in the number of these pellets were related to the length of deployment in seconds and to the distance of the weapon from the target surface. Longer duration of firing was consistently associated with a larger number of metallic deposits. Elemental composition of the latter provided clues to the type of device used and its current status in terms of wear and tear. Further trace evidence we examined included craters on the target surface and their pattern of dissemination on human skin, textiles, and leather. It is concluded that the use of carbon tabs for examination with SEM/EDS offers a practicable method for collecting trace material following stun gun deployment. Important groups of trace evidence do exist, and their collection and examination appear feasible.

REFERENCE: Sloane CM, Chan CT, Vilke GM. *Thoracic Spine Compression Fracture After TASER Activation.* Journal of Emergency Medicine, 2008; 34(3): 283-285.			**DISCLOSED INTEREST** None
STIMULATION: Taser X26 (5 second)	**SUBJECT:** 1 healthy officer	**MEASUREMENT:** magnetic resonance imaging scan	
FINDINGS (IN OUR WORDS): Review of spiral compression fracture in one police officer following Taser exposure.			
SUMMARY: A case study of thoracic spine compression fracture caused by Taser exposure. During Taser training, one officer was shot with a standard Taser for 5 seconds in the back. He did not fall before or after the exposure to the Taser, but he experienced a severe thoracic back pain immediately. Doctors accessed him using magnetic resonance imaging scan and they confirmed an acute compression fracture resulted from Taser exposure, as he did not have any medical back problems previously.			
COMMENTS + LIMITATIONS: Other similar cases have been reported. Winslow JE. *Thoracic Compression Fractures as a Result of Shock From a Conducted Energy Weapon: A Case Report*. Annals of Emergency Medicine, 2007 50(5): p. 584-586.”			
AUTHORS ABSTRACT: The TASER is a less lethal weapon seeing increased use by police jurisdictions across the country. As a result, subjects of TASER use are being seen with increasing frequency in emergency departments across the country. The potential injury patterns of the device are important for emergency physicians to understand. This report describes the case of an officer who complained of back pain after a single 5-s TASER discharge during a routine training exercise. Subsequent evaluation led to the diagnosis of an acute thoracic vertebral compression fracture. We discuss the potential mechanisms of injury in this case. Because we were unable to find any cases like this in our review of TASER-related injuries, we liken it to compression fractures that have been documented after seizures. We recommend that physicians consider obtaining back radiographs to rule out a vertebral compression fracture in any individual who has sustained a TASER discharge and has ongoing or persistent back pain.			

REFERENCE: Stratton SJ, Rogers C, Brickett K, Ginger Gruzinsk G. *Factors associated with sudden death of individuals requiring restraint for excited delirium.* Am J Emerg Med, 2001; 19(3):187–191.			**DISCLOSED INTEREST**: none
STIMULATION: choke hold, taser device, or capsicum spray Physically restrained	**SUBJECT**: 18 excited delirium sudden deaths	**MEASUREMENT:** EMS – Emergency Medical Service personnel	

FINDINGS (IN OUR WORDS):

Risk factors in 18 excited delirium sudden deaths after struggle and physical restraint were: stimulant drug use (78%), established disease states (56%), obesity (56%), capsicum spray (33%), and Taser (28%).

SUMMARY:

The authors investigated 18 excited delirium sudden deaths after struggle and physical restraint in order to identify and rank factors associated with sudden death of these individuals (between December 1992 to December 1998). They listed factors that have been identified as associated with death from excited delirium when restrained based on the information provided by emergency medical service (EMS). The factors include death attributable to stimulant drug toxicity (both acute and chronic effects), restraint asphyxia, and death secondary to underlying heart or other chronic disease. Frequently associated with sudden death of restrained excited delirium victims included a) evidence for forceful struggle (100%), b) stimulant drug use (78%), c) established natural disease states (56%), and d) obesity (56%). There was low association for capsicum spray and the Taser device, which were used in 33% and 28% of cases.

COMMENTS + LIMITATIONS:

The data collected did not allow for reliable assessment for the presence of hyperthermia as a potential factor for sudden death. Limited study size – 18 records. The 100% rate for “forceful struggle” is a direct consequence of the inclusion criterion.

AUTHORS ABSTRACT:

The purpose of this article is to identify and rank factors associated with sudden death of individuals requiring restraint for excited delirium. Eighteen cases of such deaths witnessed by emergency medical service (EMS) personnel are reported. The 18 cases reported were restrained with the wrists and ankles bound and attached behind the back. This restraint technique was also used for all 196 surviving excited delirium victims encountered during the study period. Unique to these data is a description of the initial cardiopulmonary arrest rhythm in 72% of the sudden death cases. Associated with all sudden death cases was struggle by the victim with forced restraint and cessation of struggling with labored or agonal breathing immediately before cardiopulmonary arrest. Also associated were stimulant drug use (78%), chronic disease (56%), and obesity (56%). The primary cardiac arrest rhythm of ventricular tachycardia was found in 1 of 13 victims with confirmed initial cardiac rhythms, with none found in ventricular fibrillation. Our findings indicate that unexpected sudden death when excited delirium victims are restrained in the out-of-hospital setting is not infrequent and can be associated with multiple predictable but usually uncontrollable factors.

REFERENCE:	**DISCLOSED INTEREST**
Sloane CM, Chan TC, Levine SD, Dunford JV, Neuman T, Vilke GM. *Serum Troponin I Measurement of Subjects Exposed to the Taser X-26*. Journal of Emergency Medicine, 2008; 35(1): 29-32.	None

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
Taser X-26 (mean shock duration of 4.36 s)	Human (66 people)	Blood chemical measurements.

FINDINGS (IN OUR WORDS):

Healthy volunteers exposed to a single Taser shock did not show blood chemical evidence of cardiac damage after 6 hours.

SUMMARY:

The authors of the paper investigated serum troponin I level in humans in order to identify myocardial necrosis or any other cardiac damage as a result of Taser deployment. 66 healthy law enforcement trainees were exposed Taser for maximum of 5 s. After 6 hours of CED application, the volunteers' blood (5-mL of venous blood sample) was obtained and analyzed. The test results showed that serum troponin I levels were lower than threshold level in all subjects 6 hours after the Taser shock, which indicates no cardiac damage on healthy subjects due to the Taser application.

COMMENTS + LIMITATIONS:

Healthy Law enforcement trainees were the subjects, whereas deaths from Taser activation were associated with unhealthy and illicit drug users. A single Taser shock with a mean duration of 4.36 s Only 6 hours after shock analysis may not be enough, analysis at different times is needed.

AUTHORS ABSTRACT:

The Taser is a high-voltage, low-amperage conducted energy device used by many law enforcement agencies as a less lethal force weapon. The objective of this study was to evaluate for a rise in serum troponin I level after deployment of the Taser on law enforcement training volunteers. A prospective, observational cohort study was performed evaluating serum troponin I levels in human subjects 6 h after an exposure to the Taser X-26. Outcome measures included abnormal elevation in serum troponin I level (> 0.2 ng/mL). There were 66 subjects evaluated. The mean shock duration was 4.36 s (range 1.2-5 s). None of the subjects had a positive troponin I level 6 h after exposure. It was concluded that human volunteers exposed to a single shock from the Taser did not develop an abnormal serum troponin I level 6 h after shock, suggesting that there was no myocardial necrosis or infarction.

<table>
<tr><td colspan="3">REFERENCE:

Strote J, Hutson HR. TASER use in restraint-related deaths. Prehosp Emerg Care, 2006; 10:447–50.</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
Taser</td><td>SUBJECT:
Men (age 18 to 50, 75 deaths with 37 available autopsy reports)</td><td colspan="2">MEASUREMENT:
autopsy reports</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

Based on the autopsy reports of deaths, Taser was considered a potential or contributory cause of death in 27% of cases.</td></tr>
<tr><td colspan="4">SUMMARY:

Authors investigated Taser-related deaths from the autopsy reports of patients who died after application of a Taser. They identified 75 male deaths (age 18 to 50) - with 37 available autopsy reports in which the time of death was occurred less than 24 hours from Taser use. Based on autopsy reports: a) Cardiovascular disease: 54.1%, b) Illegal substance use: 78.4% (found on toxicology screening, within that group, 86.2% were found to have been using stimulants), c) A diagnosis of excited delirium (75.7%), d) Taser: 27% (considered a potential or contributory cause of death).</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

