National Association of Medical Examiners

HANDOUTS

2014 Annual NAME Meeting
September 19-23, 2014
Portland, Oregon
Saturday – September 20, 2014
10:45 AM – 10:55 AM

2.2

The Design of a New Mortuary and Medical Examiner Facility in Abu Dhabi

Adam Denmark, AIA, LEED, AP, BD+C, SmithGroupJJR, Phoenix, Arizona, USA
Abu Dhabi Central Mortuary

Adam Denmark, AIA, LEED AP BD+C
Architect and Forensic Design Expert
Principal, SmithGroupJJR

Adam Denmark is a leader in SmithGroupJJR’s forensic design group and has experience in all project phases of facility design and construction. As a laboratory planning and design architect, he helps create safer, more sustainable lab environments. With experience across a range of laboratory types, he specializes in facilities for forensic science, medicolegal death investigation, and biocontainment. Denmark is a frequent author and speaker on forensic facilities and has presented at conferences such as the National Association of Medical Examiners Annual Meeting, the Centers for Disease Control and Prevention’s International Symposium on Biosafety, the International Centre for Infectious Diseases Canadian Biosafety Symposium, and the R&D Laboratory Design Conference.

Dr. David Fowler, MB.CHB. M.MED. PATH (FORENS). FCAP. FAAFS
Medical Examiner and Forensic Pathology Expert
Chief Medical Examiner for State of Maryland

Dr. David R. Fowler, is Chief Medical Examiner for the State of Maryland, having trained originally in Southern Africa and received his certification in Forensic pathology is also Board Certified by the American Board of Pathology in Anatomic and Forensic Pathology. An Associate Professor of Pathology and of Pediatrics at the University of Maryland at Baltimore, he is on the faculty of the National Study Center for Trauma and Emergency in Baltimore and adjunct or visiting faculty at other local and international Universities.

Dr. Fowler Chairs the inspection and accreditation committee for NAME and is a member of 10 NAME committees. In 2002 Dr. Fowler successfully motivated for a new Forensic medicine center for the state of Maryland. Over the next 8 years he was intimately involved in the process. This involved all aspects of sizing the facility, defending the need and budget, design concepts, design, and construction observation.
Saturday – September 20, 2014
5:00 PM – 5:10 PM
4.6

Evaluating the Utility of Urine Dipsticks as a Postmortem Triage Modality

Jon R. Gates, MD, Cook County Medical Examiner, Chicago, Illinois, USA
Evaluating the Utility of Urine Dipsticks as a Postmortem Triage Modality

Jon Gates MD, Fellow in Forensic Pathology, Cook County Medical Examiner’s Office

Urine dipsticks are an inexpensive, rapid tool for detecting common drugs of abuse (cocaine, oxycodone, methamphetamine, morphine, and benzodiazepines) in postmortem urine samples. For urine dipsticks to be useful as a triage modality, it is important that dipsticks have high sensitivity, specificity, positive predictive value, and negative predictive value. We tested the performance of urine dipsticks as compared with toxicological analysis of postmortem blood as the gold standard for 198 cases for at least one of five drugs of abuse during a 5 month period at the Office of the Medical Examiner of Cook County, Illinois. Toxicological screening with ELISA and confirmation with gas chromatography/mass spectrometry (GC/MS) was then performed on postmortem blood samples. The results were compared to find the sensitivity, specificity, positive predictive value, and negative predictive value of the urine dipstick screens relative to the tissue toxicology results.

Urine dipsticks were performed for cocaine (n=178). There was one case in which the urine dipstick was positive and the toxicology was negative and one case in which the urine dipstick was negative and the toxicology was positive. The sensitivity (98.0%), specificity (99.2%), positive predictive value (98.0%) and negative predictive value (99.2%) were all in the 98.0% to 99.2% range. Urine dipsticks were also performed for morphine (n=186). Of these 186 dipsticks, there was one case in which the urine dipstick was positive and the toxicology was negative and two cases in which the urine dipstick was negative and the toxicology was positive. The sensitivity (97.9%), specificity (98.9%), positive predictive value (98.9%) and negative predictive value (97.8%) were all in the 97.8% to 98.9% range. Urine dipsticks were performed for oxycodone (n=47), benzodiazepines (n=45), and methamphetamine (n=44). For all 3 of the drugs, there were no false positive or false negative dipstick results. The sensitivities, specificities, positive predictive values and negative predictive values were all 100%.

For five common drugs of abuse (cocaine, morphine, oxycodone, benzodiazepines, and methamphetamine) the sensitivity, specificity, positive predictive value, and negative predictive value of the urine dipsticks all exceeded 97%. Urine dipsticks are an accurate and reliable screening tool for drugs of abuse. This inexpensive screen may be used to triage cases to autopsy or external examination in cases where the differential includes natural disease versus drug-related death.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
<th>PPV (95% CI)</th>
<th>NPV (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocaine</td>
<td>178</td>
<td>98% (89.2%, 100.0%)</td>
<td>99.2% (95.8%, 100.0%)</td>
<td>98% (89.2%, 100.0%)</td>
<td>99.2% (95.8%, 100.0%)</td>
</tr>
<tr>
<td>Morphine</td>
<td>186</td>
<td>97.9% (92.5%, 99.7%)</td>
<td>98.9% (94.1%, 100.0%)</td>
<td>98.9% (94.2%, 100.0%)</td>
<td>97.8% (92.5%, 99.7%)</td>
</tr>
<tr>
<td>Oxy</td>
<td>47</td>
<td>100% (47.8%, 100.0%)</td>
<td>100% (91.5%, 100.0%)</td>
<td>100% (47.8%, 100.0%)</td>
<td>100% (91.5%, 100.0%)</td>
</tr>
<tr>
<td>Benzo</td>
<td>45</td>
<td>100% (79.4%, 100.0%)</td>
<td>100% (88.1%, 100.0%)</td>
<td>100% (79.4%, 100.0%)</td>
<td>100% (88.1%, 100.0%)</td>
</tr>
<tr>
<td>Meth</td>
<td>44</td>
<td>100% (15.8%, 100.0%)</td>
<td>100% (91.6%, 100.0%)</td>
<td>100% (15.8%, 100.0%)</td>
<td>100% (91.6%, 100.0%)</td>
</tr>
</tbody>
</table>

Table 1: Results for cocaine, morphine, oxycodone, benzodiazepines, and methamphetamines.
Sustaining and Saving Life – Understanding Organ and Tissue Recovery

Michelle Anna Jorden, MD, Santa Clara County Medical Examiner, San Jose, California, USA
National statistics:

- Every year, the lives of about 500,000 Americans are saved by organ and tissue donation.
- Approximately 6,000 living donations occur each year. One in four donors is not biologically related to the recipient.
- Over 1 million tissue transplants are done yearly in the U.S.
- Over 46,000 cornea transplants are done yearly in the U.S.
- Over 123,280 people are on the waiting list for an organ in the U.S.
- Every 10 minutes another person is added to that list.
- 18 people a day die – while waiting on that list.
- Overall 1/3 of the people on the list die before getting an organ they need to save them.
- Research tissue uses may have even greater impact – in terms of numbers of lives potentially saved or helped with greater scientific understanding, and the development of future therapies/drugs/gene modulation or procedures.
**How Donation can help a family:**

- A sense of meaning out of a senseless tragedy
- Something good coming out of their life/death
- The person can continue to live on – not only in memory
- A lasting legacy – to make their family proud
- It is a final act of giving – in accordance with their nature

**Minimum of 18 months in a donor services, grief program.**

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**Critical Legislation**

1987—*Uniform Anatomical Gift Act, 1987 Version*, A model statute, intended for adoption in every jurisdiction. A revision to the original 1968 UAGA to deem a person's legal consent to donate before death irrevocable (without an indication that the consent was no longer valid).

2006—*Uniform Anatomical Gift Act, 2006* —A model statute intended for adoption in every jurisdiction. This model law legally bars others from revoking the consent of a donor after death who legally registered as a donor during his or her lifetime (without an indication that the consent was no longer valid).

2013 - In late 2013, President Obama signed the *HIV Organ Policy Equity Act, or HOPE Act*, ending a ban on the transfer of HIV-positive organs to HIV patients. In order to undergo an organ transplant, a patient's HIV must be under control.

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**THE NEED FOR COOPERATION:**

Why are they asking me (the ME) for that?

ME records requests

**Donor Autopsy Report (AATB 13th edition)** Per AATB: If an autopsy was performed, the tissue bank’s Medical Director or licensed physician designee shall review the autopsy report or a summary of findings prior to the release of tissue to inventory. If a copy of the autopsy report is not available for the donor’s record, the cause of death and other pertinent autopsy findings shall be documented in the donor’s record. If it is determined that an autopsy was not performed due to infectious disease risk or, if an autopsy was performed, if any special precautions were taken that would suggest risk of a communicable disease in the donor, this information should be considered.
Most tissue banks will not release tissue until the autopsy report and other testing is in the file (the exception being exceptional release of a fresh osteochondral graft (risk is assumed).

Scene, and Investigative Reports (not currently specifically addressed by AATB) but recognized by the FDA as potentially “relevant records” to consider (police reports are similarly sometimes requested)

A scene report and or investigative summary can be invaluable information that could prevent disease transmission. i.e. Drugs/ injectable paraphernalia/prostitution evidence at scene. Or a suicide note from a man who hung himself over his closeted homosexuality (secondary historians may be unaware)

GUIDANCE AND RESOURCES:

College of American Pathologists Organ and Tissue Procurement Policy
Updated March 14, 2011

Overview
The science of organ and tissue transplantation continues to advance; however, the need for organs and tissues is much greater than the availability. People die every day waiting for organs and tissues. The pathologist plays a key role in the recovery of organs and tissues, and the majority of potential donors’ deaths are under the jurisdiction of a pathologist. Unfortunately, many potential donor cases are denied because they are considered forensic, or medicolegal. It is the responsibility of the pathologist to serve the victim/patient, but also to serve in the best interest of the public. Recovery should not be denied on the sole basis that a case is considered a forensic/medicolegal case.

The College also believes that respect for the rights of the donor requires that informed consent be obtained before a biospecimen is donated, as outlined in the College’s Informed Consent for Donation of Biospecimens policy. The specific elements that should be covered in the informed consent process will depend on the context in which the donation is made, the use to which the biospecimen is put, and applicable state law.

Statement
The College of American Pathologists supports the recovery of organs and tissues for transplantation. Such recovery should be sought in all applicable deaths including those under medicolegal jurisdiction, and when it can be accomplished without detriment to the autopsy procedure, evidence collection, or determination of cause and manner of death.
Heart valve tissue donation does not preclude the diagnosis of clinically significant pediatric cardiac abnormalities.
Pinckard JK, Graham MA.

Abstract
Medical examiners/coroners often have the responsibility of deciding whether to allow organ and tissue donation to proceed in cases under their jurisdiction. A 10-year retrospective study was conducted of autopsy cases in children younger than 6 years to determine whether the donation of cardiac valve tissue would preclude the diagnosis of clinically significant pediatric cardiac abnormalities. Only 1 case (0.1%) was found in the entire 10-year period in which valve tissue donation might have prevented the correct diagnosis. According to the results of the study, (1) most cardiac findings in forensic pediatric autopsies are not clinically significant; (2) clinically significant findings will be diagnosed in properly examined hearts, even those processed for valve tissue donation, and special studies will remain possible in nearly all hearts except those with suspicion of conduction defects; and (3) as long as there is good communication between forensic pathologists and organ and tissue procurement organizations, the concern of failing to diagnose significant cardiac findings should not inhibit medical examiners/coroners from allowing the donation of pediatric cardiac valve tissue.

Modified cardiectomy: documenting sudden cardiac death in hearts selected for valve allograft procurement.
Wetli CV, Kolovich RM, Dinhofer L.

Abstract
Medical examiners frequently deny requests by tissue procurement organizations for heart valves intended for allograft transplantation. Most of these denials are in cases of sudden apparent natural death, often where a cardiac cause is suspected. The basis of denial in these cases is that the heart must be removed and the valves procured off site under sterile conditions. This prevents the medical examiner from determining and documenting the cause of death. A dissection technique was therefore devised to increase the number of heart valves available for allograft transplantation and to simultaneously allow the pathologist to document a cardiac cause of sudden death. Interagency procedures, the dissection technique, and case summaries are provided.
Potential Donors: infants – (usually there is a defined weight or size minimum) to elderly (80’s) Depends on the bank, and current needs. Must be an absence of systemic infection or sepsis. Localized, limited or treated infections often are suitable. For tissues: No high risk lifestyle factors - for hepatitis or HIV. Possibly to still be an organ donor with known risks. Some malignancies are acceptable – eg. 1 brain or in situ skin. Recovery can occur up to 24 hours after last known alive time if the body has been cooled within 12 hours. Corneas must be recovered within 12 hours. Corneas are only viable for transplantation for 14 days. There are no donor restrictions other than the health and clarity of the cornea.

Important Pearls/Resources Points to consider regarding donation:

1. Regarding the ME/coroner mission:
   a. If I miss something, will it result in an overcall or under call of trauma?
   b. If by all accounts it is natural (but I am faced with picking the right one), what are we gaining by restricting various tissues/organs/eyes?
2. In obvious causes such as GSW head, blunt head trauma, hanging (delayed) apparent drug overdose, etc., what organ finding will trump the “cause” to preclude any specific organ donation?
3. In brain dead donors, is trace evidence collection a valid reason to restrict organs? Isn’t that opportunity best met early during hospitalizations and in effect usually a lost cause by the time of asystole and even brain death pronouncement?
4. In non-obvious causes of brain death: Doesn’t the organ donation process (with added testing such as culture of blood, sputum, urine, EKG testing, ultrasounds, etc. you name it, just ask...) provide potentially more data than what you might reasonably see/learn from a “complete cadaver” on simply a gross and histologic exam? What class I (all-compelling) cause of death on could one envision that would override a normal functioning organ on a gross/microscopic exam? Bronchopneumonia, hepatitis, myocarditis? Not really. None of these findings are “clear and compelling”, particularly in a person who has suffered a sudden catastrophic event. These are what you find people die “with” but rarely “from”. And if they do die “from” it is because of something else more proximate up the chain.
5. The donation of heart for valves does not preclude the diagnosis of primary heart disease, such as hypertensive heart disease, coronary artery disease, mitral valve prolapse, etc. In addition, regarding condition that tend to require aggressive tissue sampling (myocarditis,sarcoi) the tissue sampling done by tissue bank cardiac pathologists may not only rivals typical sampling, but usually exceeds the
routine sampling done by many medical examiners. Additional sampling if the heart is returned is also possible.

6. The only structure that heart for valves donation/transplant can restrict for diagnosis (if needed, which is rare) is examination of the AV node. However, since the heart for valve processor MUST have the autopsy report in hand to complete their suitability and finally release that tissue, an option could be (this is the logistical communication that needs to occur) to thaw the AV ring, sample that nodal region, and, of course, that means sacrificing the specific tissue. In reality this outcome is of course very rare. Pulmonary trunk/valve and perhaps other distal aortic conduit would still be OK.

7. Procurement of musculoskeletal tissue for donation does not preclude the diagnosis of a natural occurring pulmonary embolism. There have been instances of denials for the reason of missing DVT’s. Indeed, if no trauma is present/known, the source is almost always the legs/pelvis and rarely elsewhere and the manner is natural. The lack of uncovering a DVT in the legs can happen of course even in pristine, non-procured cadavers. The common sense consideration in that instance is that the clot “left”. That said, in a personal series by a tissue bank which were autopsied post-lower musculoskeletal recovery (unpublished: Daniel Schultz, MD), the majority of cases of non-traumatic pulmonary emboli were able to have DVT’s discovered in the residual lower extremity tissues even AFTER procurement by re-opening the incisions. This ability would of course depend on the method/degree of procurement (a full extremity removal for instance). The bottom line: A PE with no trauma is a natural PE, no matter what you find (or don’t find) in the legs.

AGE limits for tissue donation: Ref: AATB (13th Edition Standards). “There are no age limits for autologous tissue donation. The Medical Director and/or tissue bank Medical Advisory Committee shall determine age criteria for donor suitability” For example, donors under the age of 14 (potential non-fused long bone epiphyses would be likely unsuitable for ligamentous struts. Very older donors might be utilized for crushed bone grafts, etc. that don’t depend on structural qualities as much. The age range of any bank might fluctuate as the need/and specific donor is considered.

Absolute American Association of Tissue Banks (AATB) Contraindications for Musculoskeletal Tissue to be Released for Transplant (AATB Standards 13th Edition)

1. IV drug abuse in the last 5 years
2. Make/male sex in the last 5 years
3. septicemia,
4. certain viral disease (e.g., HIV, viral hepatitis, WNV, rabies, etc.),
5. human transmissible spongiform encephalopathies  
6. Non-suitable blood specimen for disease testing (after plasma dilution evaluation)  
7. untreated syphilis  
8. clinically active tuberculosis, leprosy(Hansen’s disease), or systemic mycosis; and/or  
9. *rheumatoid arthritis*  
10. *systemic lupus erythematosus*  
11. *Polyarteritis nodosa*  
12. *Sarcoidosis*  
13. Clinically significant metabolic bone disease  

*italicized items are historic AATB rule outs but could change (DLS note) in the future in revisitation of the rationale*

Possible Exclusion (varies by tissue bank); not mandated by AATB or FDA (MD discretion)

Malignancy: There has never been a documented case of transmission of malignancy in musculoskeletal or skin tissue; there has been a case in corneal tissue.

**AATB Infectious Disease Testing Requirement for MS tissues (always more comprehensive than FDA)**

1). Anti-HIV-1 and anti-HIV 2  
2) HIV-1 NAT  
3) HBsAg  
4) total antibodies to hepatitis B core antigen (anti-HBc—total, meaning IgG and IgM);  
5) anti-HCV);  
6) nucleic acid test (NAT) for HCV; and  
7) syphilis (a non-treponemal or treponemal-specific assay may be performed).

**Time Limits for Musculoskeletal/Skin Tissue Recovery (AATB Standards 13th Edition and D5.400 update)**

Tissue excision shall commence within 24 hours of Asystole provided the body was cooled (e.g., application of sufficient amounts of wet ice or a cooling blanket, cold weather conditions) or refrigerated within 12 hours of Asystole. Tissue excision shall commence within 15 hours of death if the deceased donor has not been cooled or refrigerated. If the body is cooled for a period of time then not cooled for a period of time, the time period the body is not cooled cannot exceed 15 cumulative hours.

**Time Limits for Cardiovascular Tissue (Heart for Valve) Recovery (AATB Standards 13th Edition and D5.400 update)**

Warm Ischemic Time (C) shall not exceed 24 hours from Asystole if the body was
cooled (e.g., application of sufficient amounts of wet ice or a cooling blanket, cold weather conditions) or refrigerated within 12 hours of Asystole. The time limit shall not exceed 15 hours if the body was not cooled or refrigerated. If the body is cooled for a period of time then not cooled for a period of time, the time period the body is not cooled cannot exceed 15 cumulative hours.

**Recovery Suite Suitability (AATB 13th Edition)**

**D5.501 Recovery Site Suitability Parameters**

These must address the control of:

1) size/space;
2) lighting;
3) plumbing and drainage for the intended use;
4) the physical state of the facility (i.e., state of repair);
5) ventilation;
6) cleanliness of room and furniture surfaces;
7) pests;
8) traffic;
9) location;
10) other activities occurring simultaneously;
11) sources of contamination; and
12) the ability to appropriately dispose of biohazardous waste and handle contaminated equipment.

**What do tissue bank medical directors actually look for when determining suitability?**

**From AATB 13th edition Standards**

The donor suitability review shall include, but is not limited to:

1) Acceptability of the consent;
2) Suitability of the Recovery Site or where Collection took place;
3) Pertinent information from the medical records generated at the time of death, including any pathology and laboratory reports, physician summaries, and transfusion/infusion information;
4) Autopsy report, if an autopsy was performed;
5) Donor Risk Assessment Interview;
6) All results of laboratory testing relevant to donor suitability;
7) Any Plasma Dilution calculations used to determine the acceptability of the blood sample used for testing;
8) All relevant culture results up to and through the completion of Recovery (e.g., blood cultures, if performed; Pre-Sterilization/Pre-Disinfection Cultures, if available);
9) Pertinent circumstantial and donor screening information relayed to Tissue Bank staff;
10) Results of the Physical Assessment or Physical Examination; and
11) Any other information gathered for the purposes of disease screening as required by Standards and applicable laws or regulations.
Does each donor really matter?

• One Organ and Tissue Donor could save the lives of

8-9 people

And enhance the lives of more than

100 others
Who Are the Medical Experts – The Medico-Legal Council?

Annie Vesterby, MD, DMSc, Aarhus University, Aarhus N, Aarhus, Denmark
Who are the medical experts? - The Medico-Legal Council?

*A. Vesterby & M. Gregersen
(*Vice Chairman of The Medico-Legal Council)
Dpt. of Forensic Medicine
University of Aarhus, Denmark
The Danish Medico-legal Council

- History
- Purpose
- Organisation and procedure
- Case presentation
Legislation

- The purpose of the council is to give medical and pharmaceutical expert opinion to public authorities, e.g., civil and criminal court, in matters concerning the legal situation of an individual.
Organisation

- 10-12 medical expert members
- Chairman and two deputy chairmen
- 100-200 ad hoc medical experts appointed by the chairman
- The council works independently
- Financed by the Department of Justice
The procedure of a case in the Medico-Legal Council

1. Public authority
2. Registration and formalities control
3. Medical Secretary (MD) Summary
4. Chairman/deputy chairman
5. Designation of experts to vote
6. 1st vote
7. 2nd vote
8. 3rd vote
9. Typing and signing of response
10. 1st vote
11. 2nd vote
12. 3rd vote
13. Chairman/deputy chairman
14. Final editing
Questions to the Council

- Must be within the expertise or competence of the council
- Must be neutral, concrete, relevant and clear
- Must not be hypothetical or show evidence/guiding
Case

- A young man suddenly went crazy. He was hand-cuffed by the police and placed on the ground face down with his arms and legs fixed by firm grasps by the police.
- He suddenly lost consciousness and died shortly afterwards without having been resuscitated by the police.
Case-result of autopsy

- Overweight (130 kg/287 lbs)
- A few conjunctival petechiae
- Minor abrasions and a contusion of the thigh due to blunt trauma (nightstick)
- Toxicology: alcohol 1.83 g/l (blood); 2.30 (urine) and cannabis (urine)
Case-result of autopsy

- Cause of death: unclear
- acute heart failure due to excitation, alcohol, cannabis, overweight and prone position with face down was, however, suggested
Second medical opinion from the Medico-Legal Council

- The case was evaluated by three experts: a forensic pathologist, a cardiologist and an anaesthesiologist
- Cause of death: unclear
- Acute heart failure due to excitation, alcohol, cannabis and difficulty of breathing due to prone position with fixed and cuffed hands on the back was suggested
Court procedure

- The experts from the Medico-Legal Council were called as witnesses
- The court/judges refused the defence attorney to call another expert witness referring to the expert opinion given by the Medico-Legal Council
Court decision

- The policemen were acquitted in court on basis of presented evidences
Conclusion

- The Danish Medico-Legal Council has a high credibility in courts and among judges due to its organisation, working procedures and highly qualified, independent medical experts
Fatal Religion Based Child Abuse in Oregon

Larry V. Lewman, MD, Oregon State Medical Examiner’s Office, Clackamas, Oregon, USA
Child Fatalities From Religion-motivated Medical Neglect

Seth M. Asser, MD,* and Rita Swan, PhD‡

ABSTRACT. Objective. To evaluate deaths of children from families in which faith healing was practiced in lieu of medical care and to determine if such deaths were preventable.