Objective: The Taser is an electric weapon capable of releasing significant amounts of electricity in rapid pulses, causing uncontrollable muscle contraction. Use of this weapon has dramatically increased over the past decade, and it is now commonly used by law enforcement officers nationwide. Emergency medical services providers are, likewise, seeing more patients who have recently been subjected to application of a Taser. We examined the autopsy reports of patients who died after application of a Taser in an attempt to identify high-risk interactions.
Methods: This is a case series of Taser-related deaths. Fatalities occurring over four years beginning in January 2001 were identified through an Internet search, and autopsy reports were requested. Reports were analyzed for patient demographics, preexisting cardiac disease, toxicology, evidence of excited delirium; restraint techniques used, and listed cause of death.
Results: Of 75 cases identified, 37 (49.3%) had autopsy reports available for review. All cases involved men, with ages ranging from 18 to 50 years. Cardiovascular disease was found in 54.1%. Illegal substance use was found on toxicology screening for 78.4%; within that group, 86.2% were found to have been using stimulants. A diagnosis of excited delirium was given for 75.7% of the cases. Use of a Taser was considered a potential or contributory cause of death in 27%.
Conclusions: This is the largest review of Taser-related fatalities reported in the medical literature. The findings are consistent with prior studies, suggesting a high frequency of restraint-related and excited delirium-related fatalities.</td></tr>
</table>

REFERENCE:		DISCLOSED INTEREST
Strote J, Campbell R, Pease J, Hamman MS, Hutson R. *The role of tasers in police restraint-related deaths*, Annals of Emergency Medicine, 2005; 46(3):S85		none
STIMULATION: Taser	**SUBJECT:** Human (30 male cases with autopsy reports, mean patient age of 35.8)	**MEASUREMENT:** autopsy reports

FINDINGS (IN OUR WORDS):

Taser-related deaths appear to occur in situations similar to other police restraint-related deaths.

SUMMARY:

Authors of this paper investigated 30 cases Taser-related deaths occurred within one hour period from Taser injury to death. They analyzed data for demographic and pre-existing cardiac disease patterns, position during restraint, presence of excited delirium, injury patterns, reported cause of death, and toxicology findings. 13 (46%) autopsies mentioned restraint; 26 individuals (87%) sustained injuries on the torso. Other important findings are 76.6% (23) with excited delirium diagnosis, 43.3% (13) consumed stimulants – cocaine, coronary artery disease 16.7% (5), cardiac arrest 36.7% (11), stimulant intoxication 40% (12).

COMMENTS + LIMITATIONS:

AUTHORS ABSTRACT:

Methods: Descriptive study of deaths occurring in police custody and associated with Taser use between January 2001 and January 2005. Cases were identified through Google search; letters were sent to the respective coroners requesting autopsy reports.Data were analyzed for demographic and pre-existing cardiac disease patterns, position during restraint, presence of excited delirium, injury patterns, reported cause of death, and toxicology findings.
Results: Autopsy reports for 41 of 75 identified cases (55%) of Taser-related deaths were received; of these, 11 (27%) were excluded for obvious alternate causes of death or a greater than one hour period from Taser injury to death, leaving 30 cases. The mean patient age was 35.8 with a range of 18-50. All patients were male. Sixteen (53%) were white; 10 (33.3%) were black; and 4 (13%) were Hispanic. Only 13 (46%) autopsies mentioned restraint: of those, one involved prone restraint and two used a “choke hold”; the rest involved cuffs only. The mean number of Taser injuries was three with a range of two to eight; 26 individuals (87%) sustained injuries on the torso.
Conclusions: Taser-related deaths appear to occur in situations similar to other police restraint-related deaths. It remains unclear if the physiologic states associated with stimulant toxicity and excited delirium may increase cardiac muscle excitability and make Taser discharge more likely to induce fatal arrhythmias.

<table>
<tr><td colspan="3">REFERENCE:

Sun H. Models of Ventricular Fibrillation Probability and Neuromuscular Stimulation After Taser® Use in Humans in Electrical Engineering. 2007, University of Wisconsin: Madison, WI. p. 239. Ph.D thesis.</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
X26 & M26</td><td>SUBJECT:
Computer model</td><td colspan="2">MEASUREMENT: Computer models were used to estimate current density in the human torso using data derived from two pig studies.</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

Based on computer models using data from pig studies, the probability of VF in humans was less than 0.1 ± 0.2% for a dart to heart distance of 10 mm.</td></tr>
<tr><td colspan="4">SUMMARY:

Computer models were used to investigate the human ventricular fibrillation probability after Taser use. Computer models are based on finite element models (FEM) of the torso using data from the two pig studies obtained by Wu et al (2008). VF probability for a given dart location decreased with the dart to heart horizontal distance (radius) on the skin surface with a maximum dangerous radius of 53.3 mm.</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

Computer models were created to estimate the ventricular fibrillation (VF) probability and motor nerve stimulation on humans directly caused by the Taser® X26, given the data of pig VF darttoheart distances, minimum human skin to heart distance and human dart landing statistics. The human VF threshold for short duration electrical stimulation was not available and difficult to directly measure. Thus, finite element (FE) models were used to compute the current distribution to determine the human VF threshold, assuming the pigs and humans have the same VF dart-to-heart threshold distances. Based on the cell stimulation strength–duration curves derived from the resistor–capacitor (RC) cell membrane model, the stimulation caused by short duration pulses of Tasers® is governed by the charge density or electric field times duration threshold. For the same Taser® waveform, dangerous dart locations were determined by comparing current density on the heart caused by the dart and threshold current density. The accuracy of FE models was validated by a selfconvergence test and by comparing with those obtained by other methods such as analytical equations. Under certain assumptions, the human VF probability had an estimated mean and standard deviation (SD) of about 0.0008 and 0.002 using resected chest wall pig study data (pig study #1); and about 0.000015 and 0.00014 using blunt probe pig study data (pig study #2). The mean of the human VF probability was statistically significantly greater than zero using each pig study data. VF probability for a given dart location decreased with the darttoheart horizontal distance (radius) on the skin surface. Under certain assumptions, the dangerous radius had a mean, maximum and SD of about 7.9 mm, 53.2 mm and 12.5 mm using pig study #1; and about 0.18 mm, 17.3 mm and 1.4 mm using pig study #2. Details of assumptions and limitations under which these results hold were provided in the thesis. The work is transferable to other Tasers® or other electromuscular incapacitating devices with similar short duration low duty cycle pulses. Necessary, but not sufficient, conditions for direct electrocution of the heart by the Taser® are (1) dart landing in a small frontal region over the heart suggested by our results, and (2) cardiac arrest of the subject</td></tr>
</table>

shortly after Taser® firing suggested by the literature. Coroners should seek to confirm these conditions before ascribing Tasers® as a contributing cause of death. These observations suggest that Taser® training should be done on the back, thus avoiding the frontal region over the heart and decreasing the risk. The nerve stimulation was examined by using a threshold found in the literature for electric field times duration (Et)min of approximately 2.98×10^{-3} (V×s/m). Using a single coarse mesh finite element model, it was found that roughly regions farther than 19 cm away from the darts are not stimulated. Keeping the inserted current constant, the single coarse mesh FE model also suggested that the current density at the heart for dart separation of less than 10 cm was less than the values for larger dart separation.

REFERENCE:			**DISCLOSED INTEREST**
Sun H, Webster JG. *Estimating neuromuscular stimulation within the human torso with Taser stimulus.* Physics In Medicine and Biology, 2007; 52(21): 6401-6411.			None
STIMULATION: Dart model (Taser X-26)	**SUBJECT:** Utah 3D mesh	**MEASUREMENT:** finite element model, computer model	

FINDINGS (IN OUR WORDS):

Computer model shows nerves are stimulated up to 19 cm from darts.

SUMMARY:

The authors built a finite element model of the human torso model and attached electrodes.
They observed that a) Current density values on the heart element increased with the larger dart separation, b) When the darts were close together current penetrated less deeply, c) Nerves at a distance greater than 19 cm from the dart were not stimulated.

COMMENTS + LIMITATIONS:

This is a FEM Model based study, based on a fairly coarse mesh was used due to computer memory limitations. Another model limitation is the assumptions that different tissues were isotropic. It is unclear whether these assumptions create any significant errors.

AUTHORS SELECTED TEXT:

Designers of electromuscular incapacitation devices need to know efficacy. Which areas of nerve and muscle are stimulated and are these areas adequate to cause incapacitation? This paper focuses on efficacy, which used a torso-sized finite element model with a mesh of about 5 mm. To estimate the neuromuscular regions stimulated by the Taser® X26, calculations of electric current density and field strength values with 1 A inserted into the torso using the Utah 3D mesh were made. Field-times-duration values for given Taser stimulation were calculated. Then the region where the motor nerve was stimulated by the Taser was estimated by using a field-times-duration threshold from Reilly (1998 Applied Bioelectricity: From Electrical Stimulation to Electropathology (New York: Springer)). Neuromuscular stimulation occurred up to about 19 cm away from the darts and included the spinal cord. The current density at the heart for dart separation less than 10 cm was smaller than for larger dart separation. Users of finite element computer models will find information for torso models and their creation, meshing and operation.

REFERENCE: VanMeenen K, Cherniak MN, Bergen M, Gleason L, Teichman R, Servatius R. *Cardiovascular Evaluation of Electronic Control Device Exposure in Law Enforcement Trainees: A Multi-site Study*. Journal of Emergency Medicine, 2010; 52(2):197-201.	**DISCLOSED INTEREST** None

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
2s, 3s, and 5 s of X-26	118 healthy police officers	12 lead ECG and blood chemistry before and after the exposure

FINDINGS (IN OUR WORDS):

Volunteers exposed to Taser emissions showed no changes in heart rhythm or cardiac or skeletal muscle 24 hours later.

SUMMARY:

This study determined the potential health risks of exposure to Taser discharges during training sessions. 118 police officers were exposed to X26 Tasers. 24 hours later ECG and blood samples were taken. No change in ECG morphology or evidence of cardiac or skeletal muscle breakdown was seen. This was a mixed group (M/F) at 7 different locations in the US. The group was mostly healthy with small numbers indicating respiratory illness (17% of the group), pre-existing abnormality as determined by the ECG, high blood pressure (3%). 91% of the group had normal ECG readings pre- and post exposure. 9% showed abnormalities at both time (all men).

COMMENTS + LIMITATIONS:

This is the most recent study of effects on humans that we have reviewed. All exposures took place on the back of the body. Exposures were delivered by darts or aligator clips attached to clothing.

AUTHORS ABSTRACT:

Objective: Occupational health risk with regard to training exercises is a relatively under studied domain for law enforcement officers. One potential health risk is exposure to electronic control devices (ECD's).

Methods: Seven different training facilities in six states participated. Law enforcement trainees (N = 118) were exposed to Taser International's (Scottsdale, AZ) X26® for up to 5 s.

Results: There was no evidence of cardiac or skeletal muscle breakdown. Exposure did not adversely affect electrocardiogram (ECG) morphology obtained 24 hours after exposure in 99 trainees. For two trainees with preexisting ECG abnormalities, ECG morphology different in the post-ECD samples.

Conclusions: The results from this large, multisite study suggest that, for most trainees, ECD exposure does not represent a signficant health risk. Further investigation is warranted for cardiac vulnerability and potential interactions with ECD exposure.

REFERENCE:			DISCLOSED INTEREST
Vilke, Gary M. *Less Lethal Technology: Medical Issues.* Policing: An International Journal of Police Strategies and Management, 2007; 30(3):341-357.			None
STIMULATION:	**SUBJECT:**	**MEASUREMENT:**	
Blunt projectiles, irritant sprays and conductive energy devices (CEDs)	reviewing case reports, animal research and human	Various types of blood, cardiac and respiratory monitoring	

FINDINGS (IN OUR WORDS):

The review paper found no evidence to support a causal link between CEWs and in-custody deaths.

SUMMARY:

The authors reviewed the medical aspects and implications of three less-lethal weapons such as blunt projectiles (baton or asp), oleoresin capsicum (OC) spray and CEDs (Taser). The paper discussed the issues of sudden in-custody death and less lethal weapons, reviewing case reports, animal research and human investigative. Various research dealing with experiments swine to human as well as various types of blood, cardiac and respiratory monitoring were reviewed. They found no evidence to support a causal link between CEDs and the incidence of in-custody deaths.

COMMENTS + LIMITATIONS:

The authors note that effects of CEDs on neurological functions are unknown, there may be risks to with subjects with pacemakers or underlying cardiac disease, uncertainty still predominates with respect to prolonged or recurrent applications.

AUTHORS ABSTRACT:

Purpose: Less lethal weapons have become a critical tool for law enforcement when confronting dangerous, combative individuals in the field. The purpose of this paper is to review the medical aspects and implications of three different types of less lethal weapons. Methodology/approach: The paper conducted a comprehensive medical literature review on blunt projectiles, irritant sprays including oleoresin capsicum (OC), and conducted energy devices such as the Taser. It reviews the history, mechanisms of action, intended and other physiologic effects, and medical safety risks and precautions of these devices. In particular, the paper focuses on the issue of sudden in-custody death and less lethal weapons, reviewing case reports, animal research and human investigative studies on this topic. Findings – In general, these three different types of less lethal weapons have been effective for their intended use. Each type of less lethal weapon has a number of physiologic effects and specific medical issues that must be considered when the weapon is used. There is no clear evidence that these devices are inherently lethal, nor is there good evidence to suggest a causal link between sudden in-custody death and the use of irritant sprays or conducted energy devices. Originality/value – While further research on the physiologic effects of these devices is needed, this paper provides law enforcement with a medical review of less lethal weapons including blunt projectiles, irritant sprays such as OC, and conducted energy devices such as the Taser.

REFERENCE:	**DISCLOSED INTEREST**
Vilke GM, Sloane C, Levine S, Neuman T, Castillo C, Chan TC. *Twelve-lead Electrocardiogram Monitoring of Subjects Before and After Voluntary Exposure to the Taser X26*. American Journal of Emergency Medicine, 2008; 26(1): 1-4.	None

STIMULTAION:	**SUBJECT:**	**MEASUREMENT:**
Taser X26 (1 to 5 s)	32 Healthy volunteers	12-lead electrocardiogram

FINDINGS (IN OUR WORDS):

Healthy volunteers receiving Taser show a significant increase in Heart Rate, but no cardiac dysrhythmia.

SUMMARY:

Authors evaluated cardiac rhythm changes on 32 healthy volunteers receiving a Taser X26 discharge. Their cardiac activities (i.e. changes in cardiac rhythm, morphology and interval duration) were monitored with 12-lead electrocardiogram (ECG) before and within 1 minute after the Taser stimulation. The authors observed a significant increase in the heart rate of subjects receiving Taser discharge, but they reported that there was no cardiac dysrhythmia, and indicated the safety of Taser for healthy subjects in their test scenario.

COMMENTS + LIMITATIONS:

This study focuses on healthy people and relatively short CEW exposures.

AUTHORS ABSTRACT:

Objectives: The Taser (Taser International, Scottsdale, Ariz) uses high-voltage electricity to incapacitate subjects. We sought to evaluate cardiac rhythm changes during deployment of the Taser on healthy volunteers.
Methods: This prospective study was performed on 32 healthy volunteer subjects receiving a Taser X26 discharge. The subjects had baseline 12-lead electrocardiogram (ECG) monitoring performed immediately before and within 1 minute after the Taser discharge. Changes in cardiac rhythm, morphology, and interval duration were evaluated. Descriptive statistics and paired-sample t test comparisons are reported.
Results: All 32 subjects had an interpretable 12-lead ECG obtained before and after the Taser activation, although 1 subject's post–PR interval could not be determined. The mean age and body mass index were 33 years and 26.5 kg/m2, respectively. Overall, there was a significant increase in heart rate (2.4; 95% confidence interval [CI], 0.0-4.9) and a decrease in PR interval (-6.5; 95% CI, -9.7 to -3.3). When stratified by sex, only the PR interval in men significantly decreased (-5.9; 95% CI, -9.2 to -2.5). There were significant changes in heart rate (4.0; 95% CI, 1.3-6.7), PR interval (-6.0; 95% CI, -11.3 to -0.7), and QT interval (-18.8; 95% CI, -33.2 to -4.3) among those with a normal body mass index, and in PR interval among those who were overweight/obese (-6.7; 95% CI, -10.8 to -2.5). None of the statistically significant differences between ECG measures were clinically relevant.
Conclusions: There were no cardiac dysrhythmia and interval or morphology changes in subjects who received a Taser discharge based on a 12-lead ECG performed immediately before and within 1 minute after a Taser activation.

REFERENCE:			DISCLOSED INTEREST
Vilke GM, Sloane CM, Bouton KD. *Physiological effects of a conducted electrical weapon on human subjects.* Ann Emerg Med, 2007; 50:569–75.			None
STIMULATION: Taser X26 (5 second)	**SUBJECT:** 32 healthy police officers	**MEASUREMENT:** Blood pressure, pulse rate, pulse oximetry (oxygen saturation), ventilator measures, blood electrolyte measures	

FINDINGS (IN OUR WORDS):

Healthy voluteers show no important changes in respiratory, cardiac or electrolyte status after a single 5-second Taser exposure.

SUMMARY:

The authors investigated the extent of physiologic stress, metabolic and ventilator effects after exposure to the Taser X26. They monitored cardiorespiratory and blood characteristics in 32 police officer volunteers (18-60 years of age) before, during and after a 5-second Taser exposure. The observations were that a) minute ventilation, tidal volume, and RR increased, b) Pulse and systolic blood pressure were higher before Taser exposure than at anytime afterward, c) Blood lactate increased and pH and bicarbonate decreased, returning to baseline at 30 minutes, d) All troponin I values were normal and there were no EKG changes, e) Ventilation was not interrupted and there was no hypoxemia or hypercarbia. They did not observe clinically important changes in their respiratory, cardiac, or electrolyte status after a single 5-second Taser exposure.