Design. Cases of child fatality in faith-healing sects were reviewed. Probability of survival for each was then estimated based on expected survival rates for children with similar disorders who receive medical care.

Participants. One hundred seventy-two children who died between 1975 and 1995 were identified by referral or record search. Criteria for inclusion were evidence that parents withheld medical care because of reliance on religious rituals and documentation sufficient to determine the cause of death.

Results. One hundred forty fatalities were from conditions for which survival rates with medical care would have exceeded 90%. Eighteen more had expected survival rates of >50%. All but 3 of the remainder would likely have had some benefit from clinical help.

Conclusions. When faith healing is used to the exclusion of medical treatment, the number of preventable child fatalities and the associated suffering are substantial and warrant public concern. Existing laws may be inadequate to protect children from this form of medical neglect. Pediatrics 1998;101:625–629; child abuse, child neglect, child fatality, Christian Science, faith healing, medical neglect, prayer, religion and medicine.

Despite the great advances of scientifically based medicine, some individuals and groups continue to look primarily outside of modern medicine for remedial care.¹ Applied to minor or self-limited problems, many nonmedical practices are probably benign, but may lead to avoidable morbidity and mortality with more serious ailments. Claims that prayer or religious beliefs have psychological or other benefits that contribute to illness recuperation are scientifically testable and perhaps supported by some evidence.² ³ Although some churches have published testimonials claiming that organic and functional diseases are healed by soliciting divine power, this has not been confirmed by scientifically valid measures.⁴ Death rates in graduates of a Christian Science college, a group whose central tenets deny the reality of disease and promote avoidance of medical services,⁵ have been reported to be higher than graduates of a secular institution.⁶

Although legal precedents have established the right of an adult to refuse life sustaining treatment, they do not allow parents or guardians to deny children necessary medical care. The US Supreme Court stated this principle eloquently: “The right to practice religion freely does not include the liberty to expose the community or child to communicable disease, or the latter to ill health or death . . . Parents may be free to become martyrs themselves. But it does not follow they are free, in identical circumstances, to make martyrs of their children before they have reached the age of full and legal discretion. . . .”⁷

Despite this ruling, in late 1974 the US Department of Health, Education, and Welfare required states receiving federal child abuse prevention and treatment grants to have religious exemptions to child abuse and neglect charges.⁸ With federal money at stake, states rapidly enacted exemptions for parents who relied on prayer rather than medical care when their children were sick or injured. A decade later nearly every state had these exemptions in the juvenile code, criminal code, or both.⁹ ¹⁰ A few cases of children who died because of religion-motivated medical neglect have received national press coverage, but most get little or none. Reports in the medical literature are also rare. The American Academy of Pediatrics’ first policy statement against religion-based medical neglect in 1988 cited press accounts rather than case reports.¹¹ Outbreaks of vaccine-preventable disease among groups with religious objections to immunization are reported frequently.¹² ¹³ ¹⁴ However, medical citations of fatalities are rare.¹⁴ ¹⁵ One study of perinatal events reported an Indiana sect that had a threefold increase in infant mortality and an 80-fold increase in maternal mortality compared with the general population.¹⁶ The study reported here describes deaths that have occurred after the federal government required religious exemptions to child abuse and neglect laws.

METHODS

We compiled a list of child fatalities in the United States that occurred during the period from 1975 through 1995. Initial cases were from the files of Children’s Healthcare Is a Legal Duty (CHILD), Inc, a nonprofit organization that gathers information on religion-based child abuse and neglect. These cases were collected from newspaper articles, trial records, personal communications, and public documents. With institutional review board approval, police records, coroners’ files, and other confidential materials were examined for additional information. During this supplemental search, 4 additional candidates were identified.

Cases were included if the available information, including clinically descriptive histories and/or post mortem medical data, was sufficient to determine the cause of death with reasonable
medical certainty, the standard for presentation of a medical opinion in most courts. This was assessed by one author (S.M.A.), a pediatrician who has qualified in court to examine records and present expert opinion in child fatality cases.

Cases were excluded if documentation of the cause of death was inadequate or if the history did not indicate that failure to seek medical care was primarily based on a reliance on faith healing. Examples of the latter include children of some Amish communities where the barriers to care are more cultural than theological and children of Jehovah’s Witnesses who were denied only blood products and were not expected to be healed by divine intervention.

After considering the underlying conditions and diagnoses that directly contributed to death, children were assigned a likely outcome with commonly available remedial or preventive medically supervised care (Table 1). Because medical advances altered expected mortality rates during the study period, comparisons were based on clinical experience and published statistics of the appropriate era. For chronic conditions (eg, tumors, diabetes) survival was compared with long-term survival rates published in journals or textbooks from the relevant field. For acute problems, such as infections and perinatal complications, the logical comparison was expected mortality during the acute process.

In most cases, the diagnosis permitted an assignment to an expected outcome based on a published statistic. For example, the mortality rate for treated cases of Rocky Mountain Spotted Fever in 1983 was 2%, less than one-third the rate for untreated cases. Thus, a death during 1984 was considered to have an excellent probable outcome with medical treatment.

In other situations, a diagnostic group could be identified, but not a specific disorder. A child with acute lymphocytic leukemia presenting for medical attention in 1977 would have an expected 3-year survival of 74% and 5-year survival near 0%. Thus this child would be placed into the good outcome group. But a child with a nonspecified leukemia could only be assigned based on overall outcome for all types of the disease and was thus placed into the fair group.

In a few instances, judgment based on clinical experience had to be applied. For example, the data in all cases of renal failure were not adequate to determine an etiology for the end-stage disease. However, they were sufficient to exclude active processes such as Lupus or cancers. All of the teenagers in that group seemed to be good dialysis candidates, ensuring a >90% chance of long-term survival. Thus, the prognosis for their condition was considered excellent. In any situation in which the heterogeneity of clinical presentations made a simple, direct classification difficult, such as in the case of a foreign body aspiration, the most conservative classification that seemed reasonable was assigned.

Infants with fetal demise were placed in favorable prognostic groups only if adequate inspection or autopsy excluded major malformations. Although in utero demise can happen under obstetrical supervision, close monitoring improves detection and treatment of high-risk circumstances that lead to fetal loss. The expected outcome of a third trimester pregnancy is a live born, surviving infant, and thus, for the purpose of this review, expected outcome with care is excellent. Likewise, many of the preterm births might have been delayed with prenatal care or had successful neonatal supportive care. Thus, the expected outcome of preterm infants and stillborns was considered good.

Some of the infants studied were given the legal term stillborn on death certificates. In many cases, however, prenatal reports and witness statements indicated that death occurred during labor or delivery from causes that would have been easily prevented or treated with skilled assistance. Thus, for the purposes of this study, these perinatal deaths were listed in categories other than fetal demise.

RESULTS

Of 201 cases reviewed, 14 lacked sufficient information to be certain of the cause of death. In 15 cases, it could not be established that exclusive reliance on faith healing contributed to the demise. This left 172 children for evaluation.

Childhood Fatalities

The diagnoses of 113 children who died after their neonatal period are summarized in Table 2. Of the 98 children who did not have cancer, 92 would have had an excellent prognosis with commonly available medical and surgical care and 4 would have had a good outcome. Only 2 would have had a good outcome. Only 2 would have not have clearly benefited from care. Many histories revealed that symptoms were obvious and prolonged. Parents were sufficiently concerned to seek outside assistance, asking for prayers and rituals from clergy, relatives, and other church members. For example, a 2-year-old child aspirated a bite of banana. Her parents frantically called other members of her religious circle for prayer during nearly an hour in which some signs of life were still present. In another case, a 6-week-old infant, weighing a pound less than at birth, died from pneumonia. The mother admitted giving the infant cardiopulmonary resuscitation several times during the 2 days before the infant’s death. In one family 5 children died of pneumonia before the age of 20 months, 3 before the study period. Although this raises the possibility of genetic disorders such as cystic fibrosis, immune deficiency, or asthma, many such conditions have a good prognosis with treatment. Their mother was a nurse before joining a church with doctrinal objections to medical care.

One father had a medical degree and had completed a year of residency before joining a church opposed to medical care. After 4 days of fever, his 5-month-old son began having apneic episodes. The father told the coroner that with each spell he “rebuked the spirit of death” and the infant “perked right back up and started breathing.” The infant died the next day from bacterial meningitis.

For the children with tumors, available medical care would have given them a reasonable chance for long-term survival and reduction of pain and suffering. A 2-year-old boy with Wilms’ tumor had a primary that weighed 2.5 kg, approximately one sixth of his body mass. A 12-year-old girl was kept out of school for 7 months while the primary osteogenic sarcoma on her leg grew to a circumference of 41 inches and her parents relied solely on prayer. A timely diagnosis would have allowed at least a modest chance for survival.

Prenatal and Perinatal Fatalities

Table 3 lists the principal causes of 59 prenatal and perinatal deaths. All but 1 of the newborns would have had a good to excellent expected outcome with

<table>
<thead>
<tr>
<th>Classification</th>
<th>Expected Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>Good</td>
<td>50%–89%</td>
</tr>
<tr>
<td>Fair</td>
<td>10%–49%</td>
</tr>
<tr>
<td>Some benefit</td>
<td>&lt;10% expected survival but expectation for pain and suffering reduction under medical care</td>
</tr>
<tr>
<td>No benefit</td>
<td>No significant improvement in outcome expected with medical care</td>
</tr>
</tbody>
</table>

TABLE 1. Classification of Expected Outcomes With Preventive or Remedial Medical Care
medical care. The mothers generally declined prenatal care and the deliveries were either unassisted or attended by nonlicensed midwives. Two mothers had prior cesarean sections and had been advised against home delivery. Siblings of 2 deceased newborns had previously received court-ordered medical care for illness or injury. In one case, a relative of an infant with respiratory difficulty called for medical assistance, but a church elder turned the responding emergency crew away saying that with prayer the infant was breathing better. The infant died within a few hours. One infant was asphyxiated because of intrapulmonary bleeding, which might have been prevented with a routine vitamin K injection.

Pseudoscience was sometimes offered along with prayer. During 1 birth, a 3-day ordeal that included difficult labor and maternal convulsions, the founding elder of the sect told the mother her copious green vaginal discharge was “a good thing,” a sign that she had peritonitis and poisons were being expelled thanks to the prayers of the group. It is likely that her discharge was meconium, a sign of fetal distress.

Deliveries attended by unlicensed midwives had tragic results. In one case, a 23-year-old woman presented to an emergency room after 56 hours of active labor with the infant’s head at the vaginal opening for 16 hours. The dead fetus was delivered via emergency cesarean, and was in an advanced state of decomposition. The mother died within hours after delivery from sepsis because of the retained uterine contents. The medical examiner noted that the corpse of the infant was so foul smelling that it was inconceivable anyone attending the delivery could not have noticed.

Five additional mothers of perinatal infants died from complications of delivery. A few mothers eventually were treated in emergency departments for vaginal lacerations and retained placentas. In 2 cases, dead newborns had twin siblings who survived after being taken to hospitals.

### Other Findings
A total of 23 denominations from 34 states were represented in this study. Five groups accounted for
83% of the total fatalities (Table 4). Several states had totals disproportionate to population. There were 50 from Indiana, home of the Faith Assembly. Pennsylvania had 16 fatalities, including 14 from the Faith Tabernacle. The Church of the First Born accounted for the majority of 15 deaths in neighboring Oklahoma and Colorado. In South Dakota there were 5 deaths from the End Time Ministries. Nationwide, the Christian Science church had 28 deaths in the study.

Contacts with public agencies and mandated reporters of suspected child neglect were not unusual among the children. Believing they were powerless in the face of the parents’ wishes, some teachers ignored obvious symptoms and sent lessons home to bedridden children. Some social workers and law enforcement officers allowed parents to decline examinations of children reported to be ill. Public officials did not investigate the deaths of some children.

One teenager asked teachers for help getting medical care for fainting spells, which she had been refused at home. She ran away from home, but law enforcement returned her to the custody of her father. She died 3 days later from a ruptured appendix.

A premature girl was delivered successfully at a hospital after her twin brother died during a home birth. Her mild respiratory distress syndrome resolved after 4 days of oxygen and other minimally invasive support. She then developed progressively severe apneic spells. The medical staff acquiesced to the parents’ request not to transfer the child to a higher level unit, despite an expected good prognosis. She died 2 days later when she could not be resuscitated after a respiratory arrest.

**DISCUSSION**

Calculations of overall incidence and mortality rates are not possible in this study as the number of children in the groups sampled is not available and the cases were collected in a nonrigorous manner. However, we think that the comparison with outcomes expected in ordinary medical settings is a valid indicator that death and/or suffering were preventable in virtually all of these children. These fatalities were not from esoteric entities but ordinary ailments seen and treated routinely in community medical centers. Deaths from dehydration, appendicitis, labor complications, antibiotic-sensitive bacterial infections, vaccine-preventable disorders, or hemorrhagic disease of the newborn have a very low frequency in the United States.

We suspect that many more fatalities have occurred during the study period than the cases reported here. Deaths of children in faith-healing sects are often recorded as attributable to natural causes and the contribution of neglect minimized or not investigated. During the course of requesting documents for this study, we were told of deaths of children because of religion-motivated medical neglect that were not previously known to us from public records, newspapers, or other sources.

In many jurisdictions the classification of stillborn for an infant who has not taken a breath preempted

---

**TABLE 3.** Perinatal Fatalities Associated With Religion-motivated Medical Neglect

<table>
<thead>
<tr>
<th>Diagnoses</th>
<th>N</th>
<th>Comments</th>
<th>Expected Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal demise</td>
<td></td>
<td>26-, 32-, 34-week gestations</td>
<td>Good</td>
</tr>
<tr>
<td>Preterm</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>6</td>
<td>Large infants, some postterm</td>
<td>Excellent</td>
</tr>
<tr>
<td>Hydrops faetalis</td>
<td>1</td>
<td>Blood group incompatibility</td>
<td>Excellent</td>
</tr>
<tr>
<td>Preterm infants</td>
<td></td>
<td>(All over 30 weeks unless noted)</td>
<td></td>
</tr>
<tr>
<td>Apnea, respiratory arrest</td>
<td>1</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Asphyxia</td>
<td>1</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Intraventricular hemorrhage</td>
<td>1</td>
<td>Nuchal cord, breech</td>
<td>Excellent</td>
</tr>
<tr>
<td>Prematurity, severe</td>
<td>1</td>
<td>34-week gestations</td>
<td>Good</td>
</tr>
<tr>
<td>Respiratory distress syndrome</td>
<td>5</td>
<td>600 g, 1 month maternal bleeding</td>
<td>Good</td>
</tr>
<tr>
<td>Respiratory failure, unspecified</td>
<td>3</td>
<td>Several lived more than a day at home</td>
<td>Excellent</td>
</tr>
<tr>
<td>Septicemia, strep</td>
<td>1</td>
<td>Subarachnoid hemorrhage</td>
<td>Excellent</td>
</tr>
<tr>
<td>Traumatic delivery</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Term infants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anencephaly, myelomeningocele</td>
<td>1</td>
<td></td>
<td>No benefit</td>
</tr>
<tr>
<td>Asphyxia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nonspecified</td>
<td>5</td>
<td>Several failed unskilled resuscitations</td>
<td>Excellent</td>
</tr>
<tr>
<td>breech</td>
<td>6</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>maternal shock</td>
<td>1</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>nuchal cord</td>
<td>2</td>
<td>From 2 to 4 days</td>
<td>Excellent</td>
</tr>
<tr>
<td>prolonged labor</td>
<td>6</td>
<td>Internal and external head injuries</td>
<td>Excellent</td>
</tr>
<tr>
<td>uncleared secretions</td>
<td>2</td>
<td>Pulmonary hemorrhage, lived 4 days</td>
<td>Excellent</td>
</tr>
<tr>
<td>Birth trauma</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic disease of newborn</td>
<td>1</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Hypothermia, shock</td>
<td>1</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Meconium aspiration</td>
<td>2</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>3</td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| TABLE 4. Religious Groups With Core Beliefs of Medical Care Avoidance |
|--------------------------|------------------|
| Organization Name        | Deaths |
| Church of the First Born | 23     |
| End Time Ministries      | 12     |
| Faith Assembly           | 64     |
| Faith Tabernacle         | 16     |
| First Church of Christ, Scientist (Christian Science) | 28 |
| Other denominations (N = 18), or unaffiliated | 29 |
| Total                    | 172    |

628 DEATHS FROM RELIGION-MOTIVATED NEGLECT
involvement of individuals involved in unattended deliveries, including unlicensed midwives.

The legal requirements for care of infants who have begun breathing are also inadequate in some states. One Indiana jury acquitted parents who let their 9-hour-old, preterm infant die without medical help. The judge instructed the jury that state law did not require the parents to obtain hospitalization until the infant had stopped breathing. Because survival after out-of-hospital cardiopulmonary arrest of infants is generally poor, such a law effectively obviates a duty to provide care.

In 1983, the federal government removed religious exemptions from federal mandate, allowing states to repeal them. The well-organized lobbying of exemption supporters, however, has defeated most repeal efforts. Today only five states, Massachusetts, Maryland, Nebraska, North Carolina, and Hawaii, have no exemptions either to civil abuse and neglect or criminal charges. The law and politics of this issue are discussed extensively elsewhere.

Twenty-six percent of the deaths in this study have occurred since 1988, when the American Academy of Pediatrics first called for elimination of religious exemption laws and several years after the federal government began allowing repeal. Excluding the Faith Assembly in which high reported maternal and child death rates declined after some prosecutions and the death of its charismatic leader, 35% of the fatalities in this sample occurred from 1988 to 1995, 38% of the study period. Thus, it seems that this form of preventable child mortality continues unchecked.

From our observation, religious exemption laws promote the assumption that parents have the right to withhold necessary medical care from their children on religious grounds. Mandated reporters have been discouraged from contacting authorities or are unaware of their obligations and of means for state intervention. State agencies have sometimes hesitated to act on reports they do receive. Whereas Christian Science church leaders advise members in Britain and Canada to obey laws requiring medical care of sick children, they have advised US members that the laws allow them to withhold medical care. Several Pentecostal clergy and parents have also claimed that exemption laws confer the right to deny medical care to children.

The American Academy of Pediatrics, American Medical Association, National District Attorneys Association, and National Committee for the Prevention of Child Abuse, among others, have adopted policy statements calling for the complete repeal of religious exemptions in child abuse and neglect and criminal statutes. The children of members of faith-healing sects deserve the same protections under the law as other children have. We believe that the repeal of exemption laws is a necessary step toward assuring such protection and should be accomplished before hundreds more children suffer needlessly and die prematurely.

ACKNOWLEDGMENTS

We thank Drs Faith Kung and Alice L. Yu for their assistance in locating data on prognoses of tumor patients. Drs Lynne M. Bird, William B. Weil, and Donna A. Rosenberg made helpful suggestions on the manuscript.

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ARTICLES 629
We at Children’s Healthcare Is a Legal Duty (CHILD) extend greetings to the forensic pathologists and hope that your national conference is very informative and enjoyable.

CHILD was founded in 1983 by Rita and Doug Swan after they lost their only son Matthew because of trusting Christian Science practitioners to heal him. They left the Christian Science church immediately after his death and within a year decided that harm to children from faith healing was an issue that should be addressed by policymakers.

**CHILD’s mission and achievements**

Our mission is to stop child abuse and neglect related to religious beliefs, cultural traditions, or quackery. We oppose harm to children that is enabled by or rationalized by belief systems, whether religious or secular. We oppose all religious exemptions from child health and safety laws.

National organizations that have adopted positions against religious exemptions from child health laws have done so after input from CHILD members. These include the American Academy of Pediatrics, American Medical Association, Prevent Child Abuse America, National District Attorneys Association, and the National Association of Medical Examiners.

Unfortunately, most states have religious exemptions from child neglect or endangerment laws. Five even have religious defenses to manslaughter and two to homicide. Every state has a religious exemption to a preventive or diagnostic measure.

CHILD has worked for decades against religious exemptions from providing medical care to sick and injured children. CHILD and its members have worked in 24 state legislatures for children to have equal protection of the law, including equal protection of medical care.

**Oregon**

We are particularly grateful for what we were able to accomplish in Oregon. For decades children died without medical care in the Oregon Followers of Christ, but public officials paid no attention until Dr. Larry Lewman became the state medical examiner. He made sure the child deaths got autopsied and forensic reports were written that could stand up in court. He presented every case to the district attorney even though the district attorney always declined to file charges because Oregon had religious defenses to homicide by abuse or neglect, manslaughter, criminal mistreatment, criminal non-support, neglect, and failure to provide.

In 1998 Dr. Lewman and a new district attorney sent the press to the Followers of Christ cemetery, who found 78 children buried there. The public was outraged. Representative Bruce Starr introduced a bill to repeal all nine of Oregon’s religious exemptions from a duty to care for sick children.
CHILD President Rita Swan made several trips to Oregon to testify and work for the bill. The legislature finally repealed five of the nine exemptions in 1999.