COMMENTS + LIMITATIONS:

Taser was tested on healthy volunteers (police officers), using 5 second of Taser stimulation. The higher pulse rate before Taser exposure is surprising. 42 officers were participated, but 10 of them were screened out because of high blood pressure, abnormal ECG or cardiac medication.

AUTHORS ABSTRACT:

Study objective: Sudden death after a conducted electrical weapon exposure has not been well studied. We examine the effects of a single Taser exposure on markers of physiologic stress in healthy humans. Methods: This is a prospective trial investigating the effects of a single Taser exposure. As part of their police training, 32 healthy law enforcement officers received a 5-second Taser electrical discharge. Measures before and for 60 minutes after an exposure included minute ventilation; tidal volume; respiratory rate (RR); end-tidal PCO2; oxygen saturation, pulse rate; blood pressure (systolic blood pressure/diastolic blood pressure); arterialized blood for pH, PO2, PCO2, and lactate; and venous blood for bicarbonate and electrolytes. Troponin I was measured at 6 hours. Data were analyzed using a repeated-measures ANOVA and paired t tests. Results: At 1 minute postexposure, minute ventilation increased from a mean of 16 to 29 L/minute, tidal volume increased from 0.9 to 1.4 L, and RR increased from 19 to 23 breaths/min, all returning to baseline at 10 min. Pulse rate of 102 beats/min and systolic blood pressure of 139 mm Hg were higher before Taser exposure than at anytime afterward. Blood lactate increased from 1.4 mmol/L at baseline to 2.8 mmol/L at 1 minute, returning to baseline at 30 minutes. pH And bicarbonate decreased, respectively, by 0.03 and 1.2 mEq/L at 1 minute, returning to baseline at 30 minutes. All troponin I values were normal and there were no EKG changes. Ventilation was not interrupted, and there was no hypoxemia or hypercarbia. Conclusion: A 5-second exposure of a Taser X26 to healthy law enforcement personnel does not result in clinically significant changes of physiologic stress.

<table>
<tr><td colspan="2">REFERENCE:

Wu JY, Sun H, O'Rourke AP, Huebner S, Rahko PS, Will JA, Webster JG, Taser Dart-to-Heart Distance That Causes Ventricular Fibrillation in Pigs. IEEE Transactions in Bio-Medical Engineering, 2007; 54(3): 503-508.</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
Taser Waveform - 5 s of stimulation</td><td>SUBJECT:
Anesthetised 10 pigs</td><td>MEASUREMENT:
Blood pressure, oxygen saturation, respiration, heart rate and ECG, echocardiogram</td></tr>
</table>

FINDINGS (IN OUR WORDS):

The dart-to-heart distance which causes VF in pigs was 17 mm. Based on this result, the estimated probability of VF in humans is < 0.02%.

SUMMARY:

Authors investigated dart-to-heart distances that causes Ventricular Fibrillation (VF) in pigs by stimulating with an EMD device (typical X26 Taser current waveforms), and compared it with skin-to-heart distances in erect humans by measuring with echocardiogram. The dart to heart distance in pigs was 17 mm.

For the dart-to-heart distance of 17 mm, the probability of a dart on the body landing in 1 cm^2 over the ventricle and causing VF is 0.000187. This probability would be decreased if the dart approached the heart at an angle. They also concluded a necessary condition for direct electrocution of the heart was the dart landing in a small frontal region over the heart.

COMMENTS + LIMITATIONS:

Authors suggested that Taser training be done on the back and avoid the front of the torso.
The authors commented the work of Ho et al. (2006) whose work did not show any VF in Humans, because of the long distance from the back to the heart as Taser was applied at the back of human that causes lower cardiac current density.

AUTHORS ABSTRACT:

Electromuscular incapacitating devices (EMDs), such as Tasers, deliver high current, short duration pulses that cause muscular contractions and temporarily incapacitate the human subject. Some reports suggest that EMDs can kill. To help answer the question, “Can the EMD directly cause ventricular fibrillation (VF)?,” ten tests were conducted to measure the dart-to-heart distance that causes VF in anesthetized pigs [mass = 64 kg ±6.67 standard deviation (SD)] for the most common X26 Taser. The dart-to-heart distance that caused VF was 17 mm ±6.48 (SD) for the first VF event and 13.7 mm ±6.79 (SD) for the average of the successive VF events. The result shows that when the stimulation dart is close enough to the heart, X26 Taser current will directly trigger VF in pigs. Echocardiography of erect humans shows skin-to-heart distances from 10 to 57 mm (dart-to-heart distances of 1–48 mm). These results suggest that the probability of a dart on the body landing in 1 cm^2 over the ventricle and causing VF is 0.000172.

REFERENCE:	DISCLOSED INTEREST
Wu JY, Sun H, O'Rourke AP, Huebner S, Rahko PS, Will JA, Webster JG. *Taser Blunt Probe Dart-to-Heart Distance Causing Ventricular Fibrillation in Pigs*. IEEE Transactions on Bio-medical Engineering, 2008; 55(12): p. 2768-2771.	None

STIMULATION:	SUBJECT:	MEASUREMENT:
Ten shots from X26 at two different stimulation sites.	5 pigs	Occurrence of VF

FINDINGS (IN OUR WORDS):

VF occurs in pigs when the average dart-to-heart distance of inserted blunt probes was 2-8 mm.

SUMMARY:

The authors wanted to determine a more precise dart-to-heart distance by advancing a long blunt probe through the surrounding tissues towards the heart. 5 pigs and 2 dart locations were tested for 10 dart-to-heart distances. The dart-to-heart distances where the Taser cause VF ranged from 2 to 8 mm.

COMMENTS + LIMITATIONS:

This is the second paper on a subsequent experiment on 5 pigs. Wu's first paper (Wu J.-Y., et al., *Taser Dart-to-Heart Distance That Causes Ventricular Fibrillation in Pigs*. IEEE Transactions in Bio-Medical Engineering, 2007. 54(3): p. 503-508.) determined larger dart-to-heart distances because the probes were not inserted as close to the heart.

AUTHORS ABSTRACT:

The maximum distance between the heart and a model Taser stimulation dart, called the dart-to-heart distance, at which the Taser can directly cause ventricular fibrillation (VF), was measured in pigs. A 9-mm-long blunt probe was advanced snugly through the surrounding tissues toward the heart. Five animals [pig mass = 61.2mm ± 6.23 standard deviation (SD) kg] for ten dart-to-heart distances where the Taser caused VF were tested. The dart-to-heart distances where the Taser caused VF of the first stimulation site ranged from 4 to 8 mm with average 6.2 mm ± 1.79 (SD) and of the second stimulation site ranged from 2 to 8 mm with average 5.4 mm ± 2.41 (SD). The results help inform the evolving discussion of risks associated with Tasers.

Appendix C: Review of individual papers with disclosed interest

From various sources, the following authors have disclosed their interests.

1. Jeffrey D. Ho has been a consultant to TASER International Inc. and a personal shareholder of TASER International stock. He is also a physician with the Department of Emergency Medicine of the Hennepin County Medical Center. Dr. Ho is the principal author of four papers that we reviewed.
2. Mark W. Kroll is a member of the Corporate and Scientific/Medical Advisory Board of TASER International. He is a professor in the Department of Biomedical Engineering at the University of Minnesota. Dr. Kroll is a co-author of one article that we reviewed.
3. Ronald Moscati has served as a consultant to TASER International Inc and a member of the Department of Emergency Medicine, SUNY at Buffalo, Erie County Medical Center. Dr. Moscati is the principal author of two articles that we reviewed and a contributor of in a third article.
4. Donald M. Dawes has served as an external medical consultant to TASER International Inc. and is a stockholder of the company. He is a physician with the Department of Emergency Medicine, Lompos District Hospital, Lompos, CA and is the principal author of two articles that we reviewed.
5. James D. Sweeney has served as a member of the Scientific and Medical Advisory Board of TASER International Inc. He is also a member of the Department of Bioengineering, Florida Gulf Coast University and the principal author of one article which we reviewed.
6. Robert A. Stratbucker has served as a full time employee of TASER International Inc. and as a medical and scientific consultant to TASER International. He holds shares in the company and has interest in patents assigned to the company. Dr. Stratbucker is retired from the University of Nebraska, Colleges of Medicine and Engineering. He is the author of one article which we identified.

REFERENCE:	**DISCLOSED INTEREST**
Dawes D, Ho J, Miner J, *The Neuroendocrine Effects of the TASER X26®: A Brief Report.* Forensic Science International, 2009; 183:14-19.	Ho JD [1]

STIMULATION:	**SUBJECT:**	**MEASUREMENT:**
1) Taser X26 – for 5 s 2) Spray of O.C. for 5 s, 3) Irritant to the eyes, 4) Exposure to 0 °C cold water for 45s, 5) Defensive tactics drill (60s)	53 human subjects (shock to the back)	salivary alpha-amylase, salivary cortisol

FINDINGS (IN OUR WORDS):

Human stress response is lower for CEW's than other uses of force such as Spray of O.C. and physical exertion.

SUMMARY:

The X26 CEW was compared to other uses of force or an established painful stimulus through the stress response measured from salivary samples 10–15 min before and at 10– 20 min and 40–60 min after the exposure. 16 subjects were exposed to Taser X26 for 5 s on their back; 10 received Spray of O.C. (Def Tac 10% pepper foam) for 5 s, Skin and mucous membrane irritant to the eyes, 16 subjects exposure of the hand and forearm in a 0 °C cold water tank for a 45s, and 10 subjects received a 1-min defensive tactics drill.

The defensive tactics drill resulted in the greatest change in salivary alpha-amylase at 10–15 min. O.C. had the greatest change in salivary cortisol at 15–20 mi, where The CEW was next with a change of 0.38, and the defensive tactics drill after that with a change of 0.25. The defensive tactics drill had the greatest delayed change from baseline in cortisol The cold-water tank immersion did not appear particularly effective activating of the HPA stress response.They found that O.C. has the most important influence on these markers of stress compared to the cold-water immersion tank or the TASER CEW. Overall, there were no adverse outcomes reported.

COMMENTS + LIMITATIONS:

Volunteers were recruited from law enforcement training courses. It is unclear whether the fact that O.C. is a primary skin and mucus membrane irritant caused an alteration in the salivary measures.

AUTHORS ABSTRACT:

Introduction: Law enforcement officers use conducted electrical weapons (CEW) such as the TASER X26 to control violently resistive subjects. There are no studies in the medical literature examining the effects of these weapons on the human stress response. This is the first study to compare the human stress response to conducted electrical weapons, oleoresin capsicum (O.C.), a cold-water tank immersion, and a defensive tactics drill.
Methods: Subjects were randomized to one of the four interventions studied. Subjects received either a 5 s exposure from the TASER X26 CEW with the probes fired into the back from 7 ft, a 5 s spray of O.C., a skin and mucous membrane irritant, to the eyes, a 45-s exposure of the hand and

forearm in a 0 C cold water tank, or a 1-min defensive tactics drill. Results: Alpha-amylase had the greatest increase from baseline at 10–15 min with the defensive tactics drill. Cortisol had the greatest increase at 15–20 min with O.C. Cortisol remained most elevated at 40– 60 min in the defensive tactics drill group.
Conclusions: Our preliminary data suggests that physical exertion during custodial arrest may be most activating of the human stress response, particularly the sympathetic–adrenal–medulla axis. This may suggest that techniques to limit the duration of this exertion may be the safest means to apprehend subjects, particularly those at high-risk for in-custody death. Conducted electrical weapons were not more activating of the human stress response than other uses of force.

<table>
<tr><td colspan="2">REFERENCE:

Ho JD, Dawes WG, Heegaard, Calkins HG, Moscati RM, Miner JR, Absence of electrocardiographic change after prolonged application of a conducted electrical weapon in physically exhausted adults. Journal of Emergency Medicine. In press: 2009.03.023.</td><td>DISCLOSED INTEREST

[1] [4]</td></tr>
<tr><td>STIMULTAION:
Taser X26 (15 second)</td><td>SUBJECT:
25 Human (exhausted healthy individuals)</td><td>MEASUREMENT:
12-lead ECG</td></tr>
<tr><td colspan="3">FINDINGS (IN OUR WORDS):

Physically exhausted healthy subjects receiving longer Taser simulations (15 s) do not show dysrhythmias</td></tr>
<tr><td colspan="3">SUMMARY:

Authors investigated the prolonged activation (15 second) of Taser X26 on 25 physically exhausted adults to detect the change in the heart activity. The exhausted subjects were monitored with a 12-lead ECG after prolonged Taser exposure on their thorax. The authors reported that cardiac dysrhythmias or other detectable abnormalities were not observed for these exhausted human subjects even after a prolonged Taser activation. They also commented on the swine model case (where CEW placed on a very precise position of swine thorax induced ventricular fibrillation and cardiac capture) might not applicable to human subjects. They did not observe any evidence of ventricular fibrillation and cardiac capture.</td></tr>
<tr><td colspan="3">COMMENTS + LIMITATIONS:

The interest of this study is that it considers exhaustion which is one possible mecahnism for may increase the risk of CEW’s. The volunteers were healthy and relatively young. (average age of 39)</td></tr>
<tr><td colspan="3">AUTHORS ABSTRACT:

Background: Conducted electrical weapons (CEWs) are used by law enforcement for control of subjects by causing neuromuscular incapacitation. There has been scrutiny of CEWs and their potential role in the occasional sudden death of subjects in custody. There is a hypothesized causal relationship due to induced cardiac dysrhythmia. Previous work has not shown dysrhythmia induction in resting humans. However, these devices are not often used on resting individuals in the field. Objective: We sought to determine if exposure to a CEW in a physically exhausted human sample population caused detectable change in the 12-lead electrocardiogram (ECG).
Methods: Human volunteers were enrolled. All subjects had a baseline ECG obtained and then underwent an exercise regimen until exhaustion. The volunteers then received a continuous 15-s application from a TASER® X26 CEW (TASER International, Scottsdale, AZ). CEW electrodes were placed on random positions of their anterior thoraces. Electrode positions involved at least a 12-inch spread and always encompassed the normal anatomic position of the heart. An ECG was obtained immediately after CEW exposure. ECGs were interpreted by a blinded cardiologist.
Results: At baseline, 24/25 ECGs were normal. One baseline ECG was abnormal due to several monomorphic premature ventricular complexes. After CEW exposure, all 25 ECGs were interpreted as normal. Conclusions: Prolonged CEW application in an exhausted human sample did not cause a detectable change in their 12-lead ECGs. Theories of CEW induced dysrhythmia in non-rested humans are not supported by our findings</td></tr>
</table>

REFERENCE:			DISCLOSED INTEREST
Ho JD, Miner JR, Lakireddy DR, Bultman LL, Heegaard WG. *Cardiovascular and physiologic effects of conducted electrical weapon discharge in resting adults*. Acad Emerg Med, 2006; 13:589–95.			[1]
STIMULATION: Taser X26 (5s)	**SUBJECT:** 66 resting adult human	**MEASUREMENT:** Blood test, 12-lead Electrocardiogram	

FINDINGS (IN OUR WORDS):

Volunteers did not show any dangerous changes in their cardiac electric activity and blood test up to 24 hours of Taser exposure.

SUMMARY:

Authors investigated CEW application in resting volunteers to investigate the presence of induced electrical dysrhythmia or direct cellular damage. 66 resting human volunteers were exposed to Taser stimulation. Their blood samples were collected before and after exposure. 12-lead ECG was performed at the similar time as the blood test. Authors noted an increase in serum bicarbonate and creatine kinase levels at 16 and 24 hours, and increase in serum lactate level immediately after exposure that decreased at 16 and 24 hours. They concluded that there were no dangerous changes in the volunteers' cardiac electric activity and blood test up to 24 hours of Taser exposure.

COMMENTS + LIMITATIONS:

Resting human volunteers will not reflect real scenarios with high risk individuals.

AUTHORS ABSTRACT:

Objectives: The TASER is a conducted electrical weapon (CEW) that has been used on people in custody. Individuals occasionally die unexpectedly while in custody, proximal to the application of a CEW. In this study, the authors sought to examine the effects of CEW application in resting adult volunteers to determine if there was evidence of induced electrical dysrhythmia or direct cellular damage that would indicate a causal relationship between application of the device and in-custody death.
Methods: Human subjects (N = 66) underwent 24-hour monitoring after a standard CEW application. Blood samples were collected before and after exposure and again at 16 and 24 hours after exposure. A subpopulation (n = 32) had 12-lead electrocardiography performed at similar time intervals. Blood samples were analyzed for markers of skeletal and cardiac muscle injury and renal impairment. The electrocardiograms were read by a cardiologist blinded to the study. Data were analyzed using descriptive statistics.
Results: There was no significant change from baseline at any of the four time points for serum electrolyte levels and the blood urea nitrogen/creatinine ratio. An increase in serum bicarbonate and creatine kinase levels was noted at 16 and 24 hours. An increase in serum lactate level was noted immediately after exposure that decreased at 16 and 24 hours. Serum myoglobin level was increased from baseline at all three time points. All troponin levels measured were <0.3 ng/mL, except for a single value of 0.6 ng/mL in a single subject. This subject was evaluated, and no evidence of acute

myocardial infarction or disability was identified. At baseline, 30 of 32 electrocardiograms were interpreted as normal. The two abnormal electrocardiograms were abnormal at baseline and remained the same at all four time points.
Conclusions: In this resting adult population, the TASER X26 CEW did not affect the recordable cardiac electrical activity within a 24-hour period following a standard five-second application. The authors were unable to detect any induced electrical dysrhythmias or significant direct cardiac cellular damage that may be related to sudden and unexpected death proximal to CEW exposure. Additionally, no evidence of dangerous hyperkalemia or induced acidosis was found. Further study in the area of the in-custody death phenomenon to better understand its causes is recommended.