We hoped that would be enough to persuade the Followers to change their behavior and for several years it seemed that it had. But in 2008 the medical neglect deaths and injuries began again.

In 2011 Senator Starr and Representative Carolyn Tomei introduced a bill to repeal the remaining four exemptions. Rita and Douglas Swan moved to Salem to work for it and the bill passed nearly unanimously as an emergency measure. No Oregon Followers of Christ children have died of medical neglect since 2009.

Idaho

There are four or more Followers of Christ churches in Idaho who have lost many children because of their religious opposition to medical care. No criminal charges have been filed in cases of religion-based medical neglect since Idaho enacted religious defenses to manslaughter and criminal injury to a child. Prosecutors and other public officials have just assumed that parents had a religious right to let their children die. In a 2010 case the Idaho police would not even report a severely injured child to Child Protective Services because his parents had religious beliefs against medical care. One coroner does not even do autopsies on children who die because of religion-based medical neglect. Idaho law requires autopsies only when a crime is suspected.

A CHILD member has walked through the Peaceful Valley Cemetery in Idaho used by the Followers of Christ and recorded names plus birth and death dates of all children buried there. 204 of the 592 graves are of minor children or stillbirths. The majority of the children died after the religious exemption laws were enacted.

A CHILD member got a bill introduced in the Idaho legislature this year to limit the religious defense to criminal injury to a child. The Speaker of the House would not allow the House Judiciary Committee to hold a hearing or vote on the bill. CHILD will try again in 2015.

The press has reported on twelve Idaho Follower of Christ children who died during the years 2011 through 2013. None had medical attention. Some of these children surely experienced great pain and terror. Sixteen-year-old Arrian Granden vomited so much that her esophagus ruptured. Sixteen-year-old Pamela Eells died of pneumonia and drowned as her lungs slowly filled with fluid. Four-day-old Micah Eells died of a bowel obstruction; he was likely screaming and vomiting for hours.

A large number of Idaho children are in danger. We consider their situation an emergency that we must try to remediate. We would be grateful for forensic pathologists, coroners and medical examiners to speak out against Idaho laws that deprive one group of children of protections the state extends to others—the protection of necessary medical care.

CHILD’s webpage at www.childrenshealthcare.org has a wealth of information about child abuse and neglect related to religious beliefs and other strongly-held belief systems. We are attaching a Pediatrics report by two CHILD officers on 172 U.S. child deaths in faith-healing sects. Today CHILD has information on over 400 U.S. children who died after medical care was withheld on religious grounds since 1975.
Medical Examiner Collection of Comprehensive, Objective Medical Evidence For Conducted Electrical Weapons and Their Temporal Relationship to Sudden Arrest

Mark W. Kroll, PhD, FACC, University of Minnesota, Minneapolis, Minnesota, USA
Brief Outline of Partial Selected CEW Research and Information\textsuperscript{1,2,3,4}

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\textsuperscript{1} This document is intended to provide a basic selected overview and selected summary of injury related information and research concerning TASER International, Inc. ("TASER") brand conducted electrical weapons ("CEW") or electronic control devices ("ECD"), and others. For a more complete current bibliography or index of CEW related research ("CEW Index") please go to www.ecdlaw.info or www.TASER.com. The most current CEW Index is included herein in its entirety. Also included for points of reference are selected data regarding general health concerns and mortality, morbidity, cause of deaths, and injuries among the United States population, other populations, and law enforcement specific.

\textsuperscript{2} This document specifically includes all referenced documents in their entirety as if they were included herein in their complete forms. The underlying or foundational documents, references, or materials, to this document are specifically included, adopted, and hereby incorporated herein as an integral part of this document (specifically including the superseding most current, including updates, draft or version of this document).

\textsuperscript{3} This document specifically supersedes, nullifies, and obsoletes any prior draft or version of this document.

\textsuperscript{4} For ease of use various documents are repeated where appropriate in different sections. This is not meant to be cumulative. Such duplications are made simply to assist the reader with expeditiously reviewing a particular concept or section.
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Selected CEW Treatises, Organization Position and Review Papers

Selected CEW Treatises:

Table 1 Selected CEW Treatises

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<th>No.</th>
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<th>Title</th>
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<tbody>
<tr>
<td>1</td>
<td>Feb. 2012</td>
<td>Atlas of Conducted Electrical Weapon Wounds and Forensic Analysis</td>
</tr>
<tr>
<td>2</td>
<td>Mar. 2009</td>
<td>TASER® Electronic Control Devices: Physiology, Pathology, and Law</td>
</tr>
<tr>
<td>3</td>
<td>Apr. 2008</td>
<td>TASER ELECTRONIC CONTROL DEVICES AND SUDDEN IN-CUSTODY DEATH: Separating Evidence from Conjecture</td>
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</table>


2. (03/2009 Kroll) TASER® Electronic Control Devices: Physiology, Pathology, and Law, by Mark W. Kroll (Editor), Jeffrey D. Ho (Editor).


Selected Treatise CEW Chapters:

Table 2 Selected Treatise CEW Chapters

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<th>No.</th>
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<tbody>
<tr>
<td>1</td>
<td>Sep. 2011</td>
<td>Chapter 8: TASER Conducted Electrical Weapons, Clinical Forensic Medicine: A Physician’s Guide. 3rd Edition</td>
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Table 3 Selected CEW Organization White Papers/Statements

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<th>Date</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and Canadian Academy of Health Sciences.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>October 2013.</td>
</tr>
<tr>
<td>3</td>
<td>May 2011</td>
<td>AAEM: Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician</td>
</tr>
<tr>
<td>4</td>
<td>May 2011</td>
<td>NIJ: Study of Deaths Following Electro Muscular Disruption</td>
</tr>
<tr>
<td>7</td>
<td>Jun. 2009</td>
<td>AMA: Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agencies (Reference Committee D)</td>
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RESTAINT stands for “Risk of dEath in Subjects That Resist: Assessment of Incidence and Nature of fAtal events.”

RESTAINT stands for “Risk of dEath in Subjects That Resist: Assessment of Incidence and Nature of fAtal events.”

## Table 4 Selected Primary CEW Review Papers

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# Selected CEW-Temporal Arrest-Related Death (ARD) Review Papers:

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   a. **(pg 98) “Discussion** The main findings of the study are as follows:

   (1) The demonstrated incidence of ECD-induced cardiac arrest is extremely low, if not zero.

   (2) Conclusions of a connection between ECD use and cardiac arrest are speculative at best.

   (3) The role of several non-ECD confounding factors explaining cardiac arrests are not accounted for in published case reports.


   a. “… Although there is no anatomic cause of death in excited delirium, catecholamine-induced cardiac arrhythmias, restraint or positional asphyxia, or adverse cardiorespiratory effects of CED (e.g. TASER®) are often cited [3–5]. However, case reviews demonstrate that the individual is medically unstable and in a rapidly declining state that has a high risk of mortality even with medical intervention or in the absence of restraint stress or CED deployment [5,6]."
   b. “Electrical incapacitation (CED) to override the CNS or pain compliance (dry stun) was used on 18% of the cases with a variable number of deployments and strikes (data not shown).”

   a. “Conclusions: In sudden deaths proximate to CEW discharge, immediate collapse is unusual, and VF is an uncommon VF presenting rhythm. Within study limitations, including selection bias and the possibility that VF terminated before the presenting rhythm was recorded, these data do not support electrically induced VF as a common mechanism of these sudden deaths.”
   b. “… For subject 1 [(GA) Gresmond Gray], who collapsed immediately (subject 6 in Table 4), neither drugs nor cardiac disease can be implicated; both the
time course and the electrode location are consistent with electrically induced VF.”


(a) “Cause of Death: PHYSIOLOGIC STRESS OF A PHYSICAL ALTERCATION AND Due to: **** HEART ENLARGEMENT AND FIBROSIS OSC: NON RECENT COCAINE USE”

(i) “OTHER SIGNIFICANT CONDITION: History of non-recent cocaine use.”

(b) “Reports of toxicological testing revealed the presence of ethyl alcohol at a level approximately equivalent to 0.145 on the Breathalyzer scale, as well as the presence of a breakdown product of tetrahydrocannabinol (THC, marijuana).”

(c) “… The heart disease consisted of microscopic evidence of heart enlargement and fibrosis (scarring). This heart disease increases the risk of a sudden fatal cardiac arrhythmia (irregular heartbeat), particularly during times of physiologic stress. Mr. Gray had a history of cocaine use, and chronic (non-recent) cocaine use may have caused or partially caused the heart disease. Hypertension may also have played a role in causing the heart disease. …”


a. “Results: There were 162 ARD events reported that met inclusion criteria. The majority were male with mean age 36 years, and involved bizarre, agitated behavior and reports of drug abuse just prior to death. Law enforcement control techniques included none (14%); empty-hand techniques (69%); intermediate weapons such as TASER® device, impact weapon or chemical irritant spray (52%); and deadly force (12%). Time from contact to subject collapse included instantaneous (13%), within the first hour (53%) and 1–48 hours (35%). Significant collapse time associations occurred with the use of certain intermediate weapons.”

b. “… We did not find any cases in which a TASER device had been used on a suspect with immediate temporal relation to their time of collapse.”

   a. TASER device used in 28% of the incidents. No TASER device used in 72% of the incidents.

   b. “… There was low association for capsicum spray and the Taser device, which were used in 33% and 28% of cases.”

   c. “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 was 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.”
Epidemiological (Field) Studies:

Epidemiological (Field) Studies: Chest Probe Hits

Table 6 Epidemiological (Field) Studies: Chest Probe Hits

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<th>Title</th>
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</thead>
</table>


   a. “RESTRAINT has also demonstrated that it is possible to prospectively document the location of conducted energy weapon deployments (including the pairing of darts) in subjects undergoing conducted energy weapon activation. We began collecting data on dart location part way through study enrollment and we have information on dart location in 115 of 336 probe mode deployments (34%). At least one dart struck the patient’s anterior chest in 40/115 (34.8%); both darts struck any part of the subject’s anterior chest in 8/115 probe deployments (7%). No subject died with darts to the chest in any configuration.” Page 3.

b. “Of the 745 CEW deployments, the mode of deployment was recorded in 565. Of those, 103 did not include actual current activation but consisted of display of the laser light sighting only. In the remaining 462 actual activations of the device(s), 336 included the use of CEW probes and 126 included contact stun deployments. When CEW was used in any fashion it was used alone in just under half of the events (44.7%). In the remaining 55.3% of CEW deployments, CEW was used in conjunction with another restraint modality.” Pages 2-3.

a. White found that only 36% (57/158) of ECD-involved arrest-related deaths had a chest probe (p = 0.004 by chi-square) thus disproving the hypothesis that an application anywhere on the chest presents a risk of VF.


   a. “Conclusion: CEW deployments with probe impact configurations capable of producing a transcardiac discharge occur in a minority of cases in field use conditions. None of these cases, transcardiac or otherwise, produced immediately fatal dysrhythmias. These data support the overall safety of CEWs and provide a benchmark estimate of the likelihood of transcardiac discharge vectors occurring in field use of CEWs.”

   b. “An estimated 609 of these (15%) may have had a transcardiac discharge; with no sudden deaths suggestive of cardiac dysrhythmia observed, the 97.5% confidence interval for an observed proportion of zero deaths in 609 criminal suspects with potential transcardiac CEW discharge is 0.0–0.6.”

Cardiac – Selected CEW Medical/Scientific Literature

Probability of CEW Induced Ventricular Fibrillation:

Table 7 Probability of CEW Induced Ventricular Fibrillation

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Lead Author</th>
<th>CEW VF Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jan. 2014</td>
<td>Kroll</td>
<td>The demonstrated incidence of ECD-induced cardiac arrest is extremely low, if not zero. Conclusions of a connection between ECD use and cardiac arrest are speculative at best.</td>
</tr>
<tr>
<td>2</td>
<td>Oct. 2013</td>
<td>Canada</td>
<td>no “confirmation or exclusion of a clear causal link”</td>
</tr>
<tr>
<td>3</td>
<td>Mar. 2013</td>
<td>Dawes</td>
<td>no more than 0.59% (even with cardiac capture)</td>
</tr>
<tr>
<td>4</td>
<td>Aug. 2012</td>
<td>White</td>
<td>disproving the hypothesis that a CEW application anywhere on the chest presents a risk of VF</td>
</tr>
<tr>
<td>5</td>
<td>May 2012</td>
<td>Bozeman</td>
<td>0.0–0.6</td>
</tr>
<tr>
<td>6</td>
<td>Nov. 2011</td>
<td>Kroll</td>
<td>1:2,500,000 (theoretical VF risk estimate)</td>
</tr>
</tbody>
</table>


   a. (pg 98) “Discussion” The main findings of the study are as follows:

   (1) The demonstrated incidence of ECD-induced cardiac arrest is extremely low, if not zero.

   (2) Conclusions of a connection between ECD use and cardiac arrest are speculative at best.

   (3) The role of several non-ECD confounding factors explaining cardiac arrests are not accounted for in published case reports.


   a. “In the [> 2,000,000 CEW] field [uses], there has not been a conclusive case of fatal ventricular fibrillation caused solely by the electrical effects of a CEW (NIJ, 2011). A small number of human cases have found a temporal relationship between CEWs and fatal cardiac arrhythmias (Swerdlow et al., 2009; Zipes, 2012) but they do not allow for confirmation or exclusion of a clear causal link. …” (Page 26).
   a. “… In our estimates, the risk of VF based on this data is no more than 0.29 %. The consensus panel estimated the risk of death in a TASER-related incident to be no more than 0.25 %, in close agreement. Even with cardiac capture, the risk of VF from our data was no more than 0.59 %.”  
   b. “a total of 354 … [CEW] exposures [in 84–85 lb swine] with no recorded cases of VF.”  
   c. “Among [CEW] exposures with [electrical cardiac] capture, the probability of VF is no more than 0.59 % (95 % CI 0.014–3.3 %).”  

   a. White found that only 36% (57/158) of ECD-involved arrest-related deaths had a chest probe (p = 0.004 by chi-square) thus disproving the hypothesis that an application anywhere on the chest presents a risk of VF.

   a. Bozeman reported that 49% (424/874) of probe-mode cases involved a probe in the chest.  
   b. “Conclusion: CEW deployments with probe impact configurations capable of producing a transcardiac discharge occur in a minority of cases in field use conditions. None of these cases, transcardiac or otherwise, produced immediately fatal dysrhythmias. These data support the overall safety of CEWs and provide a benchmark estimate of the likelihood of transcardiac discharge vectors occurring in field use of CEWs.”

---


c. “An estimated 609 of these (15%) may have had a transcardiac discharge; with no sudden deaths suggestive of cardiac dysrhythmia observed, the 97.5% confidence interval for an observed proportion of zero deaths in 609 criminal suspects with potential transcardiac CEW discharge is 0.0–0.6.”


a. “CONCLUSIONS: Sophisticated published computer models have estimated the risk of ventricular fibrillation for conducted electrical weapons. A growing body of epidemiological data has now shown that these models produced over-estimates. With the use of male body habitus data, and correcting for the differences between swine and humans the models now give a theoretical VF risk estimate of about 0.4 PPM or 1 per 2.5 million. This is consistent with the epidemiological findings to date.”
## Table 8 Prospective CEW Human Cardiac Studies

<table>
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<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
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a. “Conclusion. This study examined the acute and longer term effects of ECD exposure in healthy volunteers exposed to the X26 as a component of their law enforcement training. There was no evidence that X26 exposure induced direct injury to cardiac and skeletal muscle tissue. For those with otherwise normal 12-lead ECG, exposure to the X26 did not persistently affect ECG morphology. For those with preexisting ECG abnormalities (9 of 101 subjects), 1 showed a NSST wave change in an increased number of leads post exposure, whereas another showed the development of inferior NSST wave changes after the X26 exposure.”


   a. “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.”


   a. “Conclusions: An apparent brief myocardial capture event occurred with the NGCEWv1. This device was not released and was redesigned. The NGCEWv2 appears to exhibit a reasonable degree of cardiac safety with frontal torso exposures and multiple probe combination configurations.”


   a. “Conclusions: The mean tissue resistance was 602.3 Ω in this study. There was a decrease in resistance of 8% over the 5-second exposure. This physiologic load is different than the 400 Ω laboratory load used historically by the manufacturer. We recommend future characterization of these devices use a physiologic load for reporting electrical characteristics. We also recommend that all the electrical characteristics be reported.”

a. **Conclusion.** In agreement with 2 prior studies by these authors, the TASER X26 did not capture the myocardium when used with probe deployment, even in the cardiac electrical axis. These data are contrary to animal studies in which capture occurred. We recommend other investigators replicate our findings.


   a. **Conclusion:** CEW exposure produced no detectable dysrhythmias and a statistically significant increase in heart rate. Overall, Taser CEW exposure appears to be safe and well tolerated from a cardiovascular standpoint in this population. This study increases the cumulative human subject experience of CEW exposure with continuous ECG monitoring and includes 28 full 5-s exposures.


   a. **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.


   a. **Conclusions:** A 10-second ECD exposure in an ideal cardiac axis application did not demonstrate concerning tachyarrhythmias using human models. The swine model may have limitations when evaluating ECD technology.”

   a. “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.”


   a. “Conclusions: Prolonged 15 second CEW application in a physically exhausted adult human sample did not cause a detectable change in their 12-lead ECGs. Theories of CEW induced dysrhythmias are not supported by our findings.”


   a. “Conclusion: A 15 second CEW application on exercised volunteers did not demonstrate any evidence of induced tachyarrhythmia. It is unlikely that CEW exposure induces cardiac rate capture or tachyarrhythmia in humans.”

a. “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.”


a. “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.”
## Epidemiological Studies – No CEW Induced Cardiac Arrhythmia:

### Table 9 Epidemiological Studies – No Documented CEW Induced Cardiac Arrhythmias

<table>
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<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apr. 2013</td>
<td>Becour, B. 2013. Conducted Electrical Weapons or Stun Guns A Review of 46 Cases Examined in Casualty. Am J Forensic Med Pathol &amp; Volume 00, Number 00, Month 2013.</td>
</tr>
</tbody>
</table>


**Abstract**

**OBJECTIVE:** Conducted electrical weapons (CEWs) such as the TASER are often used by law enforcement (LE) personnel during suspect apprehension. Previous studies have reported an excellent safety profile and few adverse outcomes with CEW use in adults. We analyzed the safety and injury profile of CEWs when used during LE apprehension of children and adolescents, a potentially vulnerable population.
METHODS: Consecutive CEW uses by LE officers against criminal suspects were tracked at 10 LE agencies and entered into a database as part of an ongoing multicenter injury surveillance program. All CEW uses against minors younger than 18 years were retrieved for analysis. Primary outcomes included the incidence and type of mild, moderate, and severe CEW-related injury, as assessed by physician reviewers in each case. Ultimate outcomes, suspect demographics, and circumstances surrounding LE involvement are reported secondarily.

RESULTS: Of 2026 consecutive CEW uses, 100 (4.9%) were uses against minor suspects. Suspects ranged from 13 to 17 years, with a mean age of 16.1 (SD, 0.99) years (median, 16 years). There were no significant (moderate or severe) injuries reported (0%; 97.5% confidence interval, 0.0%-3.6%). Twenty suspects (20%; 95% confidence interval, 12.7%-29.1%) were noted to sustain 34 mild injuries. The majority of these injuries (67.6%) were expected superficial punctures from CEW probes. Other mild injuries included superficial abrasions and contusions in 7 cases (7%).

CONCLUSIONS: None of the minor suspects studied sustained significant injury, and only 20% reported minor injuries, mostly from the expected probe puncture sites. These data suggest that adolescents are not at a substantially higher risk than adults for serious injuries after CEW use.

   a. “Conclusion: CEW deployments with probe impact configurations capable of producing a transcardiac discharge occur in a minority of cases in field use conditions. None of these cases, transcardiac or otherwise, produced immediately fatal dysrhythmias. These data support the overall safety of CEWs and provide a benchmark estimate of the likelihood of transcardiac discharge vectors occurring in field use of CEWs.”
   b. “An estimated 609 of these (15%) may have had a transcardiac discharge; with no sudden deaths suggestive of cardiac dysrhythmia observed, the 97.5% confidence interval for an observed proportion of zero deaths in 609 criminal suspects with potential transcardiac CEW discharge is 0.0–0.6.”


a. “Conclusions: Significant injuries related to 6 years of law enforcement CEW use [1,001 individuals] in one city were rare. A large percentage of those subjected to CEW use had diagnoses of substance abuse and/or psychiatric conditions. Most admissions after CEW use were unrelated to law enforcement restraint.”

b. “Physiologic studies initially focused on cardiac effects. Although some researchers have found no evidence of changes in electrocardiogram tracings,34 echocardiographic changes,35 or elevations in troponin,36 others have reported QT prolongation,37 potential to induce ventricular fibrillation,38 case reports of direct cardiac effects,39,40 and theories of acute stress cardiomyopathy41 have led some experts to suggest that no conclusive results can be drawn as yet.4” Pg. 1245.


a. “When this experience is combined with previous reports of medical outcomes after consecutive field use of conducted electrical weapons, including Eastman et al (n 426), Bozeman et al (n 1201), and a recent abstract by Angelidis et al (n 1101), there is a combined experience of 4,058 consecutively monitored conducted electrical weapon uses with an electrical shock delivered. Serious injuries are clearly rare, and there are no cases in any of the reports suggesting sudden cardiac death related to the [TASER ECD].”


a. “A three-year review of all [TASER ECD] uses against criminal suspects at six law enforcement agencies found only three significant injuries out of 1,201 criminal suspects subdued by conducted electrical weapons (CEW), or Tasers, and reports that 99.75% of criminal suspects shocked by a Taser received no injuries or mild injuries only, such as scrapes and bruises. These weapons appear to be very safe, especially when compared to other options police have for subduing violent or combative suspects.”


a. No cardiac arrests caused by CEDs among 426 consecutive CED activations (November 1, 2004 through January 31, 2006).


a. “Limitations: Because this report is a descriptive case series, causal links cannot be made ...”

b. “Conclusions: Our data show that sudden deaths can and do occur after Taser use. A common factor in these deaths is extreme agitation, often in the setting of stimulant drug use and/or preexisting heart disease. This finding is consistent with prior studies of restraint-related fatalities.”


a. “The M26 appears to be a safe and effective non lethal weapon in this case series. No deaths were reported. However, a higher incidence of minor injury was noted more than previous manufacturer reports. A prospective trial of its use to better define a risk–benefit relationship is justified.”

**Skin-to-Heart Distances in Humans:**

**Table 10 Skin-to-Heart Distances in Humans**

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<th>No.</th>
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<th>Title</th>
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a. “Conclusions: In this study of adults, the average location of the site of mSHD was slightly to the left of mid sternum and just below the lowest rib insertion. There is a linear relationship between BMI and mSHD. The size of a person and the anatomic relationship of the heart to the anterior chest wall can influence the potential cardiac capture by NMIDs at the site of mSHD.”
### Table 11 CEW VF Safety Margin – Partial Publications List

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>VF Cardiac Safety Factor</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Jan. 2013</td>
<td>X26 in &quot;no VF&quot; safety of IEC 60479 Part 2</td>
<td>Adler&lt;sup&gt;9&lt;/sup&gt;, Modern Instrumentation</td>
</tr>
<tr>
<td>18</td>
<td>Mar. 2012</td>
<td>0.0–0.6[+] sudden death probability with transcardiac CEW discharge</td>
<td>Bozeman&lt;sup&gt;10&lt;/sup&gt;, Journal of Emergency Medicine</td>
</tr>
<tr>
<td>17</td>
<td>Nov. 2009</td>
<td>“very large” safety margin</td>
<td>Jauchem&lt;sup&gt;11&lt;/sup&gt;, Forensic Science Medical Pathol.</td>
</tr>
<tr>
<td>16</td>
<td>Sep. 2009</td>
<td>“low likelihood,” 50% probability of X26-like pulses ranged from 4 to 5 times higher</td>
<td>Beason&lt;sup&gt;12&lt;/sup&gt;, Journal of Forensic Science</td>
</tr>
<tr>
<td>15</td>
<td>Sep. 2007</td>
<td>“large safety factors”</td>
<td>Ideker&lt;sup&gt;13&lt;/sup&gt;, Am J Forensic Med Pathol</td>
</tr>
<tr>
<td>14</td>
<td>Sep. 2007</td>
<td>30X</td>
<td>Panescu&lt;sup&gt;14&lt;/sup&gt;, EMB Mag. IEEE</td>
</tr>
<tr>
<td>13</td>
<td>Feb. 2007</td>
<td>M26 &gt; 70X; X26 &gt; 240X</td>
<td>Holden&lt;sup&gt;15&lt;/sup&gt;, Physics in Medicine &amp; Biology</td>
</tr>
<tr>
<td>12</td>
<td>Sep. 2006</td>
<td>No VF</td>
<td>Stratbucker&lt;sup&gt;16&lt;/sup&gt;, EMBS, IEEE</td>
</tr>
<tr>
<td>11</td>
<td>Aug. 2006</td>
<td>No VF (normal X26)</td>
<td>Nanthakumar&lt;sup&gt;17&lt;/sup&gt;, J Am Coll Cardiol.</td>
</tr>
<tr>
<td>10</td>
<td>Aug. 2006</td>
<td>Significant safety margin</td>
<td>Lakkireddy (cocaine)&lt;sup&gt;18&lt;/sup&gt;, J Am Coll Cardiol.</td>
</tr>
<tr>
<td>9</td>
<td>Mar. 2005</td>
<td>240:1</td>
<td>U.K., Police Scientific Development Branch&lt;sup&gt;19&lt;/sup&gt;</td>
</tr>
<tr>
<td>8</td>
<td>Mar. 2005</td>
<td>16:1 (160 lbs)</td>
<td>U.S. Government, HECOE&lt;sup&gt;20&lt;/sup&gt;, AFRL</td>
</tr>
<tr>
<td>7</td>
<td>Jan. 2005</td>
<td>Significant safety margin</td>
<td>McDaniel&lt;sup&gt;21&lt;/sup&gt;, PACE</td>
</tr>
<tr>
<td>6</td>
<td>Oct. 2004</td>
<td>No reported VF in field or training; VF not expected in healthy adult populations</td>
<td>U.S. Government, HECOE&lt;sup&gt;22&lt;/sup&gt;, HERC Abstract</td>
</tr>
</tbody>
</table>


<sup>13</sup> 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. Sep 2007;28(3):195–201.


<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>VF Cardiac Safety Factor</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Jun. 2004</td>
<td>X26 No VF</td>
<td>Southwell\textsuperscript{22}, Australia, Alpert Hospital</td>
</tr>
<tr>
<td>4</td>
<td>Jun. 2004</td>
<td>M26/MES VF &quot;extremely unlikely&quot;</td>
<td>Sherry\textsuperscript{24}, HECOE, AFRL</td>
</tr>
<tr>
<td>3</td>
<td>Sep. 2003</td>
<td>M26 No VF</td>
<td>Southwell\textsuperscript{22}, Australia, Alpert Hospital</td>
</tr>
<tr>
<td>2</td>
<td>Sep. 2003</td>
<td>&gt;20X</td>
<td>Stratbucker\textsuperscript{26}, EMBS, IEEE</td>
</tr>
<tr>
<td>1</td>
<td>Mar. 2003</td>
<td>TASER Area Denial – power far below that necessary to cause VF</td>
<td>Gonzalez\textsuperscript{27}, HECOE, AFRL</td>
</tr>
</tbody>
</table>

**Risk of Cardiac Arrhythmia from CEW:**

**Table 12 Risk of Cardiac Arrhythmia from CEW**

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<th>Title</th>
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\textsuperscript{22} Report Summary, Releasable to the Public. The Human Effects Center of Excellence (HECOE), established by the Air Force Research Laboratory (AFRL) and the Joint Non-Lethal Weapons Program (JNLWP), conducted a Human Effectiveness and Risk Characterization (HERC) for Electromuscular Incapacitation (EMI) devices.


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   a. “Although there are isolated descriptions of arrhythmias temporally associated with Taser use (Kim and Franklin, 2005; Multerer et al., 2009), there has been no evidence to directly relate the two.” Pg. 101.


   a. “Conclusion: CEW deployments with probe impact configurations capable of producing a transcardiac discharge occur in a minority of cases in field use conditions. None of these cases, transcardiac or otherwise, produced immediately fatal dysrhythmias. These data support the overall safety of CEWs and provide a benchmark estimate of the likelihood of transcardiac discharge vectors occurring in field use of CEWs.”

   b. “An estimated 609 of these (15%) may have had a transcardiac discharge; with no sudden deaths suggestive of cardiac dysrhythmia observed, the 97.5% confidence interval for an observed proportion of zero deaths in 609 criminal suspects with potential transcardiac CEW discharge is 0.0–0.6[%].”


   a. “Despite individual medical publications that associate CEWs with effects on human cardiac physiology, the majority of human research could not confirm a risk of inducing ventricular fibrillation. Accordingly, CEWs appear to have a reasonable degree of cardiac safety.”


   a. “21. Whether or not the discharge current from the Taser X26 or M26 is able directly to influence heart rhythm remains controversial. Additional human experimental studies with these devices should help to clarify the risk from discharge applied to the frontal chest through skin-embedded Taser barbs.” Pgs 5–6.
b. “76. It is not known whether there is a risk of cardiac capture with the Taser X26 or M26 (paras. 14–21). If there is a risk, then children and thin adults may be more vulnerable to discharge administered through barbs that have penetrated the frontal chest in the region overlying the heart. Although DOMILL does not provide operational advice on Taser point-of-aim, the Committee notes that any risk that does exist would be mitigated by avoiding, where tactically feasible, the firing of barbs into the frontal chest overlying the heart. While the outcome of a short (five second) period of rapid cardiac capture, should it occur in an otherwise healthy individual, would likely be benign (para. 17), those with established heart conditions or who are under the influence of certain drugs may be at higher risk (paras. 18–19). There is a need for further human experimental studies to inform the risk of cardiac capture from the Taser devices currently available for police use in the UK.” Pg. 12.


a. “CONCLUSIONS: Sophisticated published computer models have estimated the risk of ventricular fibrillation for conducted electrical weapons. A growing body of epidemiological data has now shown that these models produced over-estimates. With the use of male body habitus data, and correcting for the differences between swine and humans the models now give a theoretical VF risk estimate of about 0.4 PPM or 1 per 2.5 million. This is consistent with the epidemiological findings to date.”

“CONCLUSIONS: Over the range of pulse rates of 10–30 PPS, the capability of rapid short pulses to induce ventricular fibrillation is given by the aggregate current, which is the pulse charge multiplied by the pulse rate. The ability of rapid short pulses to induce VF is approximately equal to a 60 Hz AC current with an RMS current of 7.4 times the aggregate current of the rapid short pulses.

This allows for the risk assessment of conducted electrical weapons by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”


a. “[C]urrent research does not support a substantially increased risk of cardiac arrhythmia in field situations, even if the CED darts strike the front of the chest.” Page viii.

b. “There is currently no medical evidence that CEDs pose a significant risk for induced cardiac dysrhythmia in humans when deployed reasonably.” Page 9.

c. “The risks of cardiac arrhythmias ... remain low and make CEDs more favorable than other weapons.” Page 10.

d. “[E]xperiments using healthy human volunteers have found no cardiac dysrhythmias9,10 ...following exposures less than 45 seconds.” Page 27.

e. “Swine studies involving exposure durations of 15 seconds or less are not associated with increased risks for ventricular fibrillation.” Page 27.


a. “[I]mmediate induction of ventricular fibrillation does not seem to be a likely mechanism of electronic control device-associated death.”


a. **[Article Summary]** “3. What are the key findings?** These studies did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after exposure to CEW electrical discharges of up to 15 seconds.” Pg. 604.

b. “Results: There were 140 articles on CEWs screened, and 20 appropriate articles were rigorously reviewed and recommendations given. These studies did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after exposure to CEW electrical discharges of up to 15 s.”

c. “Studies have looked for dysrhythmias during and immediately after CEW use (1,11–14,19,20). There have been no reports of ectopy, dysrhythmia, QT prolongation, interval changes, or other ECG changes immediately after CEW use. Additionally, studies have looked at delayed monitoring findings and there have been no changes in ECGs 60 min or longer post CEW use (13,17,20).”

d. “Echocardiograms during CEW use have also shown no abnormalities during activation to suggest electrical capture or structural cardiac damage (3,11).”


a. “There is no report of life threatening arrhythmia induction during application of these devices on healthy subjects. Based on these findings, CEW is considered safe from a cardiovascular stand-point.”


a. “(04/10 IACP) [94 ECD] research papers were reviewed during the preparation of this document. Seven of these received financial support from a manufacturer. … The totality of information presently available suggests that [ECDs] do not create an increased risk of pacemaker malfunction, heart fibrillation, or death or serious injury, absent the legitimate concern of secondary injuries from falling down.”

   a. “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 systole. Therefore, it should be possible to design and build an X26-type device that operates efficiently at levels higher than the X26.”


   a. “No evidence of dysrhythmia or myocardial ischemia is apparent, even when the barbs are positioned on the thorax and cardiac apex.” Pp. 4–5.


   a. “Experimental studies in human volunteers have found no cardiac dysrhythmias, ischemia, or necrosis after standard (5-second) or prolonged (15-second) conducted electrical weapon exposure.”


   a. TASER X26 ECD has a 30X safety factor.


   a. “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.”


a. “Conclusion: Numerically simulated TASER current density in the heart is about half the threshold for myocytes excitation and more than 500 times lower than the threshold required for inducing ventricular fibrillation. Showing a substantial cardiac safety margin, TASER devices do not generate currents in the heart that are high enough to excite myocytes or trigger VF.”


a. Table 6. Predicted Threshold for Ventricular Fibrillation Above Normal X26 TASER Output: (Pg. 40)
b. “Based on these threshold estimates one would conclude that for large children and adults, even those who might be sensitive responders, the risk of inducing VF is very small, since a large margin of safety exists. For example, the VF threshold for a 40-pound child is expected to be 3.5 times greater than the normal X26 operating output to induce ventricular fibrillation, if the darts are placed on the chest above and below the heart. For very small children, however, where the margin is limited (e.g., approximately 1.5 times above normal output), the data are insufficient to conclude that there would be no VF risk.” Pg. 40.


a. “The overall conclusion of this X26 statement is that ‘The risk of a life-threatening event arising from the direct interaction of the currents of the X26 Taser with the heart, is less than the already low risk of such an event from the M26 Advanced Taser.’” Pgs. 49–50.

b. “It was found in Langendorff preparation hearts that neither the M26 nor X26 simulated waveforms could evoke VEBs. However they could be evoked if the peak current densities were increased above those predicted by the modelling. However, the safety margin was 60-fold. It was also found that
neither the M26 nor X26 simulated waveforms could evoke VF within the maximum output of the equipment – at least a 70-fold increase for the M26 and a 240-fold increase for the X26. This, coupled with the fact that the hearts of larger animals (including humans) are less susceptible to VF leads to the conclusion that ‘On the basis of the present study, it is considered unlikely that the electrical discharge from the M26 and X26 Taser devices will influence cardiac rhythmicity by a direct action on the heart of healthy individuals.’” Pg. 49.


a. Significant safety margin as weight increased from 30 to 117 kg. (P < 0.001).

b. “The safety index for an NMI discharge was significantly and positively associated with weight. Discharge levels for standard electrical NMI devices have an extremely low probability of inducing VF.”


a. “The conclusion reached is that the current output of the X-26 [ECD] is significantly below the fibrillation threshold set out in the Standard.” Pg. 2.

b. “The short pulse length of the Taser [X26 ECD] output makes cardiac and breathing arrest very unlikely. Respiratory arrest difficulties are reduced by the automatic 1-second de-activation after 7.5 seconds, which is then repeated for each subsequent 6.5 seconds of use. No reports were found of cardiac arrest or breathing arrest solely from pulsed high frequency current at the levels produced by the Taser [X26 ECD].” Pg 7.

c. “Results were compared with limits specified by Australian Standard AS3859 – 1991 – ‘Effects of current flowing through the human body’”. Pg. 2.

d. “The measured X·26 results were compared with recognised Australian/New Zealand and the International Electro-technical Commission (IEC) electrical safety standards for the application of electric current to the human body. Both M-26 and X-26 Taser outputs were then compared with some typical
medical and domestic equipment. As shown in the table (section 3.5), the M-26 Taser output is less than 2% of the normalised current likely to produce ventricular fibrillation. The X-26 improves this figure even more to less than 1% of normalised current likely to cause ventricular fibrillation.” Pg. 24.

e. “The conclusion reached is that the output of the X-26 Taser is below the fibrillation threshold set out in the Standard. Our testing showed that the X-26 design is improved over the M-26 providing greater pulse power output with lower total energy outlet. This provides greater electrical safety and better performance than the M-26. From an electrical safety viewpoint the device presents an acceptable risk when used by trained law enforcement officers in accordance with the manufacturers directions for use.” Pg. 25.


a. (Abstract) “…The threshold for causing fibrillation (and likely asystole) using standard TASER darts is at least an order of magnitude higher than extrapolated curves based on current safety standards. On the basis of these results, either fibrillation or asystole would be extremely unlikely with the use of a battery-powered hand-held T ASER and standard-sized TASER darts.”


a. “ABSTRACT: This paper covers the cardiac safety studies of a high voltage (TASER) less-lethal weapon, and outlines the safety margin of the Taser X26. The cardiac safety test protocol was based on the rigorous safety protocol required by the Office of Naval Research for government funded basic science oriented research program.”

b. “The safety testing involved 13 adult domestic pigs, weighing between 92 and 158 pounds. The final round of the cardiac safety testing program involved 30 percent of these animals whose body weights were in the range of comparable human subjects. 71 discharge sequences with approximately 6,745 individual electrical pulse discharges directly to the chest of the animals were administered using a Taser-like bipolar skin electrode configuration encompassing the point of maximum mechanical impulse on the left chest wall.”

c. “These results were reproducible in all subjects, namely that the minimum level of a high intensity test pulse that could just cause fibrillation was about
twenty times the intensity level of the standard TASER X26. Recalling that the electrodes were always placed in the most sensitive positioning for cardiac stimulation, a safety margin of 20:1 would therefore exist. The safety margin appears to be even greater than 20:1 for field applications.”


a. “The power level of the Taser is far below the power necessary to cause heart fibrillation, in the worst-case scenario. The Taser has been shown in laboratory tests that it will not damage or interfere with operation of a pacemaker. Modern pacemakers are designed to withstand electrical defibrillator pulses, which are about 1,000 times stronger than the Taser output. (McNulty, 1995).”

Targeting of CEW to Center Mass/Chest:

Table 13 Not Stated to Avoid CEW Targeting Center Mass/Chest Table

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
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<tbody>
<tr>
<td>7</td>
<td>Jul. 2012</td>
<td>Consent Decree Regarding the New Orleans Police Department, United States of America v. City of New Orleans, United States District Court for the Eastern District of Louisiana, Case Number 12-1924, Sect. E. Mag. 2.</td>
</tr>
</tbody>
</table>

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<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Jun. 2008</td>
<td>Letter from the National Association of Medical Examiners (NAME) President, Jeffrey Jentzen, M.D.</td>
</tr>
</tbody>
</table>

a. “… A large body of research has explored the effects of CEDs on human beings both in laboratory settings and in the field, focusing primarily on cardiac rhythm disturbances, breathing, metabolic effects, and stress (Bozeman et al. 2009; Ho et al. 2006; NIJ 2011; Pasquier et al. 2011; Vilke et al. 2011). This research has consistently concluded that the TASER poses low risk for healthy human adults, and that deaths following exposure are caused by other factors including substance abuse, pre-existing medical conditions, and excited delirium (NIJ 2011).” (Emphasis added.)


a. (pg 98) “Discussion” The main findings of the study are as follows:

(1) The demonstrated incidence of ECD-induced cardiac arrest is extremely low, if not zero.

(2) Conclusions of a connection between ECD use and cardiac arrest are speculative at best.

(3) The role of several non-ECD confounding factors explaining cardiac arrests are not accounted for in published case reports.


a. “In the [> 2,000,000 CEW] field [uses], there has not been a conclusive case of fatal ventricular fibrillation caused solely by the electrical effects of a CEW (NIJ, 2011). A small number of human cases have found a temporal relationship between CEWs and fatal cardiac arrhythmias (Swerdlow et al., 2009; Zipes, 2012) but they do not allow for confirmation or exclusion of a clear causal link. …” (Page 26).

a. “Indeed, our study seems to suggest the “no chest” targeting might be somewhat conservative since it seems to be an area around the heart that would potentially be at risk, and not the entire chest.”

b. “While these numbers suggest a small risk, the risk is not zero and policy surrounding the use of the devices would be well advised to have a reasoned harm:benefit risk analysis. Avoiding the highest risk area in lower risk scenarios, and consideration of deploying devices with a better safety advantage in testing, such as done here, assuming a reasonably equal efficacy, would be advised by these authors.”


   a. White found that only 36% (57/158) of ECD-involved arrest-related deaths had a chest probe (p = 0.004 by chi-square) thus disproving the hypothesis that an application anywhere on the chest presents a risk of VF.

2. (07/24/2012 CRD/DOJ) Consent Decree Regarding the New Orleans Police Department, United States of America v. City of New Orleans, United States District Court for the Eastern District of Louisiana, Case Number 12-1924, Sect. E. Mag. 2.

   b. The Civil Rights Division of the U.S. Department of Justice does not prohibit anterior chest shots, does not lower the preferred targeting zone lower than the chest, and does not include the chest/breast as a “sensitive area.”

   “61. [Electronic Control Weapons (“ECWs”)] may not be applied to a subject's head, neck, or genitalia, except where lethal force would be permitted, or where the officer has reasonable cause to believe there is an imminent risk of serious physical injury.” Pg. 21.


   a. “[T]he risk of such dysrhythmias, even in the presence of a transcardiac CEW discharge, is low, and suggest that policies restricting anterior thoracic discharges of CEWs based on cardiac safety concerns are unnecessary.”

   a. “Despite individual medical publications that associate CEWs with effects on human cardiac physiology, the majority of human research could not confirm a risk of inducing ventricular fibrillation. Accordingly, CEWs appear to have a reasonable degree of cardiac safety.”


   a. “21. Whether or not the discharge current from the Taser X26 or M26 is able directly to influence heart rhythm remains controversial. Additional human experimental studies with these devices should help to clarify the risk from discharge applied to the frontal chest through skin-embedded Taser barbs.” Pgs 5–6.

   b. “76. It is not known whether there is a risk of cardiac capture with the Taser X26 or M26 (paras. 14–21). If there is a risk, then children and thin adults may be more vulnerable to discharge administered through barbs that have penetrated the frontal chest in the region overlying the heart. Although DOMILL does not provide operational advice on Taser point-of-aim, the Committee notes that any risk that does exist would be mitigated by avoiding, where tactically feasible, the firing of barbs into the frontal chest overlying the heart. While the outcome of a short (five second) period of rapid cardiac capture, should it occur in an otherwise healthy individual, would likely be benign (para. 17), those with established heart conditions or who are under the influence of certain drugs may be at higher risk (paras. 18–19). There is a need for further human experimental studies to inform the risk of cardiac capture from the Taser devices currently available for police use in the UK.” Pg. 12.


   a. “Law enforcement personnel are trained to target center body mass when using CEDs. TASER® International, Inc., (a major CED manufacturer) has recently recommended a change in target zone to below the chest. TASER® Bulletin 15 states, “By simply lowering the preferred target zone by a few inches to lower center mass, the goal of achieving Neuro Muscular Incapacitation (NMI) can be achieved more effectively while also improving
risk management." The panel does recognize that CED use involving the area of the chest in front of the heart area is not totally risk-free; current research does not support a substantially increased risk of cardiac dysrhythmia in field situations from anterior chest CED dart penetrations."

Page 12.


a. “The potential for electronic control devices to induce ventricular fibrillation by electrical stimulation of the heart during the vulnerable phase of cardiac repolarization is thought to be very low, based on both experimental and theoretical models. Nevertheless, a theoretical risk does exist and increases with low body weight, as well as with short dart-to-heart distances.” Pgs. 183–184.

b. “In the absence of clear evidence of an increase in arrest-related deaths in people exposed to an electronic control device discharge, and because it is not possible to confirm that the individual would have survived if the electronic control device had not been used, the role of electronic control device in mortality remains speculative.” Pg. 184.


a. PERF/DOJ do not recognize the chest/breast as a “sensitive area.”