REFERENCE:			DISCLOSED INTEREST
Ho JD. *Electrocardiographic Effects of the CEW*. Taser Conducted Energy Weapons: Physiology, Pathology, and Law. Chapter 10. Springer, 2009			[1]
STIMULATION: n/a	**SUBJECT:** n/a	**MEASUREMENT:** n/a	

FINDINGS (IN OUR WORDS):

The author concludes that there is no risk of CEW's inducing clinically significant arhythmias.

SUMMARY:

The author reviews several key research reports and concludes that existing data do not support the possibility of CEW's inducing clinically significant arhythmias in humans. Neither is the data supportive of problems being caused to intra cardiac devices.The Nanthakumar study (2006) was characterized with respect to uncertainty that cardiac irritability was due to the administration of epinephrine to the anesthetized pig. Studies of electrocardiac physiology by Wu, Ho, Lakireddy and Nanthakumar. Ho cautions that using epinephrine on anesthetized animals is a source of confusion because of the potency of this stimulant.

COMMENTS + LIMITATIONS:

The author argues that that the extension of results from animal testing is to be treated with caution. Specifically, the point is made that the six pigs in the Nanthakumar study were subject to 150 different shocks.

AUTHORS SELECTED TEXT:

Conclusion: There is a growing body of research information in the area of electrocardiographic effcts of CEW's. While some of the animal data can be confounding, the human data available does not support the theory of CEW's being able to induce clinically significant arrhythmias in humans. This data also does not support CEWICD from an electrically induced arrhythmogenic standpoint. Future research will likely be conducted in this area to validate the current data that can only be seen as helpful as CEW's continue to be investigated.

REFERENCE:			**DISCLOSED INTEREST**
Ho JD. *The State of Current Human Research and Electronic Control Devices ECDs*, Proc. 4th European Symposium on Non- Lethal Weapons, May 21-23, 2007. Ettlingen, Germany.			[1] [3]
STIMULATION: n/a	**SUBJECT:** n/a	**MEASUREMENT:** n/a	

FINDINGS (IN OUR WORDS):

The authors suggest that there was no a causal relationship between ECD application and conditions associated with sudden death among subjects.

SUMMARY:

The authors investigated Taser research in general. They argued that the press and other media played important role in shaping public opinion. They also expressed concern that ECDs and sudden death are not easily understood concepts and therefore tend to be at high risk for misunderstanding and inappropriate logic. With reference to the human research, physically exhausted healthy subjects receiving Taser for continuous 15 second as a worst case scenario do not show cardiac dysrhythmias. Similar conclusions were pointed out in other research including ECD use and cellular physiology (contribution of ECD to instances of ED via increases in blood pH or other acidosis), ECD use and altered physiologic states (mimicking as much as possible those instances of taser use where the subject is suffering from ED or other agitated states – physical exhaustion, intoxication, acidosis), ECD use and Thermoregulation, ECD use and mental illness. The authors concluded that their studies did not show a causal link between ECD application and conditions associated with sudden death among subjects.

COMMENTS + LIMITATIONS:

AUTHORS' SELECTED TEXT:

There appears to be increasing interest in ECD use in society from law enforcement, military and personal defense perspectives. Along with increasing use of these devices, there is also a heightened awareness of perceived association with SD events. This perception may be stimulated by media inaccuracy and sensationalism at times. It may also be the product of misapplied logic.

There have been numerous human studies investigating the possible association between ECD application and SD events. To date, no clear association has been demonstrated when examining the currently recognized etiologies of sudden death such as cardiogenic, pulmonary, metabolic or thermoregulatory causes. Additionally, data exists to show that ECD use has the potential to save human lives within certain populations. We believe that further study of ECDs is recommended to validate our findings.

REFERENCE:		**DISCLOSED INTEREST**
Lakkireddy D, Khasnis A, Antenacci J, Ryshcon K, Chung MK, Wallick D, Kowalewski W, Patel D, Mlcochova H, Kondur A, Vacek J, Martin D, Natale A, Tchou P, *Do Electrical Stun Guns (TASER-X26®) Affect the Functional Integrity of Implantable Pacemakers and Defibrillators?* Europace, 2007; 9(7): 551-556.		Funded by Taser
STIMULATION: TASER-X26 (5 second)	**SUBJECT:** Sedated male pig (28 kg)	**MEASUREMENT:** Echocardiography, seven ICDs and nine pacemakers

FINDINGS (IN OUR WORDS):

Pacemakers and implantable cardioverter defibrillator (ICD) in pigs were not affected to the exposure from Taser X26 for 5 seconds.

SUMMARY:

Authors investigated the effects of CED deployment on the integrity of implantable pacemakers and defibrillators using sixteen such devices implanted within swine's chests. A male pig (28 kg) was sedated and then intubated. Nine pacemakers and seven implantable cardioverter defibrillator (ICD) were attached to a pig. The results showed disruptions of telemetry monitoring during the 5s exposure, but devices did not malfunction. The authors concluded that ICDs and PMs were not affected after expose to Taser X26 for 5 seconds.

COMMENTS + LIMITATIONS:

A single pig was used and nine pacemakers (PM) and seven intercardiac devices (ICD) were tested. Although significant electrical artefact was seen, devices did not malfunction. The evaluations were based on one 5s of Taser exposure and the authors avoided longer time or repeated shocks – but they speculated that multiple shocks may damage the PM's and ICD's.

AUTHORS ABSTRACT:

Aims: High voltage electric current can adversely affect pacemakers (PM) and implantable cardioverterdefibrillator (ICD). The standard shock from an electrical stun gun (TASER- X26, TASER International, Scottsdale, AZ) consists of a 5-s long application of high voltage, low current pulses at 19 pulses per second. Its effect on the functional integrity of PM and ICDs is unknown. Methods and results We tested the functional integrity of nine PMs and seven ICDs in a swine model after a standard stun gun shock. A transvenous, dual coil, bi-polar ICD lead (St Jude-SP01) and a PM lead were placed in the right ventricular (RV) apex and connected to pulse generators buried in the prepectoral pocket. The two darts were placed at the sternal notch (SN) and apex of the heart bracketing the device pocket. Standard neuromuscular incapacitating (NMI) discharges were delivered. Functional parameters of the devices and leads were checked before and after the shocks. The mean pacing thresholds, sensing thresholds, pacing impedances, and defibrillation coil impedances of the ICD lead were similar before and after the shocks. Similarly, pacing thresholds, sensing thresholds, and impedances of the PM lead were not significantly different before and after the shocks. No significant change was noted in battery voltage and projected longevity. Implantable cardioverter-defibrillator generators detected the NMI impulses at a mean cycle length of 176+20 ms with detection to charge time of 5.9±1.5 s. Shock delivery was aborted in all tests as tachycardia detection abruptly terminated at the end of the 5 s NMI application. None of the devices exhibited power on reset (POR), elective replacement indicator (ERI), or noise mode behaviour after the shock. Conclusion Pacemakers and ICD generators and leads functions were not affected by the tested standard 5 s stun gun shocks.

REFERENCE: Lakkireddy D, Wallick D, Ryschon K, Chung, M, Butany J, Martin D, Saliba W, Kowalewski W, Ntatale A, Tchou P. *Effects of Cocaine Intoxication on the Threshold for Stun Gun Induction of Ventricular Fibrillation*. J American College of Cardiology, 2006; 48(4): 805–11	**DISCLOSED INTEREST** Funded by Taser

STIMULATION: 5 s of custom built variable output device compatible with X26 waveshape and power	**SUBJECT:** 5 pigs	**MEASUREMENT:** ECG

FINDINGS (IN OUR WORDS):

Cocaine use reduced the pigs' vulnerability to VF or increased the threshold to VF by 50-100%. Increased distance of electrodes from the heart increased the safety margins.

SUMMARY:

CEW discharge into 5 adult pigs at normal levels of energy did not induce VF anywhere on pigs' body. Histopathological damage to the heart was not caused even by cumulative discharges 2000 times stronger than the standard values. Cocaine increased the required strength of discharge at all positions in the body.

COMMENTS + LIMITATIONS:

The findings run counter to the common opinion that cocaine use increases vulnerability to cardiac events during CEW discharge.