"28. Personnel should not intentionally target sensitive areas (e.g., head, neck, genitalia).” Pg. 20.


a. [Article Summary] “3. What are the key findings? These studies did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after
exposure to CEW electrical discharges of up to 15 seconds.” Pg. 604.

b. “Results: There were 140 articles on CEWs screened, and 20 appropriate articles were rigorously reviewed and recommendations given. These studies did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after exposure to CEW electrical discharges of up to 15 s.”

c. “Studies have looked for dysrhythmias during and immediately after CEW use (1,11–14,19,20). There have been no reports of ectopy, dysrhythmia, QT prolongation, interval changes, or other ECG changes immediately after CEW use. Additionally, studies have looked at delayed monitoring findings and there have been no changes in ECGs 60 min or longer post CEW use (13,17,20).”

d. “Echocardiograms during CEW use have also shown no abnormalities during activation to suggest electrical capture or structural cardiac damage (3,11).”


a. “Number one, as of this year, based upon the science and, to a certain extent, the art of this type of situation, the panel is of the view that there is no conclusive medical evidence within the research as it stands now that there is a high or, another term, significant risk of serious injury or death to humans from the direct or indirect cardiovascular or metabolic effects of short-term CED exposure in healthy, normal, nonstressed and non-intoxicated persons. A little bit more on that later.” (Highlighting added.)

b. “Number four, unlike secondary injury due to such events as falling as a result of the neuromuscular incapacitation or other types of traumatic injury, human death due directly to the primary — due directly or primarily, excuse me — to the electrical effects of CED application has not been — one of those words again — conclusively demonstrated.” (Highlighting added.)


a. “Ninety-four ECW research papers were reviewed during the preparation of this document. Seven of these received financial support from a manufacturer.”
b. “[94 ECD] research papers were reviewed during the preparation of this document. Seven of these received financial support from a manufacturer. … The totality of information presently available suggests that [ECDs] do not create an increased risk of pacemaker malfunction, heart fibrillation, or death or serious injury, absent the legitimate concern of secondary injuries from falling down. *Independent studies done by authorities in England and Canada reached a similar conclusion: [ECWs] are safe enough for police to use …*”

c. Model policy does not restrict chest area as a target area.


a. “No evidence of dysrhythmia or myocardial ischemia is apparent, even when the barbs are positioned on the thorax and cardiac apex.”


a. “The primary finding that 99.75% of subjects experienced mild or no injuries represents the first assessment of the safety of this class of weapons when used by law enforcement officers in field conditions.”

b. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.14,15,22-26 Other studies of conducted electrical weapon exposure in combination with exercise designed to simulate the physiologic effects of fleeing from or struggling with police demonstrate changes in pH, lactate, and other markers comparable to that induced by exercise of the same duration.27-31 No study has demonstrated a pathophysiologic mechanism or effect that would account for delayed deaths minutes to hours after conducted electrical weapon exposure. Findings from independent investigations have been concordant with those performed with industry support. Collectively, these data are broadly reassuring and constitute the current best understanding of the human physiologic effects of conducted electrical weapons.”
c. “The possibility of direct cardiac effects is a common concern with conducted electrical weapons.” Experimental studies in human volunteers have found no cardiac dysrhythmias, ischemia, or necrosis after standard (5-second) or prolonged (15-second) conducted electrical weapon exposure. However, animal studies of conducted electrical weapon discharges in anesthetized swine have produced contradictory results. Some have shown no cardiac dysrhythmias with standard conducted electrical weapon outputs and large safety margins before dysrhythmia induction. Other studies have observed myocardial capture or ventricular dysrhythmias with standard conducted electrical weapon discharges. Extrapolation of these contradictory results to humans is problematic, and conclusive human evidence is currently lacking. Additional investigations of the dysrhythmogenic potential of conducted electrical weapons are needed in human subjects and animal models.

19. (06/2008 Jentzen) Letter from the National Association of Medical Examiners (NAME) President, Jeffrey Jentzen, M.D.

a. “Many of you have read the recent release from the National Institute of Justice (NIJ): “Study of Deaths Following Electro Muscular Disruption: Interim Report.” As you may know over twenty-five NAME members were directly involved in this project; as members of the NIJ’s National Medical Review Panel and as literature reviewers to support the panel. Both John Hunsaker; who co-chaired the Steering Group and Steve Clark; who organized the literature review deserve special thanks for their dedication and tenacity in delivering this project which has potential impact on our forensic practice.”

b. “The report concludes that although exposure to Conducted Energy Devices (CED) is not risk free, there is no conclusive medical evidence within the state of current research that indicates a high risk of serious injury or death from the direct effects of CED exposure.” In addition, the report suggests that CED technology may be a contributor to ‘stress’ when stress is an issue related to cause of death.” Studies of the effects of CED’s are very limited and addition research needs to be done. Moreover, as the certifier of death, the medical examiner has a responsibility for investigation deaths associated with the deployment of CEDs by law enforcement personal.”


a. Findings: “Although exposure to CED is not risk free, there is no conclusive medical evidence within the state of current research that indicates a high risk
of serious injury or death from the direct effects of CED exposure. Field experience with CED use indicates that exposure is safe in the vast majority of cases. Therefore, law enforcement need not refrain from deploying CEDs, provided the devices are used in accordance with accepted national guidelines. (For example: Electronic Control Weapons, a model policy of the International Association of Chiefs of Police.)" Page 3.

b. Findings: … “There is currently no medical evidence that CEDs pose a significant risk for induced cardiac dysrhythmia when deployed reasonably. Research suggests that factors such as thin stature and dart placement in the chest may lower the safety margin for cardiac dysrhythmia. There is no medical evidence to suggest that exposure to a CED produces sufficient metabolic or physiologic effects to produce abnormal cardiac rhythms in normal, healthy adults.” Page 3.


a. “12. Officers should avoid firing darts at a subject's head, neck and genitalia.”


a. “12. Officers should avoid firing darts at a subject's head, neck and genitalia.”


a. “… information presently available suggests that ECWs do not create an increased risk of pacemaker malfunction or heart fibrillation or an increased risk of death or serious injury, aside from the legitimate concern of secondary injuries from falling. “Independent studies done by authorities in England and Canada reached a similar conclusion: [ECWs] are safe enough for police to use …” Page 3.

b. “Aiming point. Whenever possible, the weapon should be aimed at center body mass—that is, with the sights or laser dot between the shoulder blades—to ensure that darts make solid body contact. …” Page 4.
c. Model policy does not restrict chest area as a target area.

Cardiac Membrane Time Constant: “there should be almost no additive effect of the [CEW] pulses”


a. “If a series of pulses is delivered quickly in succession, it is possible that their effects could summate to change the transmembrane potential more than that caused by a single pulse (Fig. 6A). The TASER X26 delivers 19 pulses per second, which means that the onsets of successive pulses are approximately 53 ms apart.5 If the time constant of the cardiac membrane is 3.6 ms,11,12 the time between pulses is almost 15 time constants. Therefore, any change caused in the cardiac transmembrane potential by a pulse will have returned to within 0.0001% (63% reduction 15 sequential times) of the initial resting value before the onset of the next pulse (Fig. 6B). Thus, there should be almost no additive effect of the pulses.”34 Page 198.
Figure 2 Effects of multiple electrical stimuli on trans-membrane potential (Ideker 2007, pg 199)

![Graph showing effects of multiple electrical stimuli on trans-membrane potential.](image)
Partial List of Cardiac Safety Dependent Upon Swine/Human Weight/Size:

Table 14 Partial List of Cardiac Safety Dependent Upon Swine or Human Weight/Size

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
</table>


   a. **Results** Cardiac stimulation, characterized by an abrupt increase in heart rate, reduction in myocardial contractility and mitral valve standstill, was detected with chest dart application in small pigs with all devices except the Taser X3 and in large pigs only with the S200 AT device (Table 1). Cardiac stimulation did not occur with abdominal dart application. VF was not observed.
   
a. **Conclusions:** Consistent with the literature, the susceptibility to the external induction of VF is strongly and negatively correlated with body mass. For human weights < 20 kg VF induction is possible for CEW chest exposures which include the heart between the barbs.


**Figure 3 Meta-analysis: swine VF studies shows that the human risk stops at about 30 kg (66 lbs).**

   
a. Pig weights: 34 ± 8.7 kg (75 ± 19 lbs) [56–94 lbs]

---

b. Significant X26 CEW discharge safety factor


a. Table 6. Predicted Threshold for Ventricular Fibrillation Above Normal X26 TASER Output: (Pg. 40)

Table 6. Predicted Threshold for Ventricular Fibrillation Above Normal X26 TASER Output

<table>
<thead>
<tr>
<th>Body Weight (pounds)</th>
<th>Predicted Threshold for Ventricular Fibrillationa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typical human</td>
</tr>
<tr>
<td>10</td>
<td>2.4</td>
</tr>
<tr>
<td>20</td>
<td>3.6</td>
</tr>
<tr>
<td>40</td>
<td>5.8</td>
</tr>
<tr>
<td>60</td>
<td>8.1</td>
</tr>
<tr>
<td>80</td>
<td>10</td>
</tr>
<tr>
<td>120</td>
<td>13</td>
</tr>
<tr>
<td>160</td>
<td>16</td>
</tr>
<tr>
<td>200</td>
<td>19</td>
</tr>
<tr>
<td>240</td>
<td>22</td>
</tr>
<tr>
<td>280</td>
<td>24</td>
</tr>
</tbody>
</table>

a. Values are calculated from the regression equations plotted in Figure 3. The value shown represents the fold increase in X26 TASER output (total electrical current) above normal operating output to exceed the VF threshold for typical or sensitive humans of a given body weight.

b. “Based on these threshold estimates one would conclude that for large children and adults, even those who might be sensitive responders, the risk of inducing VF is very small, since a large margin of safety exists. For example, the VF threshold for a 40-pound child is expected to be 3.5 times greater than the normal X26 operating output to induce ventricular fibrillation, if the darts are placed on the chest above and below the heart. For very small children, however, where the margin is limited (e.g., approximately 1.5 times above normal output), the data are insufficient to conclude that there would be no VF risk.” Pg. 40.

a. Significant safety margin as weight increased from 30 to 117 kg. (P < 0.001).

b. “The safety index for an NMI discharge was significantly and positively associated with weight. Discharge levels for standard electrical NMI devices have an extremely low probability of inducing VF.”


Cardiac Safety Dependent Upon Dart Orientation and Pig Size:


a. "Results Cardiac stimulation, characterized by an abrupt increase in heart rate, reduction in myocardial contractility and mitral valve standstill, was detected with chest dart application in small pigs with all devices except the Taser X3 and in large pigs only with the S200 AT device (Table 1). Cardiac stimulation did not occur with abdominal dart application. VF was not observed.”

b. “Conclusion Cardiac stimulation occurs during ECD application in pigs. Stimulation is dependent upon dart orientation and pig size. Refinement in waveform characteristics may result in ECD’s with a lower risk of cardiac stimulation. Table 1: Heart Rate Response During ECD Stimulation *P < 0.0001 comparing cardiac heart rate with abdominal heart rate (Group 1).”

<table>
<thead>
<tr>
<th>Table 1: Heart Rate Response During ECD Stimulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Device</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td><strong>Group 1</strong></td>
</tr>
<tr>
<td><strong>Abdominal</strong></td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
</tr>
<tr>
<td><strong>Abdominal</strong></td>
</tr>
</tbody>
</table>

*P < 0.0001 comparing cardiac heart rate with abdominal heart rate (Group 1)

   a. No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance

   b. “This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”


Graphic Demonstrative Illustrations – CEW Dart-to-Heart (DTH) Distances:

Figure 4 CEW Dart-to-Heart (DTH) Distances
Graphic Demonstrative Illustrations – Joule Comparisons:

Figure 5 Joule Comparisons 1

What Is a “joule”?

“joule”: International system of units measurement of energy (mechanical, electrical, or thermal) describing the energy delivered in a single pulse.

Automated External Defibrillator (AED): Delivers 360 joules
Infants & Children: 2–10 joules/kilogram
TASER X26: Delivers up to about 0.1 joule

Figure 6 Joule Comparisons 2

Pediatric Advanced Life Support Guidelines


It is acceptable to use an initial dose of 2 to 4 J/kg (Class Ila, LOE C), but for ease of teaching an initial dose of 2 J/kg may be considered (Class IIb, LOE C). For refractory VF, it is reasonable to increase the dose to 4 J/kg (Class Ila, LOE C). Subsequent energy levels should be at least 4 J/kg, and higher energy levels may be considered, not to exceed 10 J/kg or the adult maximum dose (Class IIb, LOE C).
Swine CEW Cardiac Research

Animal Model Differences (including Swine):


   a. “Because they have a heart-body weight ratio and general cardiac anatomy similar to that of humans, swine have been used in the testing and development of pacemakers and implantable cardiac defibrillators. However, swine have a relatively low threshold for ventricular fibrillation, in part, because their Purkinje fibers cross the entire ventricular wall, in contrast to human hearts in which these fibers are largely confined to a thin layer in the endocardium. Additionally, the cardiac impulse proceeds from the epicardium to the endocardium in swine, potentially increasing their sensitivity to externally applied electrical currents compared with humans. These differences diminish the relevance of this model for evaluating the safety of CED exposure in humans.” Pg. 4.


   a. With regard to swine, specifically see “2. Comparative electrocardiography and electrophysiology,” starting on page 278.


   a. “The electrocardiogram. Ventricular activation in miniature pigs is different from that in man and dogs due to a difference in penetration of Purkinje fibers through both the right and left ventricular free walls[26].”


Epinephrine Increases VFT:


Table 15 Zipes, 1975 Epinephrine increased VFT. (pg III-123)

<table>
<thead>
<tr>
<th>Increased RPD or decreased VFT</th>
<th>Decreased RPD or increased VFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial ischemia&lt;sup&gt;49&lt;/sup&gt;</td>
<td>Epinephrine (initial ↓ VFT)&lt;sup&gt;22, 49&lt;/sup&gt;</td>
</tr>
<tr>
<td>Slower heart rates without ischemia&lt;sup&gt;51&lt;/sup&gt;</td>
<td>Slower heart rates with ischemia&lt;sup&gt;49&lt;/sup&gt;</td>
</tr>
<tr>
<td>Faster heart rates with ischemia&lt;sup&gt;49&lt;/sup&gt;</td>
<td>Faster heart rates without ischemia&lt;sup&gt;49&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sympathetic nerve stimulation&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Vagal stimulation&lt;sup&gt;16, 17&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ventricular premature systoles&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Drugs: lidocaine,&lt;sup&gt;48&lt;/sup&gt; bretylium,&lt;sup&gt;49&lt;/sup&gt; procainamide,&lt;sup&gt;48&lt;/sup&gt; diphenhydantoin,&lt;sup&gt;51&lt;/sup&gt; propranolol,&lt;sup&gt;49&lt;/sup&gt; quinidine,&lt;sup&gt;49&lt;/sup&gt; nitroglycerin,&lt;sup&gt;22&lt;/sup&gt; adrenaline&lt;sup&gt;47&lt;/sup&gt;</td>
</tr>
<tr>
<td>Acidosis&lt;sup&gt;11, 12&lt;/sup&gt;</td>
<td>Aminophylline&lt;sup&gt;6&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oubain toxicity&lt;sup&gt;13&lt;/sup&gt;</td>
<td>(after first 30 min following i.v. administration)</td>
</tr>
<tr>
<td>(for first 30 min after i.v. administration)</td>
<td>Digitalis in intact dog or after stellate stimulation&lt;sup&gt;11&lt;/sup&gt;</td>
</tr>
<tr>
<td>Digitalis with autonomic denervation or propranolol&lt;sup&gt;44&lt;/sup&gt;</td>
<td>Respiratory acidosis with hypoxia&lt;sup&gt;23&lt;/sup&gt;</td>
</tr>
<tr>
<td>Hypothermia&lt;sup&gt;13&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Quinidine (high doses)&lt;sup&gt;26&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Chloroform&lt;sup&gt;26&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: RPD = refractory period dispersion; VFT = ventricular fibrillation threshold.

Epinephrine Infusion Alone Causes Ventricular Tachycardia:


a. Initial VFT was 15.9 ± 1.5 mA.

b. For 0–4 minutes after start of norepi infusion VFT went down to 11.4 ± 1.1 mA.

c. For 4–10 minutes after start of norepi infusion VFT was 20.2 ± 1.8 mA (or an increase of 27% over baseline).

Epinephrine – ½ Life:


a. “… in the present study (115 to 140 L/h, corresponding to a half-life of 3.5 minutes) …”


a. Figure 1.

![Figure 1](image_url)

**Figure 1** Mean (±SE) plasma epinephrine and norepinephrine concentrations before, during, and after 60-min epinephrine infusions at the five nominal infusion rates. The mean (±SE) measured infusion rates are listed at the right of the epinephrine plots.
Published Animal Studies with TASER X26 CEW and Probes in the Chest: \(^{30}\)

Pig/Sheep Studies: weight and X26 CEW exposure duration of pigs/sheep that had CEW-induced VF:

**Conclusions:** Six (6) incidents of VF out of 100s of CEW exposures (see Kroll\(^{31}\))
- No instance of VF in less than 10 seconds of CEW discharge (other than Wu)
- No instance of VF in pigs weighing more than 79 lbs (with just CEW discharge)
- One instance of VF in pig weighing 110 lbs (with simultaneous epinephrine infusion)
- No instance of VF in pigs weighing more than 110 lbs (even with epinephrine infusion)

**Table 16 Six (6) instances of small pigs that experienced CEW\(^{32}\) induced VF**

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 2006</td>
<td>Nanthakumar (^{33})</td>
<td>3–6 mo</td>
<td>50 kg (110 lb)</td>
<td>5, 15 s</td>
<td>6 pigs, 150 CEW discharges, 16 with simultaneous infused epinephrine infusion (See Zipes, 1975, after initial decrease epinephrine increased VFT)(^{34})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>[All animals weighed: - 45–55 kg or - 99–121 lb]</td>
<td>15 s</td>
<td>only one instance had VF in 16 attempts with infused epinephrine</td>
</tr>
<tr>
<td>Sep. 2007</td>
<td>Dennis (^{35})</td>
<td>3–6 mo</td>
<td>29 kg (64 lb) 31 kg (68 lb)</td>
<td>80 s total 2 x 40 s</td>
<td>31 kg pig had a thoracotomy</td>
</tr>
<tr>
<td>Jan. 2008</td>
<td>Walter (^{36})</td>
<td>3–6 mo</td>
<td>28 kg (62 lb)</td>
<td>80 s total 2 x 40 s</td>
<td></td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>Valentino (^{37})</td>
<td>3–4 mo</td>
<td>25 kg (55 lb) 36 kg (79 lb)</td>
<td>10 s</td>
<td>XP probes</td>
</tr>
</tbody>
</table>

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\(^{32}\) In this table “CEW” refers to a TASER X26 CEW at standard discharge levels.