AUTHORS ABSTRACT:

Objectives: This study sought to assess cocaine's effects on Taser-induced ventricular fibrillation (VF) threshold in a pig model.
Background: Stun guns are increasingly used by law enforcement officials to restrain violent subjects, who are frequently intoxicated with cocaine and other drugs of abuse. The interaction of cocaine and the stun gun on VF induction is unknown.
Methods: We tested five adult pigs using a custom device built to deliver multiples of standard neuromuscular incapacitating (NMI) discharge that matched the waveform of a commercially available electrical stun gun (Taser X-26, Taser International, Scottsdale, Arizona). The NMI discharges were applied in a step-up and step-down fashion at 5 body locations. End points included determination of maximum safe multiple, minimum VF-inducing multiple, and ventricular fibrillation threshold (VFT) before and after cocaine infusion.
Results: Standard NMI discharges (x1) did not cause VF at any of the 5 locations before or after cocaine infusion. The maximum safe multiple, minimum VF-inducing multiple, and VFT of NMI application increased with increasing electrode distance from the heart. There was a 1.5- to 2-fold increase in these values at each position after cocaine infusion, suggesting decreased cardiac vulnerability for VF. Cocaine increased the required strength of NMI discharge that caused 2:1 or 3:1 ventricular capture ratios at all of the positions. No significant changes in creatine kinase-MB and troponin-I were seen.
Conclusions: Cocaine increased the VFT of NMI discharges at all dart locations tested and reduced cardiac vulnerability to VF. The application of cocaine increased the safety margin by 50% to 100% above the baseline safety margin.

REFERENCE: Lakkireddy D, Wallick D, Verma A, Rytschon K, Kowalewski W, Wazni O, Butany J, Martin D, Tchou P. *Cardiac effects of electrical stun guns: does position of barbs contact make a difference?* Pacing and Clinical Electrophysiology, 2008; 31(4):398-408		**DISCLOSED INTEREST** Funded by Taser
STIMULATION: X26 and custom generator X1 up to X100 stored pulse charge	**SUBJECT**: 13 adult pigs	**MEASUREMENT**: Surface ecg, blood gases, serum electrolytes

FINDINGS (IN OUR WORDS):

Standard X26 discharges did not induce VF in any of the animals.

SUMMARY:

Initiation of VF in pigs requires higher levels of energy than the X26 delivers and depends on the position of the barbs. Anaesthetized pigs received three shocks at ×1, ×5, ×10 and up to ×100 pulse charge of an X26 until VF resulted three times in a row. Anaesthetized pigs were debfibrillated with 300 J and rested between applications. It was determined that barbs bracketing the heart had the lowest safety margin. Barbs on the back had the highest.

COMMENTS + LIMITATIONS:

AUTHORS ABSTRACT:

Background: The use of electrical stun guns has been rising among law enforcement authorities for subduing violent subjects. Multiple reports have raised concerns over their safety. The cardiovascular safety profile of these devices in relationship to the position of delivery on the torso has not been well studied. Methods: We tested 13 adult pigs using a custom device built to deliver neuromuscular incapacitating (NMI) discharge of increasing intensity that matched the waveform of a commercially available stun gun (TASERr X-26, TASER International, Scottsdale, AZ, USA). Discharges with increasing multiples of output capacitances were applied in a step-up and step-down fashion, using two-tethered barbs at five locations: (1) Sternal notch to cardiac apex (position-1), (2) sternal notch to supraumbilical area (position-2), (3) sternal notch to infraumbilical area (position-3), (4) side to side on the chest (position-4), and (5) upper to lower mid-posterior torso (position-5). Endpoints included determination of maximum safe multiple (MaxSM), ventricular fibrillation threshold (VFT), and minimum ventricular fibrillation induction multiple (MinVFIM). Results: Standard TASER discharges repeated three times did not cause ventricular fibrillation (VF) at any of the five locations. When the barbs were applied in the axis of the heart (position-1), MaxSM and MinVFIM were significantly lower than when applied away from the heart, on the dorsum (position-5) (4.31 ± 1.11 vs 40.77 ± 9.54, $P<0.001$ and 8.31 ± 2.69 vs 50.77 ± 9.54, $P<0.001$, respectively). The values of these endpoints at position-2, position-3, and position-4 were progressively higher and ranged in between those of position-1 and position-5. Presence of ventricular capture at a 2:1 ratio to the delivered TASER impulses correlated with induction of VF. No significant metabolic changes were seen after standard NMI TASER discharge. There was no evidence of myocardial damage based on serum cardiac markers, electrocardiography, echocardiography, and histopathologic findings confirming the absence of significant cardiac effects. Conclusions: Standard TASER discharges did not cause VF at any of the positions. Induction of VF at higher output multiples appear to be sensitive to electrode distance from the heart, giving highest ventricular fibrillation safety margin when the electrodes are placed on the dorsum. Rapid ventricular capture appears to be a likely mechanism of VF induction by higher output TASER discharges.

<table>
<tr><td colspan="3">REFERENCE:

Moscati R, Ho JD, Dawes DM, Miner JR. Physiologic Effects of Prolonged Conducted Electrical Weapon Discharge in Ethanol Intoxicated Adults. Amer J Emerg Med, 2010; 28(5):582-587</td><td>DISCLOSED INTEREST
[1] [3]</td></tr>
<tr><td>STIMULATION:
TASER X2
6 (15-second)</td><td>SUBJECT:
22 alcohol-intoxicated adults</td><td colspan="2">MEASUREMENT:
Blood samples,
handheld breath tester</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

15 second of Taser activation on 22 alcohol-intoxicated adults did not show any clinically significant effects.</td></tr>
<tr><td colspan="4">SUMMARY:

The authors of this paper investigated the physiologic effects of prolonged Taser activation on alcohol-intoxicated adult subjects. 22 subjects ingested mixed drinks until clinical intoxication (alcohol level of 0.08 mg/dL). The blood sample measurements were taken at (i) baseline, (ii) immediately after alcohol ingestion, (iii) immediately after exposure to a 15-second TASER X26 discharge, and (iv) 24 hours post-alcohol ingestion. They observed that: a) pH and bicarbonate decreased, and lactate increased after alcohol ingestion, b) Lactate further increased and pH dropped after CEW exposure, c) at 24 hours all values returned to baseline levels except lactate, which slightly increased. All subjects received 15 second of Taser exposure did not experience a significant ill effect in terms of metabolic acidosis.</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:

Healthy trainee individuals.
Study suggests alcohol has some similar effects to CEW, and thus there may be cumulative effects</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

Objectives: This study examines the physiologic effects of prolonged conducted electrical weapon (CEW) exposure on alcohol-intoxicated adult subjects.
Methods: Adult volunteers were recruited at a TASER International training conference. All subjects ingested mixed drinks until clinical intoxication or until a minimum breath alcohol level of 0.08 mg/dL was achieved. Blood samples for venous pH, Pco2, bicarbonate, and lactate were measured in all subjects at baseline, immediately after alcohol ingestion, immediately after exposure to a 15-second TASER X26 discharge (Taser International Inc, Scottsdale, AZ), and 24 hours post-alcohol ingestion. Laboratory values were compared at sampling times using repeated-measure analysis of variance. A focused analysis comparing time points within groups was then performed using paired t tests.
Results: Twenty-two subjects were enrolled into the study. There was a decrease in pH and bicarbonate and an increase in lactate after alcohol ingestion. There was a further increase in lactate and drop in pH after CEW exposure. No subject experienced a significant adverse event. All values had returned to baseline levels at 24 hours except lactate, which demonstrated a small but clinically insignificant increase.
Conclusions: Prolonged continuous CEW exposure in the setting of acute alcohol intoxication has no clinically significant effect on subjects in terms of markers of metabolic acidosis. The acidosis seen is consistent with what occurs with ethanol intoxication or moderate exertion.</td></tr>
</table>

<table>
<tr><td colspan="3">REFERENCE:

Moscati R, Cloud S. Rhabdomyolysis. Chapter 13. <u>Taser® Conducted Electrical Weapons: Physiology, Pathology and the Law</u>. Springer, 2009.</td><td>DISCLOSED INTEREST

[3]</td></tr>
<tr><td>STIMULATION:
n/a</td><td>SUBJECT:
n/a</td><td colspan="2">MEASUREMENT:
n/a</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

CEW discharge does not cause muscle cell death.</td></tr>
<tr><td colspan="4">SUMMARY:

Rhabdomyolysis is the clinical condition when muscle cells are damaged. The diagnosis of Rhabdomyolosis occurs when creatine phosphokinase (CPK) is at 5x the normal limit. In one third of the cases of Rhabdomyolosis, death is caused by acute renal failure. A report on CEW injuries seen in the ER (Ordog G et al 1987) did not report actual lab values but an overwhelming majority of cases had been using drugs or alcohol and demonstrating bizarre behaviour. Each of these factors is by itself a cause of rhabdomyolysis.</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:

This report is a review of 218 Taser injuries seen in the Emergency Room of hospitals as well as the Jauchem acidosis study (pigs) and the Ho human volunteer study (66 adults)</td></tr>
<tr><td colspan="4">AUTHORS SELECTED TEXT:

Rhabdomyolosis is a consequence of muscle injury from overuse or direct damage as a result of mechanical or electrical trauma. While CEW application can cause exposure to electrical discharges and repeated muscle contraction, the data from case series, animal models and human studies demonstrate that mild and transient increases in CPK occur without evidence of clinically significant increases leading to rhabdomyolysis.</td></tr>
</table>

REFERENCE:	DISCLOSED INTEREST
Sweeney, James. *Transcutaneous Muscle Stimulation*. Kroll and Ho, Eds. Taser Conducted Energy Weapons: Physiology, Pathology, and Law. Chapter 5. Springer, 2009.	[5]

STIMULATION:	SUBJECT:	MEASUREMENT:
Experimental results, modeling of electric fields	n/a	Computer modelling

FINDINGS (IN OUR WORDS):

This chapter describes and justifies the choice of waveform in Taser X26 and M26.