Table 17 Detailed Table of Animal Studies: Induced VF Results at 1X X26 CEW Discharge Levels

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep. 2003</td>
<td>Stratbucker*36</td>
<td>38–158 lbs</td>
<td>5 s</td>
<td>&quot;... the electrodes were always placed in the most sensitive position for cardiac stimulation, a safety margin of 20:1 would therefore exist.&quot; &quot;The safety margin appears to be even greater than 20:1 for field applications.&quot;</td>
<td></td>
</tr>
<tr>
<td>Jan. 2005</td>
<td>McDaniel*39</td>
<td>No VF</td>
<td>Weight: 60 ± 28 kg</td>
<td>Significant safety factor</td>
<td></td>
</tr>
<tr>
<td>Aug. 2006</td>
<td>Jauchem*30</td>
<td>No VF</td>
<td>Weight: 49.5–58 kg (109–128 lbs)</td>
<td>Cocaine VF threshold study Significant X26 CEW discharge safety factor</td>
<td></td>
</tr>
<tr>
<td>Aug. 2006</td>
<td>Lakkireddy*41</td>
<td>No VF</td>
<td>Weight: 34 ± 8.7 kg (75 ± 19 lbs) (56–94 lbs)</td>
<td>5, 15 s</td>
<td></td>
</tr>
<tr>
<td>Aug. 2006</td>
<td>Nanthakumar*42</td>
<td>No VF in any instance that did not have simultaneous epinephrine infusion</td>
<td>5, 15 s</td>
<td>6 pigs, 150 CEW discharges, 16 with simultaneous infused epinephrine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50 kg (110 lb)</td>
<td>Only one instance had VF in 16 attempts with infused epinephrine</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 2007</td>
<td>Jauchem</td>
<td>No VF</td>
<td>Weight: 50.8 ± 1.6 kg 46–61 kg (101–134 lbs)</td>
<td>15 s</td>
<td></td>
</tr>
<tr>
<td>May 2007</td>
<td>Valentino</td>
<td>No VF (MK63)</td>
<td></td>
<td>2 x 40 s</td>
<td>10 Yucatan minipigs Lengthy EMI exposures did not cause extreme acidosis or cardiac arrhythmias</td>
</tr>
<tr>
<td>Sep. 2007</td>
<td>Dennis</td>
<td>3–6 mo</td>
<td>29 kg (64 lb) 31 kg (68 lb)</td>
<td>2 x 40 s</td>
<td>31 kg pig had a thoracotomy</td>
</tr>
<tr>
<td>Jan. 2008</td>
<td>Walter</td>
<td>3–6 mo</td>
<td>28 kg (62 lb)</td>
<td>2 x 40 s</td>
<td></td>
</tr>
<tr>
<td>Feb. 2008</td>
<td>Valentino</td>
<td>3–4 mo</td>
<td>No VF</td>
<td>5–15 s</td>
<td>Barb placement study</td>
</tr>
<tr>
<td>Apr. 2008</td>
<td>Lakkireddy</td>
<td>No VF</td>
<td>Weight: 34.4 ± 6.95 kg 76 ± 15 lbs 61–91 lbs</td>
<td>5–15 s</td>
<td></td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>Valentino</td>
<td>3–4 mo</td>
<td>25 kg (55 lb) 36 kg (79 lb)</td>
<td>10 s</td>
<td>XP probes</td>
</tr>
<tr>
<td>Jun. 2009</td>
<td>Kroll</td>
<td>19.5 &amp; 20 kg 43 &amp; 44 lbs</td>
<td></td>
<td>5 s</td>
<td>3.4 mm and 7.9 mm DTH no induction of VF at pulse charges up to 300 μC</td>
</tr>
<tr>
<td>Apr. 2010</td>
<td>Dawes</td>
<td>No VF</td>
<td>Weight: 26–78 kg (57–172 lbs)</td>
<td>5, 15, 30, and 40 seconds</td>
<td>16 Dorset Sheep with methamphetamine NO VF with X26 CEW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep. 2011</td>
<td>Walcott⁵²</td>
<td>No VF</td>
<td>Weight: 20–25 kg (44–55 lbs)</td>
<td>No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance</td>
<td>&quot;This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.&quot;</td>
</tr>
<tr>
<td>Dec. 2012</td>
<td>Flaker³⁵</td>
<td>No VF</td>
<td></td>
<td></td>
<td>No cardiac stimulation with TASER X3 CEW</td>
</tr>
<tr>
<td>Mar. 2013</td>
<td>Dawes (SAEM poster presentation)⁵⁵</td>
<td>No VF or other dysrhythmias after any CEW exposure</td>
<td>5 &amp; 10 seconds</td>
<td>X26 and X2 CEW swine cardiac capture study model X2 CEW had a smaller “window” of capture</td>
<td></td>
</tr>
<tr>
<td>Mar. 2013</td>
<td>Dawes⁵⁶</td>
<td>No VF</td>
<td>84–85 lbs</td>
<td>5 &amp; 10 seconds</td>
<td>a total of 354 included exposures with no recorded cases of VF X26 and X2 CEW swine cardiac capture study model X2 CEW had a smaller “window” of capture</td>
</tr>
</tbody>
</table>

---


<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2013</td>
<td>Masse</td>
<td>unk</td>
<td>No VF</td>
<td>5 &amp; 15 seconds</td>
<td>94 transcardiac discharges, 74 stimulated heart, average time for cardiac capture was 3.6 seconds; no reported 2:1 capture, VF, cardiac arrest, or lethal cardiac consequences</td>
</tr>
<tr>
<td>May 2013</td>
<td>Hado</td>
<td>unk</td>
<td>No VF</td>
<td>4 anesthetized pigs. Total of 46 CEW discharges were applied. Ventricular capture was seen in 39 discharges of the total 43 discharges that captured the ventricle. <strong>Conclusion:</strong> Our work in this animal model suggests that stun gun capture of the atrium is commonly due to VA stimulation from ventricular capture. Our findings indicate that stun gun discharges could potentially lead to atrial arrhythmias. Further research in this field is needed to substantiate such atrial capture and arrhythmias in humans.” No reported VF, cardiac arrest, or lethal cardiac consequences.</td>
<td></td>
</tr>
<tr>
<td>June 2014</td>
<td>Dawes</td>
<td>unk</td>
<td>No VF</td>
<td>144 CEW exposures</td>
<td>63 exposures with cardiac capture no cases of VF.</td>
</tr>
<tr>
<td>Aug. 2014</td>
<td>Koerber</td>
<td>unk</td>
<td>No VF</td>
<td>160 CEW exposures</td>
<td>Highest capture rate: 239 BPM The TASER X3 CEW did not result in cardiac stimulation in small or large pigs. [Also, note, the X3 CEW’s waveform and output are similar to those of the TASER X2 and X26P CEWs.]</td>
</tr>
</tbody>
</table>

**X26/X2 CEWs Comparative Cardiac Capture Safety Study:**

57 (2013;10:S186) Masse, S., Desfosses-Masse, J., Hado, H., Waxman, M.B., Nanthakumar, K. (2013 HRS Poster) Determining the Safe Duration for Stun Gun Discharges Across the Chest. Also, it is suspected that this POSTER is simply a rehash of the 2006 Nanthakumar swine study and not new or original research.


   a. Studied 5 different CEW models and administered 160 CEW exposures to 2 groups of swine: (1) small swine weighing 25 kg, and (2) large swine weighing 68 and 71 kg.

   b. 160 CEW exposures

      (1) Highest capture rate: 239 BPM

   c. The TASER X3 CEW did not result in cardiac stimulation in small or large pigs.

      (1) [Also, note, the X3 CEW’s waveform and output are similar to those of the TASER X2 and X26P CEWs.]


   a. A total of 144 CEW exposures with no cases of VF.

      (1) TASER X2 CEW:

         (a) 7 exposures resulted in full capture (median rate, 240, range 185–248)

         (b) 2 resulted in partial capture

      (2) Karbon Arms MPID CEW:

         (a) 43 exposures resulted in full capture (median rate 212, range 153–257)

         (b) 10 resulted in partial capture

   b. Probabilities:

      (1) In this swine study setting, the probability of VF is no more than 0.69 % (95 % CI 0.018–3.8 %).

      (2) There were a total of 63 exposures with cardiac capture with no cases of VF.
(a) Among exposures with capture, the probability of VF in this study setting is no more than 1.6% (95% CI 0.040–8.5%).

c. “As shown in both Fig. 2a–c, the study demonstrated reasonably well-demarcated boundaries on the chest within which the top dart captured the heart. The results indicate that a “transcardiac” pathway is a less important determinant of cardiac capture than the proximity of the dart to the heart, similar to what was shown with the prior study.”


a. “… In our estimates, the risk of VF based on this data is no more than 0.29%. The consensus panel estimated the risk of death in a TASER-related incident to be no more than 0.25%, in close agreement. Even with cardiac capture, the risk of VF from our data was no more than 0.59%.”

b. “a total of 354 … [CEW] exposures [in 84-85 lb swine] with no recorded cases of VF.”

c. “Among [CEW] exposures with [electrical cardiac] capture, the probability of VF is no more than 0.59% (95% CI 0.014–3.3%).”

d. “Our results suggest that the TASER X2 [CEW] has an improved safety margin over the TASER X26 [CEW].”

e. “The TASER X2 [CEW] appears to have a safety advantage over the TASER X26 [CEW] in single bay exposures with a smaller “window” of cardiac capture on the anterior chest …”

f. “One animal inexplicably died shortly after being paralyzed, but before any CEW exposures …” This death illustrates the fragility of the swine study.


model. (John Webster, Ph.D. has had similar experiences with the swine model.63)
DTH Distances in Swine:

Table 18 DTH distances in swine cardiac effects.

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Weight</th>
<th>DTH Distances</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun. 2014</td>
<td>Dawes 64</td>
<td>81–85 lbs</td>
<td>-3.4–18.0 mm</td>
<td>No VF. No capture &gt; 257 bmp.</td>
</tr>
<tr>
<td>Mar. 2013</td>
<td>Dawes 65</td>
<td>84–85 lbs</td>
<td>2.7–25.2 mm</td>
<td>No VF. No capture &gt;313 bpm.</td>
</tr>
<tr>
<td>Sep. 2011</td>
<td>Walcott 66</td>
<td>44–45 lbs</td>
<td>10 mm</td>
<td>No VF</td>
</tr>
<tr>
<td>Jun. 2009</td>
<td>Kroll 67</td>
<td>43–44 lbs</td>
<td>3.4 &amp; 7.9 mm</td>
<td>No VF at pulse charges up to 300 μC</td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>Wu 68</td>
<td>121–149 lbs</td>
<td>2–8 mm</td>
<td>VF through pre-bored hole to heart</td>
</tr>
<tr>
<td>Apr. 2008</td>
<td>Lakkireddy 69</td>
<td>61–91 lbs</td>
<td>12–23 mm 70</td>
<td>No VF. Significant VF safety margin.</td>
</tr>
<tr>
<td>Jul. 2006</td>
<td>Lakkireddy 71</td>
<td>59.1–81.6 lbs</td>
<td>12.3–16.5 mm 14</td>
<td>No VF. Significant VF safety margin.</td>
</tr>
<tr>
<td>Jun. 2003</td>
<td>Stratbucker 73</td>
<td>92–158 lbs</td>
<td></td>
<td>No VF. Probes on sensitive areas of thorax. &gt;20X VF safety factor.</td>
</tr>
</tbody>
</table>


b. 13 millimeter (mm) XP probes, all darts were hand-placed to a full depth at a 90-degree angle to the skin for each exposure.

(1) -3.4 to 18.0 mm DTH distances.

c. A total of 144 CEW exposures with no cases of VF.

(1) TASER X2 CEW:

(a) 7 exposures resulted in full capture (median rate, 240, range 185–248)

---


70 Personal communication. Review of Lakkireddy’s study’s raw data.


72 Personal communication. Review of Lakkireddy’s study’s raw data.

(b) 2 resulted in partial capture

(2) Karbon Arms MPID CEW:

(a) 43 exposures resulted in full capture (median rate 212, range 153–257)

(b) 10 resulted in partial capture

d. Probabilities:

(1) In this swine study setting, the probability of VF is no more than 0.69 % (95 % CI 0.018–3.8 %).

(2) There were a total of 63 exposures with cardiac capture with no cases of VF.

(a) Among exposures with capture, the probability of VF in this study setting is no more than 1.6 % (95 % CI 0.040–8.5 %).
<table>
<thead>
<tr>
<th>Subject 1 (a)</th>
<th>Subject 2 (b)</th>
<th>Subject 3 (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>STH (cm)</td>
<td>DTH (mm)</td>
</tr>
<tr>
<td>-1</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>-2</td>
<td>2.38</td>
<td>10.8</td>
</tr>
<tr>
<td>1</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>2</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>3</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>4</td>
<td>2.48</td>
<td>11.8</td>
</tr>
<tr>
<td>5</td>
<td>1.91</td>
<td>6.1</td>
</tr>
<tr>
<td>6</td>
<td>1.95</td>
<td>6.5</td>
</tr>
<tr>
<td>7</td>
<td>1.63</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>1.62</td>
<td>3.2</td>
</tr>
<tr>
<td>10</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>11</td>
<td>2.05</td>
<td>7.5</td>
</tr>
<tr>
<td>12</td>
<td>2.13</td>
<td>8.3</td>
</tr>
<tr>
<td>13</td>
<td>2.79</td>
<td>14.9</td>
</tr>
<tr>
<td>17</td>
<td>2.47</td>
<td>11.7</td>
</tr>
<tr>
<td>18</td>
<td>3.05</td>
<td>17.5</td>
</tr>
<tr>
<td>23</td>
<td>5.93</td>
<td>N/A</td>
</tr>
</tbody>
</table>


a. Animal weights 84–85 pounds [38–39 kg].

b. 13 millimeter (mm) XP probes, all darts were hand-placed to a full depth at a 90-degree angle to the skin for each exposure.

c. For the 13 mm XP steel dart:

(1) 32 exposures resulted in Full Capture (median rate 250, range 192–313),

(2) 30 resulted in Partial Capture (median rate 172, range 109–294), and

(3) 44 resulted in sinus rhythm (median rate 104, range 84–143).

(4) None resulted in ventricular fibrillation, cardiac arrest, or other lethal cardiac consequences.

d. Cardiac capture ratio:

(1) Mean 232 BPM X 26 CEW and 222 BPM X 2 CEW = 5:1 capture ratio.

(2) Highest capture rate was 313 BPM = 3.5:1 capture ratio.

e. Dart-to-Heart (DTH) distances as narrow as 4.1 millimeter (mm).

f. The skin-to-heart distances for each of these animals are shown in Fig. 2a–d of the Dawes' paper.

Table 20 2013 Dawes 2013 Swine Study – Fig. 2a–d. STH / (calculated) DTH Distances.

<table>
<thead>
<tr>
<th>Subject 1 (a)</th>
<th>Subject 2 (b)</th>
<th>Subject 3 (c)</th>
<th>Subject 4 (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>STH (cm)</td>
<td>DTH (mm)</td>
<td>PL</td>
</tr>
<tr>
<td>1</td>
<td>2.80</td>
<td>15.0</td>
<td>-2</td>
</tr>
<tr>
<td>2</td>
<td>2.00</td>
<td>7.0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>2.80</td>
<td>11.0</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>2.20</td>
<td>9.0</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>2.40</td>
<td>11.0</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>2.80</td>
<td>15.0</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>2.20</td>
<td>9.0</td>
<td>8</td>
</tr>
<tr>
<td>12</td>
<td>2.60</td>
<td>13.0</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 21 2013 Dawes Swine Study – Fig. 5a–c. STH / (calculated) DTH Distances.

<table>
<thead>
<tr>
<th>Subject 5 (a)</th>
<th>Subject 6 (b)</th>
<th>Subject 7 (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>STH (cm)</td>
<td>DTH (mm)</td>
</tr>
<tr>
<td>6</td>
<td>2.32</td>
<td>10.2</td>
</tr>
<tr>
<td>11</td>
<td>2.55</td>
<td>12.5</td>
</tr>
<tr>
<td>12</td>
<td>2.69</td>
<td>13.9</td>
</tr>
<tr>
<td>13</td>
<td>3.01</td>
<td>17.1</td>
</tr>
<tr>
<td>17</td>
<td>2.39</td>
<td>10.9</td>
</tr>
<tr>
<td>18</td>
<td>2.74</td>
<td>14.4</td>
</tr>
<tr>
<td>17</td>
<td>3.82</td>
<td>25.2</td>
</tr>
<tr>
<td>18</td>
<td>2.71</td>
<td>14.1</td>
</tr>
<tr>
<td>19</td>
<td>3.32</td>
<td>20.2</td>
</tr>
<tr>
<td>23</td>
<td>2.36</td>
<td>10.6</td>
</tr>
<tr>
<td>24</td>
<td>2.29</td>
<td>9.9</td>
</tr>
</tbody>
</table>


b. No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance. (Using 15 centimeter (cm) electrode.)

Figure 7 Walcott 15 cm probe.

... (image of 15 cm probe)

... (Continued)

c. “This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”


a. 19.5 (43 lbs) and 20 kg (44 lbs).

b. 3.4 mm and 7.9 mm DTH.

c. No induction of VF at pulse charges up to 300 μC.


a. Pig mass = 61.2 ± 6.23 (SD) kg [135 ± 13.73 (SD) lbs].

b. Probes:

(1) 100 mm long skin-to-heart-distance testing probe.

(2) 50 mm long blunt-probe delivered the TASER X26 CEW current.
c. **Stimulation probe was inserted into a pre-bored hole to the heart:** “A shallow 2 mm wide skin-incision was made only to get through the tough skin. Then the distance testing probe was inserted through the fat layer, muscle layer, intercostal muscle layer to reach the pericardium to determine the skin-to-heart distance. It penetrated snugly through these layers. The insertion depth was determined by feeling the mechanical heart contraction behavior through the distance testing probe. The whole process was designed to minimize the disturbance of the natural anatomical structure. After the skin-to-heart distance was measured, the skin-to-heart-distance testing probe was carefully removed from the stimulation site. ... The blunt-probe was slid through the previously made stimulation site track. ...”
d. The dart-to-heart distance where the TASER X26 CEW caused VF:

1. first stimulation site: 4 to 8 mm with average 6.2 mm ± 1.79 (SD), and
2. second stimulation site: 2 to 8 mm with average 5.4 mm ± 2.41 (SD).


a. Weight 34.4 ± 6.95 kg (76 ± 15 lbs) 61–91 lbs.

b. Dart-to-Heart distances: 12–23 mm (actually 11.6–22.9 mm) (Personal communication. Review of Lakkireddy’s study’s raw data).

c. “It should be noted that we chose what we considered a worst-case scenario by inserting the barbs to their maximum depth at the PMI in relatively light pigs compared to typical humans. The tips of the barbs at the PMI averaged only 1.6 cm from the myocardial surface.”
d. “A standard TASER discharge for 5 seconds even when the barbs were placed at the most vulnerable areas of the chest in our experiments did not induce VF.”

e. “**Conclusions.** Standard discharge from a TASER X-26 weapon did not induce VF at any of the five tested locations in our pig model including when barbs were inserted near the cardiac apex. ...”


a. Swine weights 34 ± 8.7 kg (75 ± 19 lbs) (56–94 lbs).

b. Dart-to-Heart distances: 12–23 mm (actually 11.6–22.9 mm) (Personal communication. Review of Lakkireddy’s study’s raw data).

c. “Two darts were inserted to full depth at the mentioned sites. The mean distance of the PMI dart tip from the epicardial surface measured by echocardiography was 18 ± 4 [14–23] mm.”


a. Swine weighed 92–158 pounds.

b. “The high voltage pulses were administered using carefully controlled “maximum susceptibility” experimental scenarios in every animal. To accomplish this goal, the pulse delivery probes were placed on the previously identified sensitive areas of the thorax and a critical shape parameter of the pulse waveform was systematically varied to maximize the potential for adverse cardiac electrical interactions. In order to quantify a safety margin, the stimulation waveform was adjusted to 100% of the electrical output of the standard, commercially available X26.”
c. “Because the heart rate and blood pressure are unchanged during the TASER X26 stimulation, it proves the stimulation intensity is below the ventricular fibrillation threshold. Moreover, the X26 stimulation intensity is below the threshold level to evoke even an occasional paced beat of the heart. Other physiologic variables being equivalent, paced beats have a significantly lower stimulus threshold than does the induction of ventricular fibrillation. Hence, the X26 waveform must be well below the fibrillation threshold.”

d. “... the electrodes were always placed in the most sensitive positioning for cardiac stimulation, a safety margin of 20:1 would therefore exist. The safety margin appears to be even greater than 20:1 for field applications.”

Swine CEW Drive Stun and Dart Separation Research:

Table 25 Swine CEW Drive Stun and Dart Separation Research

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Citation</th>
</tr>
</thead>
</table>


a. “However, instead of inserting the darts into the skin, both darts were either taped to the skin surface (nonpenetrating, vector 10) or elevated 1/2 inch above the skin using insulating foam blocks (vector 11). This latter arrangement resulted in arcing through the air between the dart tips and the skin surface during the discharge.” Page 1480.

b. “Figure 1. ... For vectors 10 and 11, darts did not penetrate the skin. Instead, they were taped to the skin surface (vector 10) or held 1/2 inch above the skin using insulating blocks (vector 11).” Page 1480.

c. “Interestingly, there were two transcardiac discharge vectors which did not result in capture of ventricular rhythm. For one of these, both darts were taped to the skin surface, not penetrating the epidermis, and the current emitting dart was on the abdomen (vector 10 left abdomen). Some cardiac
d. **Ventricular Capture did not Require Skin Penetration of Darts**

Interestingly, for two of the vectors studied (vectors 10 and 11), the darts did not penetrate the skin but a 75% capture rate was nonetheless observed. For vector 10, the darts were both laid flat on and taped to the skin with one dart on the right chest and the other over the left upper abdomen (see Fig. 1) in an arrangement previously shown to result in 100% capture.17,18 When the darts were taped to the skin, a 50% capture rate was seen. When this vector was repeated with the darts held away from the skin by insulating foam blocks, a 100% rate of capture was seen." Page 1482.

e. “Further, it was not necessary for the darts to penetrate or even to be in contact with the skin to elicit capture (vectors 10 and 11).” Page 1483.

f. “It would seem unlikely that these same discharges would be responsible for sudden death in the average seventy-kilogram human. How would you then explain that several reported deaths have also been associated with dry tasing or the drivestun mode, where the discharge is delivered by laying the TASER gun directly in contact with the skin? In these situations, no barbs are deployed into the human subject and thus, it would be much harder to create that trans-cardiac vector of electrical current.” Page 1486.


a. “In seven pigs, we also tested the effects of direct drive-stun mode where the stun gun was placed against the skin without barbs. The gun has a 3-cm interelectrode spacing on the front end and thus the current was relatively confined to this region. Drive mode was applied at ×1 standard strength at the SN, PMI, and mid-SN-PMI axis as well as at each of the other barb positions to assess V-capture.” Page 401.

b. **Effects of Drive Stun** Drive stun is the direct application of NMI discharge through the tip electrodes of the device without using the tethered barbs. These electrodes are separated by 3.6 cm. Occasionally, in the field, drive stuns are reportedly used by law enforcement personnel in close proximity to the subject instead of shooting the barbs. No VF or V-capture was noted when drive stun was applied to SN, PMI, supraumbilical, infraumbilical, lateral chest wall, upper back, or lower back segments. Drive stun in the middle of
the SN-PMI axis did cause 3:1 or 4:1 V-capture without initiating VF. No V-capture was noted at all in other segments." Page 405.


a. “**Conclusions:** … However even in the closest possible application along the cardiac axis no VF was induced with TASER current application.”

b. “**Conclusions:** Myocardial capture ratio tends to decrease with increasing dart separation up to 15 cm in the cardiac axis. Shorter dart separations tend to cause less rapid myocardial capture probably related to current jump across shorter distances and the relative differences in current density. However even in the closest possible application along the cardiac axis no VF was induced with TASER current application.”

c. “**Results:** There was no V-capture at 2.5 cm separation either from the SN or from the PMI in all 7 pigs. At 5 cm separation from the PMI there was an average of approximately 5:1 capture and the capture decreased to 3:1 at the maximum separation of around 15 cm indicative of more rapid myocardial capture. When the SN dart was fixed and the other dart separated at 5 cm, there was capture in only 4 of the 7 pigs yielding an average capture ratio of 28:1 (0.036 on the graph). With greater separations, the capture ratio decreased quickly to 3:1 at the 15 cm separation. No VF induction was seen during any of these TASER applications.”

**Polarity Testing in Swine:**


a. “We found no polarity effect in the risk of VF in small swine (~ 20 kg (44 lbs)] with larger charge (~5x) pulses.

b. “[E]xperimental data show that there is no difference in the ability of the anode vs the cathode to induce VF. We sought to evaluate the effect of polarity changes on cardiac capture and the induction of VF. Small swine (~ 20.0 kg [44 lbs]) were anesthetized and ventilated. The apex of the heart was located via echocardiography and a CEW probe was fully inserted towards the apex. Echocardiography was used to monitor cardiac contractions to
determine cardiac capture. Both the X26 and the 72 μC pulses were delivered at both polarities to test for cardiac capture. Higher charge pulses (375 μC) were then delivered with both polarities to test for VF risk. The 72 μC experimental unit was unable to cause cardiac capture even in small swine with fully inserted probes directly over the apex of the heart. We found no polarity effect in the risk of VF in small swine with larger charge (~5x) pulses."


a. “Ten second discharges were administered for each vector and for reverse polarity with each vector. To obtain reverse polarity, the darts were not moved but the cartridge was removed from the gun, rotated 180 degrees, and then reattached so that another 10 seconds discharge could be administered.”

Fragility of Swine Model: Experimental Swine Dying Before Test:

1. Professor John G. Webster, Ph.D. testified that he has experienced a swine dying in experiments before the swine was exposed to a stimulus.75 According to Dr. Webster, the “experience [is] one time in 100.”76


a. “One animal inexplicably died shortly after being paralyzed, but before any CEW exposures …”

---

75 Russell v. Wright, Case No. 3:11-cv-00075-GEC, U.S. District Court, Western Division of Viriginia, Charlottsville Division, Deposition of John G. Webster, Ph.D., taken on September 24, 2012, Page 38, line 10 to page 40, line 6.

76 Russell v. Wright, Case No. 3:11-cv-00075-GEC, U.S. District Court, Western Division of Viriginia, Charlottsville Division, Deposition of John G. Webster, Ph.D., taken on September 24, 2012, Page 40, line 3.
Human Body’s Resistances to Penetration of Electrical Current

Basics of electrical charge diversion, shunting, and depth of penetration of the body:

- Skeletal muscle anisotropy and high-resistivity fat divert 88% of electrical current away from deeper tissue layers by longitudinal muscle electrical conduction (anisotropy).
- Deale and Lerman studied the ratio of transcardiac to transthoracic threshold electrical currents in dogs:
  - the thoracic cage shunted 82% of the input current, and
  - the lungs shunted 14%.
  - Only the remaining 4% of the input electrical current passed through the heart.
  - Note that this when the patches were placed in the optimal locations thought to deliver current to the heart.

Table 26 Human Body Resistances to Penetration of Electrical Current

<table>
<thead>
<tr>
<th>NO.</th>
<th>GRAPHIC ILLUSTRATION</th>
<th>ILLUSTRATION DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image" alt="External Anatomy" /></td>
<td>External View of Torso</td>
</tr>
</tbody>
</table>

77 Two-dimensional graphic illustration modeling is static and is not precisely accurate for all situations. The human body, and all of its structures and processes, is dynamic, and humans have ranges of physiologic diversity. Also, the heart can have some movement due to the person's position (supine, standing, lateral decubitus, etc.) and the subject's physiologic parameters (inspiration versus expiration timing, rotation of the thorax, etc.).


<table>
<thead>
<tr>
<th>No.</th>
<th>Graphic Illustration</th>
<th>Illustration Description</th>
</tr>
</thead>
</table>
| 2   | ![Subcutaneous Fat Layer](image) | **Subcutaneous Fat Layer**  
Subcutaneous fat layer showing after removal of epidermis and dermis  
Note: Fat is highly resistive to the flow of electrical current. |
| 3   | ![Upper Muscles Layer](image) | **Upper Muscles Layer**  
Muscles visible after removal of skin and subcutaneous fat layer.  
Note: Anisotropy (horizontal grain) of the muscles.  
Note: Multiple muscle layers in next illustrations. |
| 4   | ![Muscle Group 1 Removed](image) | **Muscle Group 1 Removed**  
Platysma—neck  
Pectoralis major—chest  
Deltoids—shoulders  
Trapezius—shoulders |
<table>
<thead>
<tr>
<th>No.</th>
<th>Graphic Illustration</th>
<th>Illustration Description</th>
</tr>
</thead>
</table>
| 5   | ![Muscle Group 2 Removed](image1.png) | **Muscle Group 2 Removed**  
External Oblique–upper abdomen  
Pectoralis minor–chest  
Latissimus dorsi–side  
Long/short head of Biceps brachii–arms  
Note: Intercostal muscles between ribs of thoracic cage. Also, anisotropy of intercostal muscles.  
Note: Thoracic cage shunts 82% of input electrical current. |
| 6   | ![Muscle Group 3 Removed](image2.png) | **Muscle Group 3 Removed**  
Internal Oblique–upper abdomen  
Omohyoid–neck region  
Teres major–shoulder region  
Serratus Anterior–along ribs |
| 7   | ![Muscle Group 4 Removed](image3.png) | **Muscle Group 4 Removed**  
Intercostal Externus–along ribs  
Coracobrachialis–upper arm  
Scalenes–along neck  
Rectus Abdominis–middle abdomen |
<table>
<thead>
<tr>
<th>No.</th>
<th>GRAPHIC ILLUSTRATION</th>
<th>ILLUSTRATION DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td><img src="image1.png" alt="Image" /></td>
<td><strong>Muscle Group 5 Removed</strong>&lt;br&gt;Transversus Abdominis—middle abdomen&lt;br&gt;Inferior Pharyngeal Constrictor—neck&lt;br&gt;Longissimus Cervicis—neck&lt;br&gt;Subscapularis—shoulder area&lt;br&gt;Supraspinatus—shoulder area&lt;br&gt;Sternothyroid—neck&lt;br&gt;Subclavius—collar bone area&lt;br&gt;Triceps/all—upper arm</td>
</tr>
<tr>
<td>9</td>
<td><img src="image2.png" alt="Image" /></td>
<td><strong>Muscle Group 6 Removed</strong>&lt;br&gt;Intercostal Innermost—ribs&lt;br&gt;Note: Lungs beneath muscles and thoracic cage. Lungs have multiple layers and shunts 14% of input electrical current. Also, air in lungs also is an insulator, not a conductor.</td>
</tr>
<tr>
<td>10</td>
<td><img src="image3.png" alt="Image" /></td>
<td><strong>Muscle Group 5 Removed</strong>&lt;br&gt;Transversus Thoracis—sternum area&lt;br&gt;Subcostalis—ribs area&lt;br&gt;Visible ribs, lung outer pleura, heart behind sternum</td>
</tr>
<tr>
<td>No.</td>
<td>Graphic Illustration</td>
<td>Illustration Description</td>
</tr>
<tr>
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<td>--------------------------</td>
</tr>
<tr>
<td>11</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Ribs 1-10 Removed from Left Side</td>
</tr>
<tr>
<td>12</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Ribs 11-12 Removed from Left Side</td>
</tr>
<tr>
<td>13</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Removal of the Parietal Pleura Surrounding the Left Lung</td>
</tr>
<tr>
<td>No.</td>
<td>Graphic Illustration</td>
<td>Illustration Description</td>
</tr>
<tr>
<td>-----</td>
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<td>--------------------------</td>
</tr>
<tr>
<td>14</td>
<td><img src="image1.png" alt="Image of removal of visceral pleura surrounding the left lung" /></td>
<td>Removal of the Visceral Pleura Surrounding the Left Lung</td>
</tr>
</tbody>
</table>
| 15  | ![Image of lung showing as transparency revealing the pulmonary vessels](image2.png) | Lung Showing as Transparency Revealing the Pulmonary Vessels  
Note: The heart is in the pericardial sac [or pericardium] consisting of two layers.  
The pericardial sac [or pericardium] is a conical sac of fibrous tissue which surrounds the heart and the roots of the great blood vessels. |
<p>| 16  | <img src="image3.png" alt="Image of removal of transparent lung revealing pulmonary vessels" /> | Removal of Transparent Lung Revealing Pulmonary Vessels |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Graphic Illustration</th>
<th>Illustration Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td><img src="image1" alt="Removal of Remaining Ribs, Sternum, and Lung Exposing Heart and Pulmonary Vessels" /></td>
<td>Removal of Remaining Ribs, Sternum, and Lung Exposing Heart and Pulmonary Vessels</td>
</tr>
<tr>
<td>18</td>
<td><img src="image2" alt="Fading of Pulmonary Vessels to Show Heart" /></td>
<td>Fading of Pulmonary Vessels to Show Heart</td>
</tr>
<tr>
<td>19</td>
<td><img src="image3" alt="Removal of Pulmonary Vessels to Completely Show Heart" /></td>
<td>Removal of Pulmonary Vessels to Completely Show Heart</td>
</tr>
</tbody>
</table>
X2 CEW Human Studies

X2 CEW Prospective Human Studies:


   a. “Conclusions: There was no evidence of dangerous physiology found in the measured parameters. The physiologic effects of the X2 CEW are similar to older-generation CEWs. We encourage further study to validate these results.”
Biomarkers/Respiration – Selected CEW Medical/Scientific Literature

M26/X26 CEW Simulated Isometric Forces About 46% of Maximal:

   a. “Simulated isometric forces evoked at 19 Hz with either device are moderately intense (about 46% of maximal). Lower frequencies would likely not provide sufficient levels of contraction to override volitional motor control.”

   a. “… 19 hertz stimulation evokes simulated peak forces on the order of about half (specifically, 46% for this example) of those for the comparable 100 hertz pattern. While 19 hertz stimulation then presumably evokes peak forces on the order of those that a subject could elicit through strong voluntary contractions (see above), we expect that significantly higher frequency bursts (e.g. 50 or 100 hertz) could generate excessive forces in subjects beyond those needed to incapacitate. Lower frequency patterns, such as those seen for 10 hertz and below might fail to generate powerful, well-fused contractions sufficient to immobilize.”

No Clinically Significant Biochemical/Physiologic Changes:

   a. “According to the available results, the physiologic changes from electronic control device exposure appear to be safe in healthy individuals who undergo an exposure duration of 5 to 15 seconds, ie, the duration that corresponds to the majority of field exposures.”

   a. “Results: There were 140 articles on CEWs screened, and 20 appropriate articles were rigorously reviewed and recommendations given. These studies
did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after exposure to CEW electrical discharges of up to 15 s.”

   a. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.”
   b. “Other studies of conducted electrical weapon exposure in combination with exercise designed to simulate the physiologic effects of fleeing from or struggling with police demonstrate changes in pH, lactate, and other markers comparable to that induced by exercise of the same duration.”

No Clinically Significant CK Increase (Rhabdomyolysis) from CEW:

   a. “In summary, recent medical research could not prove a direct link between CEWs and the development of rhabdomyolysis. Even though a modest increase in creatine kinase cannot be excluded, no clinical features were noted.”

   a. “Although we cannot draw conclusions about the individual devices included in this analysis, our findings indicated that multiple contact points or exposures may result in a larger increase in CK, but the duration of the exposure does not appear to have a significant effect on CK. There is a correlation between the distance between the probes and the change in CK.”
No Clinically Relevant Lactate from Short-Duration CEW Discharge:


   a. "Abstract: In previous studies, blood lactate concentration (BLac) consistently increased in anesthetized animals and in human subjects after exposures to TASER® conducted energy weapons (CEWs). Some have suggested the increased BLac would have detrimental consequences. In the current review, the following are evaluated: (a) the nature of muscle contractions due to CEWs, (b) general aspects of increased BLac, (c) previous studies of conventional neuromuscular electrical stimulation and CEW exposures, and (d) BLac in disease states. On the basis of these analyses, one can conclude that BLac, per se (independent of acidemia), would not be clinically relevant immediately after short-duration CEW applications, due to the short time course of any increase."

Breathing – Evidence Suggests CEW Increases Respiratory Parameters:


   a. “Research to date, however, shows that human subjects seem to maintain the ability to breathe during exposure to a CED. In fact most evidence suggests hyperventilation with an increase in respiratory rate, tidal volume, and minute ventilation during CED exposure.” Page 15.

   b. “[E]xperiments using healthy human volunteers have found no ... respiratory dysfunction11 following exposures less than 45 seconds." Page 27.


   a. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.”
CEW Exposure Does Not Raise Blood Pressure:

1. Systolic and diastolic blood pressure has been evaluated before and after ECD exposure in 6 papers. The weighted average effect is for the systolic pressure to go down by 3.1 mmHg and diastolic pressure to go down by 2.6 mmHg.

Table 27 CEW exposure blood pressure

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>SBP1</th>
<th>SBP2</th>
<th>Delta</th>
<th>DBP1</th>
<th>DBP2</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dawes</td>
<td>11</td>
<td>141.3</td>
<td>142.9</td>
<td>1.6</td>
<td>81.8</td>
<td>76</td>
<td>-5.8</td>
</tr>
<tr>
<td>Ho</td>
<td>45</td>
<td>149</td>
<td>147</td>
<td>-2</td>
<td>86</td>
<td>83</td>
<td>-3</td>
</tr>
<tr>
<td>Ho</td>
<td>12</td>
<td>139</td>
<td>141</td>
<td>2</td>
<td>88</td>
<td>84</td>
<td>-4</td>
</tr>
<tr>
<td>Bozeman</td>
<td>28</td>
<td>138.6</td>
<td>145.8</td>
<td>7.2</td>
<td>82.8</td>
<td>85.6</td>
<td>2.8</td>
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<tr>
<td>Vilk</td>
<td>25</td>
<td>139</td>
<td>128</td>
<td>-11</td>
<td>86</td>
<td>78</td>
<td>-8</td>
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<tr>
<td>Vilk</td>
<td>32</td>
<td>139</td>
<td>128</td>
<td>-11</td>
<td>84</td>
<td>83</td>
<td>-1</td>
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<tr>
<td>Totals</td>
<td>153</td>
<td></td>
<td></td>
<td>-3.1</td>
<td></td>
<td></td>
<td>-2.6</td>
</tr>
</tbody>
</table>

Number of CEW Discharges: Multiple and Prolonged CEW Discharges:

   a. “The findings from this report reaffirm the CMC’s view that Tasers are a useful tool for police. Indeed, there are a range of situations where a multiple or prolonged Taser deployment may be the most appropriate use of force option.” Pg. v.
   b. “most people who were the target of a multiple or prolonged deployment were exposed to cycles totalling between 6 and 15 seconds (83%).”
   c. “Most multiple or prolonged Taser deployments involve people from “medically vulnerable or at-risk” groups who are displaying violent behavior”

---

No Evidence of Negative Effects with CEW Extended Duration Discharge:

   a. “The medical risks of repeated or continuous CED exposure beyond the [45 second] durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.
   b. “Studies examining the effects of extended exposure in humans to CEDs are limited to humans exposed to less than 45 seconds.” Page 27.
   c. “… [E]xperiments using healthy human volunteers have found no cardiac dysrhythmias9,10 or respiratory dysfunction11 following exposures less than 45 seconds.” Page 27.
   d. “Because the physiologic effects of prolonged or repeated CED exposure are not fully understood, law enforcement officers should refrain, when possible, from continuous activations of greater than 15 seconds, as few studies have reported on longer time frames.” Page viii.

   a. Definition of “extended [CEW] durations: “There may be a desire, in some cases, to incapacitate humans for “extended durations (more than three minutes).”

   a. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.”
   b. “Other studies of conducted electrical weapon exposure in combination with exercise designed to simulate the physiologic effects of fleeing from or
struggling with police demonstrate changes in pH, lactate, and other markers comparable to that induced by exercise of the same duration.”

**No Increased Mortality with Longer Duration CEW Exposure (swine study):**

   
   a. “This suggests that swine (based on physiology) will not experience a fatal event when exposed to the TASER X26 [CEW] for a continuous 3 min. Conclusions regarding longer duration (10–30 min) are not as certain due to the small sample sizes at these time intervals.”

   
   a. “5. **Conclusions.** 5.3.2 *Deaths are not cumulative.* The dose does not seem to be cumulative. We did not observe an accumulation of TASER effect to a ‘toxic’ level. There was no increased mortality with longer [30 minute] duration TASER exposure.” Page 26.

**Multiple Simultaneous CEW Discharges:**

   
   a. **Methods:** This was a prospective study of human subjects during NGCEW training courses. Subjects received a NGCEW probe deployment to the frontal torso in 1 of 3 configurations: 2, 3, or 4 embedded probes and then underwent a 10-s exposure. …

   b. **Conclusions:** An apparent brief myocardial capture event occurred with the NGCEWv1. This device was not released and was redesigned. The NGCEWv2 appears to exhibit a reasonable degree of cardiac safety with frontal torso exposures and multiple probe combination configurations.”
   a. “Methods: This was a prospective, observational study of human subjects. A master instructor shot subjects with a TASER X3 in the anterior thorax with either one or two cartridges. Each subject received a 10-s exposure from the device. . . .”
   b. “Conclusions: In our study, the respiratory, metabolic, and neuroendocrine effects were similar to previous generation devices. There was an increase in CK with more probes deployed.”

   a. “Conclusion: Our study suggests that this device may have a reasonable risk/benefit ratio when used to protect an area from a threat.”

CEW Induced Stress Comparable or Less Than Some Other Force Options:

   a. “In general, the stress of receiving CED discharge(s) should be considered to be of a magnitude that is comparable to the stress of other components of subdual. All aspects of an altercation (including verbal altercation, physical struggle or physical restraint) constitute stress that may heighten the risk of sudden death in individuals who have pre-existing cardiac or other significant disease.” Page ix.

Acidosis/Stress of Five-Second CEW Discharge ≤ 20 Meter Sprint:


December [online September] 2013, Pages 84–89.87

a. Abstract: “Both profound acidosis and catecholamine excess have been proposed as underlying physiologic derangements in subjects at high risk for arrest related death (ARD). In this study, the objective was to determine a level of physical exertion that is “equivalent” in terms of levels of acidosis and catecholamines to a “standard” TASER X26 exposure. Data were collected on subjects who underwent a 5-second TASER X26 exposure or a sprint of variable distances during a law enforcement training exercise. Our results show that levels of acidosis and catecholamines are less among subjects exposed to the TASER X26 than among subjects who sprinted 20 yards or more.

b. “Conclusion: A 5-second TASER X26 exposure in terms of markers of acidosis and stress was less than or equal to a 20-yard sprint. It is imperative to consider relative stressors when discussing the issues of use of force and the risk of ARD.”

c. The CEW exposure – “A TASER master instructor shot subjects in the back from 10 feet with a TASER X26 using standard 25-foot cartridges and XP (13 mm) darts and allowed the device to run for the standard 5-second cycle.” Thus, the probe spread would be 18” on the back.


a. “Conclusion: A 5-second CEW exposure effects markers of acidosis and stress less than or equal to a 20-yard sprint.”


a. The markers of acidosis and stress for a 5-second TASER X26 CEW exposure were less than or equal to a 20 yard sprint [A standard baseball diamond base-to-base distance is 30 yards.]

87 [originally published online as:] J.D. Ho, D.M. Dawes, P.C. Nystrom, D.P. Collins, R.S. Nelson, J.C. Moore, J.R. Miner, Markers of Acidosis and Stress in a Sprint Versus a Conducted Electrical Weapon, Forensic Science International (2013), http://dx.doi.org/10.1016/j.forsciint.2013.08.022. (Accepted Manuscript)
Acidosis/Catecholamine Following Simulated Force Encounters:


a. Results: … “The greatest changes in acidosis markers occurred in the sprint and heavy bag groups. Catecholamines increased the most in the heavy bag group and the sprint group and increased to a lesser degree in the TASER, OC, and K-9 groups. Only the sprint group showed an increase in CK at 24 hours. There were no elevations in troponin I in any group, nor any clinically important changes in potassium.”

b. Acidosis:

![Figure 10 Acidosis](image)

- Median pH by groups at each timepoint
- Median Lactate by groups at each timepoint

![Figure 11 Catecholamines](image)

- Median Catecholamines by groups at each timepoint

b. Acidosis:

c. Catecholamines:

CEW Physiologic Effects After Exercise/Exhausted:


   a. “There are recent data in the literature of human studies looking at the effect of exercise and CED exposure and their individual contributions to blood acidosis. CED exposure does not appear to add to acidosis above and beyond that seen with exercise to exhaustion. CED exposure without exertion produces only a mild acidosis.4–6” Page 16.


   a. “Conclusion: Subjects who had [15 second] CEW Exposure only had higher pH and lower lactate values than subjects who completed the Exertion protocol only. CEW exposure does not appear to worsen acidosis in exhausted subjects any differently than briefly continued exertion.”


   a. “Conclusions: A 5-second exposure of a TASER following vigorous exercise to healthy law enforcement personnel does not result in clinically significant changes in ventilatory or blood parameters of physiologic stress.”


   a. “Conclusion: Prolonged [15 second] CEW application on exhausted humans was not associated with worsening change in pH or troponin. Decreases in pCO2 and potassium and a small increase in lactate were found. Worsening acidosis theories due to CEW use in this population are not supported by these data.”
Neurocognitive Effects – Selected CEW Medical/Scientific Literature


   a. “Conclusions The questions driving this study involve serious issues including constitutionally protected rights of the accused, use of force by police, and previously unexamined effects of the TASER on the human body. The pilot study represents a critical first step in exploring the effects of the TASER on cognitive functioning. Moreover, the results provided the authors with important information that will guide their larger study, a randomized controlled trial where healthy human volunteers will be randomly assigned to four groups, two of which receive a TASER exposure.”
   b. “… A large body of research has explored the effects of CEDs on human beings both in laboratory settings and in the field, focusing primarily on cardiac rhythm disturbances, breathing, metabolic effects, and stress (Bozeman et al. 2009; Ho et al. 2006; NIJ 2011; Pasquier et al. 2011; Vilke et al. 2011). This research has consistently concluded that the TASER poses low risk for healthy human adults, and that deaths following exposure are caused by other factors including substance abuse, pre-existing medical conditions, and excited delirium (NIJ 2011).” (Emphasis added.)

   a. Abstract: “While the physiologic effects of modern conducted electrical weapons (CEW) have been the subject of numerous studies, their effects on neurocognitive functioning, both short-term and long-term, are less well understood. It is also unclear how these effects compare to other use-of-force options or other arrest-related stressors. We compared the neurocognitive...
effects of an exposure to a TASER® (TASER International, Inc., Scottsdale, AZ) X26™ CEW to four other use-of-force scenarios during a training exercise using a well-established neurocognitive metric administered repeatedly over 1 h. Overall, we found that there was a decline in neurocognitive performance immediately post-scenario in all groups, but this effect was transient, of questionable clinical significance, and returned to baseline by 1 h post-scenario.”

b. Key points:

(1) There was no difference between the neurocognitive effects of the five use-of-force scenarios.