SUMMARY:

The chapter investigates the theory of how the M26 and X26 waveforms produce skeletal muscle stimulation by modelling the electric fields. Author offers argument why 19 Hz is the right frequency for skeletal muscle stimulation. Higher frequencies "...could generate excessive forces in subjects beyond those needed to incapacitate..." Cardiac strength-duration time constants are 10-20 times higher than ά motor neuron fibres. Heart excitability is thus lower. Two types of muscle are: "slow twitch" for postural function and "fast twitch" for phasic activities such as eye movement.

COMMENTS + LIMITATIONS:

Sweeney is a member of the Scientific and Medical Advisory Board of Taser International. He is Chair of the Department of Bioengineering at Florida Gulf Coast University.

AUTHORS' SELECTED TEXT:

Summary: While the TASER X26 and M26 CEW waveforms exhibit some similarity to stimulation waveforms utilized in medical devices, these systems necessarily incorporate leading high frequency sinusoidal components with open-circuit voltage amplitudes designed to produce arcing between the TASER CEW darts and subjects. TASER CEW waveforms are also necessarily brief in duration so as to insure cardiac safety while still delivering sufficient current so as to ÈcapttureÈ volues of skeletal muscle that effectively incapacitate subjects.
In this chapter, we have focused analysis upon the predicted electric field strengths that should be needed within the body in order to stimulate the α-motor neurons that innervate skeletal muscle. We have also presented computer modeling of the strength-duration behaviour of the TASER X26 and M26 CEW waveforms, contrasting their predicted threshold stimulation levels against each other and in comparison to simpler sinusoidal and rectrangular stimuli, as well as the C26 CEW waveform subcomponents. Consideration of pertinent experimental results, as well as implementation of a modelling approact to prediction of mixed, fiber-type skeletal muscle evoked forces due to varying frequencies of electrical stimulation, confirms also that the frequency of the TASER CEW stimulation is appropriate for generation of powerful muscle contractions within physiological ranges.

Appendix D: Editorials and Letters to the Editor

<table>
<tr><td colspan="3">REFERENCE:

Hall C. Public risk from tasers: Unacceptably high or low enough to accept? Canadian Journal of Emergency Medicine, 2009; 11(1): 84-86.</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
None</td><td>SUBJECT:
None</td><td colspan="2">MEASUREMENT:
None</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

The editorial argues for the establishment of a (Canadian) national physicians working group with an interest in in-custody deaths.</td></tr>
<tr><td colspan="4">SUMMARY:

Hall points out the difficulties faced by police and ER physicians in managing violent and unstable patients. Both police and ER physicians are required to make “...rapid assessment in an often deteriorating situation...” and forego “...an orderly linear progression...” Manufacturer-funded research is not an acceptable alternative. Reporting of data from Taser use has just begun in Canada and the US. Canada does not have a standardized format for reporting and no national database.</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:

Editorial in Canadian Journal of Emergency Medicine</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

N/A (editorial)</td></tr>
</table>

<table>
<tr><td colspan="3">REFERENCE:

Koscove EM., Physiological Effects of the Taser. Annals of Emergency Medicine, 2008; 52(1): 85</td><td>DISCLOSED INTEREST
none</td></tr>
<tr><td>STIMULATION:
n/a</td><td>SUBJECT:
n/a</td><td colspan="2">MEASUREMENT:
n/a</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

Author recommends a funded study on animals infused with both cocaine and catecholamines.</td></tr>
<tr><td colspan="4">SUMMARY:

Author commends Vilke (see below) study but questions the prolonged (longer than 30 minutes) lactate elevation in human volunteers after Tasering. He questions whether the cascaded effects of agitation and sympathomimetic elevation could lead to delayed onset of fatal arrhythmia.</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:

This is a letter to the editor commenting on Vilke, G.M., et al., Physiological Effects of a Conducted Electrical Weapon on Human Subjects. Annals of Emergency Medicine, 2007. 50(5): p. 569-575.</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

n/a</td></tr>
</table>

<table>
<tr><td colspan="3">REFERENCE:

Stanbrook, Matthew B. Tasers in medicine: an irreverent call for proposals. Canadian Journal of Emergency Medicine, 2008; 178(11):1401-1402</td><td>DISCLOSED INTEREST
None</td></tr>
<tr><td>STIMULATION:
None</td><td>SUBJECT:
None</td><td colspan="2">MEASUREMENT:
None</td></tr>
<tr><td colspan="4">FINDINGS (IN OUR WORDS):

The author calls for the CIHR (Canadian Institute for Health Research) to fund studies because Taser usage constitutes a public safety issue.</td></tr>
<tr><td colspan="4">SUMMARY:

The author calls for funding of Taser usage studies because "...New and independent research, both epidemiologic and biological, in whether Tasers can kill is essential..."</td></tr>
<tr><td colspan="4">COMMENTS + LIMITATIONS:

This is an editorial in CMAJ. The author is very critical of Taser International`s influence in coroner and postmortem decisions. Litigation has supplanted science. The company`s influence in funding scientific work has skewed the perception of independence.</td></tr>
<tr><td colspan="4">AUTHORS ABSTRACT:

n/a</td></tr>
</table>

Appendix E: Reports and publicly available documents

REFERENCE:			DISCLOSED INTEREST
Sloane CM, Chan TC, Vilke GM. *A Medical Review of the Physiological Effects of Conducted Energy Devices (CED)* Report for the Houston Police department (Date unavailable)			None
STIMULATION: n/a	**SUBJECT:** n/a	**MEASUREMENT:** n/a	
FINDINGS (IN OUR WORDS): CED's do not appear to cause cardiac rhythm problems or negative aspects on human respiration although there is potential for negative effect on pacemakers. Special attention and medical evaluation is recommended and attention for certain high risk groups.			
SUMMARY: Comprehensive literature review of Animal Studies, Case Studies and Reports and Human Physiological Studies. Detailed review of physiologic effects on various body systems.			
COMMENTS + LIMITATIONS: n/a			
AUTHORS SELECTED TEXT: ...where a subject is under the influence of drugs or in a state of excited delirium. These subjects require particular care in their evaluation and treatment. The effects of CEDs vary depending on the ... organ system in question, placement and distance between the probes...as well as the physical condition of the subject. CED's do not appear to have any permanent effects on the muscular system other than an increased risk for strains and th epotential for causing muscle breakdown with repeated, sustained use. Published research on the health effects and safety of CEDs on humans is limited. The effect of CEDs on the brain and central nervous system are unknown. There have not been any reported adverse effects. CEDs do not appear to cause cardiac rhythm problems, though data are limited. There appears to be the potential for negative consequences on cardia pacemakers and internal defibrillators. The effect of CEDs on the pregnant subject is unknown... There is simply not enough data regarding the specifics of the effects of CEDs on children and the elderly....the following subjects on whom a CED has been used warrant special attention and medical evaluation: 1) Those under the influence or suspected to be under the influence of stimulant drugs, 2) Those in a state of excited delirium, 3) Those with an implantable cardiac pacemaker or internal defibrillator, 4) Pregnant subjects, 5) The very young or very old.			

Appendix F: Institutions involved in research on CEWs

Brooke Army Medical Center
Florida Gulf Coast University
Hennepin County Medical Center
John Hopkins University
Rush University
SUNY at Buffalo
University of Alabama
University of British Columbia
University of Calgary
University of California (San Diego and Los Angeles)
University of Kansas
University of Medicine and Dentistry (NJ)
University of Minnesota
University of Nebraska
University of Toronto
University of Wisconsin
US Air Force Research Laboratory
Washington University

Cleveland Clinic
Hartford Hospital
Lompoc District Hospital
Navy Medical Center
Southlake Regional Hospital
St. Michael's Hospital
Stronger Hospital of Cook County
The Heart and Vascular Institute
Toronto General Hospital
Vancouver Island Health Authority