(2) The use-of-force scenarios led to a decline in neurocognitive functioning but this effect was transient and may not have reached the level of important clinical significance.

(3) There was no apparent impact on the subjects’ ability to follow basic instructions.


a. “Conclusions: We did not find a difference between the neurocognitive effects of the five use-of-force scenarios. The use-of-force scenarios led to a decline in neurocognitive functioning but this effect was transient and may not have reached the level of important clinical significance.”


b. “Conclusion: LEO UOF or physical resistance simulations do not appear to impair a person’s neurocognitive ability as evaluated by SFSTs.”


a. “Conclusion: LEO UOF or physical resistance simulations do not appear to impair a person’s neurocognitive ability as evaluated by SFSTs.”


a. A few quotes:

(1) “A majority of subjects were able to hear commands given both during (90.6%) and after (96.9%) exposure.”

(2) “87.5% believed they would be unable to follow simple orders, had they been provided (e.g. raising arms).”

(3) “A reported 80.6% of subjects claimed to regain control within one second after exposure ceased.”

(4) “Mean response time to execute the test once exposure ended was 1.14 (±0.85) seconds …”

(5) “Subjects were able to retain consciousness, hearing and vision capabilities before, during and after application.”

b. “Psychomotor function was evaluated by measuring the time elapsed between the onset of X-26 TASER® exposure and first switchbox trigger event. Response times to execute the button-press task are shown in Figure 2. Figure 2 (a) corresponds to the audio stimulus button-press response times (n=7); a reduced number but sufficient for characterizing the baseline response because of tight grouping of the data, and consultation with a statistician has confirmed that this data has sufficient power to establish confidence. Mean baseline response time of the control set was 0.98 (±0.25) seconds. Figure 2 (b) depicts a distribution of the response times to execute
the psychomotor task in the presence of the X-26 TASER® stimulus (n=30). Two subjects were excluded due to data acquisition failures. Mean response time with the X-26 TASER® exposure was 6.06 (±0.91) seconds; two subjects were able to execute the task during the exposure period; response times for these individuals were 2.56 seconds and 4.59 seconds. A comparison of the response times for these two groups is shown in Figure 2 (c). The average time taken to press the button after start of X-26 TASER® stimulus minus the average time taken to press the button after start of audio stimulus is 5.08 seconds which is roughly equal to the duration of TASER stimulus (5 sec)."

c. “Mean response time to execute the test once exposure ended was 1.14 (±0.85) seconds and is shown in Figure 3 (b) (n=30). The negative time delays correspond to the two subjects able to trigger the switchbox before the five-second application ended. Figure 3 (c) compares the data with baseline. The average difference in response time from baseline is 0.16 seconds. The ability to press the button after the X-26 TASER® stimulus ended is roughly the same as the ability to press the button after an audio stimulus.”

d. “The interviews conducted immediately following exposure contain information on the sensory and behavioral effects of X-26 TASER® exposure. Results are summarized in Table 3. Immobility and pain were the most common terms used to describe the sensation of exposure. Thoughts during exposure were primarily of the pain and tolerating the application, while those afterwards were of task completion and relief. Seventy five percent of subjects reported being conscious of their surroundings; 90.6% retained hearing capabilities and 81.3% maintained vision capabilities (five subjects closed their eyes during). A majority of subjects were able to hear commands given both during (90.6%) and after (96.9%) exposure. 71.9% of participants were unable to control their actions during X-26 TASER® exposure; 87.5% believed they would be unable to follow simple orders, had they been provided (e.g. raising arms). A reported 80.6% of subjects claimed to regain control within one second after exposure ceased.”

e. “45.2% of the study population asserted that exposure would render them incapable of concentrating on the execution of a hypothetical attack during exposure; 32.2% believed it would be possible provided with an external cue or prompt. One subject claimed to have control of his actions during exposure. Eight subjects reportedly retained partial control of their actions. Had they had been attacked by someone prior to X-26 TASER® application, 96.9% of participants believed they would fail in task execution.”
CEW Recovery Time


**Abstract**

**Purpose** Law enforcement officers expect that a TASER CEW (Conducted Electrical Weapon) broad-spread probe exposure will temporarily incapacitate a subject who will then be able to immediately (~1 s delay) recover motor control in order to comply with commands. However, this recovery time has not been previously reported.

**Methods** A total of 32 police academy students were exposed to a very broad-spread 5 s CEW stimulus as part of their training and told to depress a push-button as soon as they sensed the stimulus. A subgroup also depressed the push-button after being alerted by an audio stimulus.

**Results** The response time after the audio trigger was 1.05 ± 0.25 s; the median was 1.04 s (range 0.69–1.34 s). For the paired CEW triggered group the mean response time was 1.41 ± 0.61 s with a median of 1.06 s (range 0.92–2.18 s), which was not statistically different. Only 2/32 subjects were able to depress the button during the CEW exposure and with delays of 3.09 and 4.70 s from the start. Of the remaining 30 subjects the mean response time to execute the task (once the CEW exposure ended) was 1.27 ± 0.58 s with a median of 1.19 s (range 0.31–2.99 s) (NS vs. the audio trigger).
Reduced Deadly Force/Injuries - Selected CEW Literature

CEWs Reduce Use of Deadly Force:

Table 28 CEWs Reduce Use of Deadly Force

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
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<tr>
<td>10</td>
<td>Jul. 2005</td>
<td>Sergeant Brian A. Bruce, Six Month [TASER ECD] Study July 5, 2005, City of Columbus, Ohio Division of Police.</td>
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   a. 67 (26.7%) of the 249 (of the 580 total) law enforcement officers who used the TASER ECD at least once in the field stated that they have used the ECD in a situation where they would have been legally justified in using deadly force (i.e. firearm).


   a. “Studies by law enforcement agencies deploying CEDs have shown reduced injuries to both officers and suspects in use-of-force encounters and reduced
use of deadly force. More recently, independent researchers have come to similar conclusions, when appropriate deployment and training policies are in place.” Page VII.


a. “In addition, use of the ECD will often prevent the need to use a more serious level of force such as deadly force.” Page 4, FN 4.


a. “ECWs can reduce the incalculable human costs suffered when officers must use deadly force because a less-lethal option is unavailable.” Page 19.


a. “Most studies undertaken by law enforcement agencies (and others) indicate that deploying CEDs relative to other use-of-force options, such as pepper spray, physical force, police dogs, and batons, reduces injuries to officers and suspects and reduces the use of lethal force.”


a. “Police agencies have reported that since the TASER weapon was deployed to officers in the field, the use of deadly force by officers and the number of officers injured during arrest confrontations has been dramatically reduced.” Chapter 3, page 29.


a. “In March 2008 findings from the inquest of the deaths of four young men who were shot dead by police were released by the Queensland State Coroner. In the findings, the coroner referred to the trial of T[ASER ECDs] by Queensland police, and the evaluation of the trial by the CMC. The coroner recognized
that: [had] the officers involved in this incident had access to a [TASER ECD] they would have been deployed… [and] such deployment may have resulted in each of the incidents being resolved without anyone being killed." Page 29.

b. “Police Commissioner Andrew Scipione stated that an increase in violent attacks on officers had prompted the extension. In addition, he stated: If this is but one option that gives the police officers in the streets of NSW some alternative rather than to use deadly force, rather than to shoot somebody and killing them, then this is a good option.” Page 38.


a. “Law enforcement professionals are able to comply with CED policies of their agencies. Rational and supported CED policies allow for decreased uses of lethal force. … Police were compliant with policy in all cases, and, in addition to avoiding the use of lethal force in a significant number of circumstances [23 of 426 incidents, or 5.4%], the safety of CED use was demonstrated despite one death subsequently attributed to lethal toxic hyperthermia.”


a. “[T]he Committee agrees with the great majority of witnesses that the T[ASER] gun has its place in police work and that it can save lives during police interventions that would otherwise involve the use of deadly force.” Page 13.

10. (07/2005 Bruce) Sergeant Brian A. Bruce, Six Month T[ASER ECD] Study July 5, 2005, City of Columbus, Ohio Division of Police.

a. “Based upon the study, there were fourteen [out of 172 (or 8.1%)] incidents where deadly force would have been justified where the [TASER ECD] was used.” Page 7.

b. “There were fourteen [out of 172 (or 8.1%)] incidents officers responded to where deadly force was justified, but officers were able to use time, distance, and barriers to deploy the [TASER ECD] as the response verse using deadly force to control the subjects.”

a. “A review of MPD T[ASER ECD] deployments shows that in six [out of 83 or 7.2%] cases it can fairly be said that the T[ASER ECD] deployment allowed officers to avoid having to utilize deadly force.” Page 5.

b. “Also, several of the instances in which T[ASER ECD] use was threatened or the T[ASER ECD] was displayed (but not deployed) involved armed subjects. Those incidents easily could have rapidly escalated to deadly force encounters without the presence of the T[ASER ECD].” Page 6.


**CEWs Reduce Suspect Injuries:**

Table 29 CEWs Reduce Suspect Injuries

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<td>11</td>
<td>Dec. 2008</td>
<td>Butler, C., Staff Sergeant, Calgary Police Service, Christine Hall, MSc MD FRCPC, Principal Investigator, RESTRAINT Study, Department of Emergency Medicine, Vancouver Island Health Authority, 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 (Calgary Police Services, Calgary, Alberta, Canada), Law Enforcement Executive Forum, 2008.</td>
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1. See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®).


   a. “Another intermediate target-hardening weapon, which is now widely used by officers, is known as the conducted energy device (CED) or electronic control device (ECD). The most common of these devices is the Taser. Smith, Kaminski, Rojek, Alpert, and Mathis (2007) studied the impact of the CED on injuries and suggest that CED and pepper spray use may reduce the likelihood of injury to both officers and suspects, especially when compared to hand-to-hand combat. Lin and Jones (2010) also found that ECD use decreased officer injury among the Washington State Patrol. When CED was used alone, Paoline, Terrill, and Ingram’s (2012) work agreed that officer injury decreased. When used in conjunction with other police weapons (e.g., batons and guns), however, the risk of officer injury increased. Furthermore, Taylor and Woods (2010) report lower rates of officer injuries among law enforcement agencies that used CEDs compared to those that did not. Finally, Brandl and Stroshine (2012) suggest that greater availability and use of CEDs are potential contributors to the recent declines in officer injuries.”

a. “This evaluation of dart punctures, however, carries an injury inflation bias for CEWs relative to other force options. As noted earlier, routine dart punctures are similar to what is produced by a medium gage hypodermic needle, and if they are defined and counted as injuries under the guise of including all physical harms, then we should also be counting any skin irritation that occurs from the application of pepper spray, pressure point control tactics, joint locks, handcuffing, and so forth. Under such a scenario, injury rates associated with these tactics also would increase to varying degrees. This would undoubtedly shift the evaluation of CEW injuries relative to other force options. Pepper spray, in particular, would have an injury profile exceeding that of CEWs if routine dart punctures and skin irritation from OC are counted.”

b. “In summary, the weight of the available research to date suggests that CEWs reduce the odds of suspect and officer injury when minor dart punctures are not counted as injuries. The fact that injuries tend to increase when other types of force are used in conjunction with CEWs and that CEW use atone is associated with a decreased incidence of injury or the effects are benign suggests that CEWs are an effective option for stopping suspect resistance with minimal harmful effects. Without question, CEWs often produce minor dart punctures to the skin. From a cost/benefit perspective, however, this harm should be balanced against the greater harm that is likely to occur if officers must use alternative types of force to control a resistant suspect. The effort to redefine CEW-related injuries to include minor skin punctures associated with the intended functioning of the weapon attempts to shift the rhetoric of force in a manner that few researchers and even fewer practitioners have heretofore seemed willing to embrace.”


a. “Across 12 agencies and more than 25,000 use of force cases, the odds of a suspect being injured decreased by 70 percent when a CED was used. Controlling for other types of force and resistance, the use of CEDs significantly reduced the probability of injuries. In very rare cases, people have died after being pepper sprayed or shocked with a Taser, although no clear evidence exists that the weapons themselves caused the deaths.”


a. “ECD adoption did not result in a reduction of citizen injury claims.” Pg. 163.

b. “[I]t was found that ECD-involved cases had a lower arrestee injury rate than non-ECD involved cases, an effect highly influenced by the ECD display only cases.” Pg. 171.


a. Overall findings:

(1) “The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects.” Pg. 1.

(2) “All in all, our data suggest that we found consistently strong effects for CEDs on increasing officer and suspect safety. Not only are CED sites associated with improved safety outcomes compared to a matched group of non-CED sites, but also within CED agencies, in some cases the actual use of a CED by an officer is associated with improved safety outcomes compared to use of other less-lethal weapons.” Pg. 6.

(3) “For five of the eight comparisons, the cases where an officer uses a CED were associated with the lowest or second lowest rate of injury, injuries requiring medical attention, or injuries requiring hospitalization.” Pg. 6.

(4) “The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects. Similar results were obtained in a study by Smith et al. (2008), who recommended that CEDs should be authorized as a possible response in cases where suspects use defensive resistance (e.g., suspect struggles to escape physical control of officer) or higher levels of suspect resistance, in order to avoid up-close combative situations.” Pg. 6.

b. Suspect injuries reduced:
(1) “For an agency that deploys CEDs, our data suggest that the odds of a suspect being injured are reduced by more than 40%.” Pg. 4.

(2) “For an agency that deploys CEDs, our data suggest that the odds of a suspect being severely injured are reduced by over 40%.” Pg. 4.

(3) “For our CED-only site analyses, our data suggest that CEDs were associated with the lowest levels of suspect severe injuries compared to other forms of force.” Pg. 4.

(4) “CEDs seem to have a neutral effect on the number of suspect deaths related to officer use-of-force cases.” Pg. 5.

   a. “Most studies undertaken by law enforcement agencies (and others) indicate that deploying CEDs relative to other use-of-force options, such as pepper spray, physical force, police dogs, and batons, reduces injuries to officers and suspects and reduces the use of lethal force.”

   a. “The injury reduction ranged from 24% to 82%. These were weighted by the number of CEWs. The weighted mean injury rate reduction was 64%. The 95% confidence bounds were 52–75%.”

   a. “The Monitoring Team also noted a significant decline in serious force-related incidents at this time. We attribute much of this decrease to the department-wide deployment of the Taser. Our review of use of force reporting and investigative files showed that the Taser replaced other types of force in the majority of incidents. Moreover, injuries to officers and citizens also declined.” Page 36.
11. (12/2008 Butler) Chris Butler, Staff Sergeant, Calgary Police Service, Christine Hall, MSc MD FRCPC, Principal Investigator, RESTRAINT Study, Department of Emergency Medicine, Vancouver Island Health Authority. 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 (Calgary Police Services, Calgary, Alberta, Canada), Law Enforcement Executive Forum, 2008.

a. “The commonly held belief that the conducted energy weapon carries a significant risk of injury or death for the population of interest is not supported by the data. Within the force modality framework most commonly available to police officers, the CEW was less injurious than either the baton or empty hand physical control. Although the study used the intention to treat analysis, when we removed the incidents where the use of the CEW was unsuccessful (n = 14) (thereby requiring subsequent alternative force options—typically physical control), the safety profile of the CEW rose to 88.7% (i.e., no injury or minor injury to subjects only).”


a. “CED use was associated with a 677 percent increase in the odds of suspects not being injured during use-of-force encounters. Thus, whereas hands on tactics significantly increased the risk of injury among both officers and suspects, CEDs significantly decreased the risk of injury to both groups.” Page 437.

b. “[T]he use of soft-hand tactics, hard-hand tactics, and canines by officers increased the odds of both minor and major injury to suspects, while the use of CEDs significantly decreased the odds of both types of injury.” Page 437.

c. “Given the minor nature of most injuries to officers and suspects, though, the substitution of OC spray or CEDs for hands-on control primarily will result in the prevention of bruises, abrasions, sprains, and the like. Balanced against this injury savings are the pain, irritation, and decontamination requirements associated with OC spray and the minor dart puncture wounds and rare
complications associated with CEDs. Nonetheless, every use-of-force encounter carries with it the potential for serious injury and even minor injuries can result in the need for medical treatment or time lost from work. More importantly, the use of less lethal technologies from a stand-off distance may help to prevent the occasional serious injury that might otherwise occur from physical contact between officers and citizens. Consequently, the use of CEDs or OC spray under these conditions makes the control of resistant persons safer for everyone.” Page 440.


a. “We found officer injury rates associated with M26 deployment were lower than those for CS spray and baton use. Subject injury rates were lower in M26 deployment than in deployment of CS spray, batons or police dogs. We suggest that the M26 should be made more widely available to police officers in the UK.”

CEWs Reduce Officer Injuries:

1. See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®).


a. “Another intermediate target-hardening weapon, which is now widely used by officers, is known as the conducted energy device (CED) or electronic control device (ECD). The most common of these devices is the Taser. Smith, Kaminski, Rojek, Alpert, and Mathis (2007) studied the impact of the CED on injuries and suggest that CED and pepper spray use may reduce the likelihood of injury to both officers and suspects, especially when compared to hand-to-hand combat. Lin and Jones (2010) also found that ECD use decreased officer injury among the Washington State Patrol. When CED was used alone, Paoline, Terrill, and Ingram’s (2012) work agreed that officer injury decreased. When used in conjunction with other police weapons (e.g., batons and guns), however, the risk of officer injury increased. Furthermore, Taylor and Woods (2010) report lower rates of officer injuries among law enforcement agencies that used CEDs compared to those that did not. Finally, Brandl and Stroshine (2012) suggest that greater availability and use of CEDs are potential contributors to the recent declines in officer injuries.”

a. “This evaluation of dart punctures, however, carries an injury inflation bias for CEWs relative to other force options. As noted earlier, routine dart punctures are similar to what is produced by a medium gage hypodermic needle, and if they are defined and counted as injuries under the guise of including all physical harms, then we should also be counting any skin irritation that occurs from the application of pepper spray, pressure point control tactics, joint locks, handcuffing, and so forth. Under such a scenario, injury rates associated with these tactics also would increase to varying degrees. This would undoubtedly shift the evaluation of CEW injuries relative to other force options. Pepper spray, in particular, would have an injury profile exceeding that of CEWs if routine dart punctures and skin irritation from OC are counted.”

b. “In summary, the weight of the available research to date suggests that CEWs reduce the odds of suspect and officer injury when minor dart punctures are not counted as injuries. The fact that injuries tend to increase when other types of force are used in conjunction with CEWs and that CEW use alone is associated with a decreased incidence of injury or the effects are benign suggests that CEWs are an effective option for stopping suspect resistance with minimal harmful effects. Without question, CEWs often produce minor dart punctures to the skin. From a cost/benefit perspective, however, this harm should be balanced against the greater harm that is likely to occur if officers must use alternative types of force to control a resistant suspect. The effort to redefine CEW-related injuries to include minor skin punctures associated with the intended functioning of the weapon attempts to shift the rhetoric of force in a manner that few researchers and even fewer practitioners have heretofore seemed willing to embrace.”


a. suggest that greater availability and use of CEDs are potential contributors to the recent declines in officer injuries.


a. “[W]e may conclude that the adoption of ECD did indeed reduce the rate of officer injury to a noteworthy extent.” Pg. 163.
b. “[T]he evidence is rather convincing that the adoption of electronic control devices by the agency has led to fewer injuries to officers resulting from officer-arrestee confrontation.” Pg. 171.


a. Overall findings:

(1) “The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects.” Pg. 1.

(2) “All in all, our data suggest that we found consistently strong effects for CEDs on increasing officer and suspect safety. Not only are CED sites associated with improved safety outcomes compared to a matched group of non-CED sites, but also within CED agencies, in some cases the actual use of a CED by an officer is associated with improved safety outcomes compared to use of other less-lethal weapons.” Pg. 6.

(3) “For five of the eight comparisons, the cases where an officer uses a CED were associated with the lowest or second lowest rate of injury, injuries requiring medical attention, or injuries requiring hospitalization.” Pg. 6.

(4) “The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects. Similar results were obtained in a study by Smith et al. (2008), who recommended that CEDs should be authorized as a possible response in cases where suspects use defensive resistance (e.g., suspect struggles to escape physical control of officer) or higher levels of suspect resistance, in order to avoid up-close combative situations.” Pg. 6.

b. Officer injuries reduced:

(1) “For agencies that deploy CEDs, our data suggest that the odds of an officer being injured are reduced by over 70%.” Pg. 4.
(2) “Also, for our CED-only site analyses, when officers actually use CEDs our data suggest that there is a 76% reduction in officer injuries.” Pg. 4.

(3) “For an agency that deploys CEDs, our data suggest that the odds of an officer receiving an injury requiring medical attention is reduced by at least 80%.” Pg. 4.

(4) “For our CED-only site analyses, when officers actually use CEDs our data suggest that there is a 63% reduction in the probability of an officer receiving an injury requiring medical attention.” Pgs. 4–5.


a. “Most studies undertaken by law enforcement agencies (and others) indicate that deploying CEDs relative to other use-of-force options, such as pepper spray, physical force, police dogs, and batons, reduces injuries to officers and suspects and reduces the use of lethal force.”


a. “The reported officer injury rate reduction ranged from 20% to 100%. The injury reduction statistics were weighted by the number of CEWs. The weighted mean injury reduction was 63%. The 95% confidence bounds were 55–72%.”


a. “We found officer injury rates associated with M26 deployment were lower than those for CS spray and baton use. Subject injury rates were lower in M26 deployment than in deployment of CS spray, batons or police dogs. We suggest that the M26 should be made more widely available to police officers in the UK.”

CEWs Are Associated With Less Injury Than “Physical Force”:

Table 30 CEWs Are Associated With Less Injury Than “Physical Force”

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<td>Hagans v. Franklin County Sheriff's Office, 695 F.3d 505, 510 (6th Cir. (Ohio) Aug 23, 2012); quoting the May 24, 2011 NIJ/Laub study</td>
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2. (08/2012 6th Cir.) Hagans v. Franklin County Sheriff's Office, 695 F.3d 505, 510 (6th Cir. (Ohio) Aug 23, 2012); quoting the May 24, 2011 NIJ/Laub study:

   a. “... The taser remains a relatively new technology, and courts and law enforcement agencies still grapple with the risks and benefits of the device. Even as of a year ago, however, it could be said that tasers carry “a significantly lower risk of injury than physical force” and that the vast majority of individuals subjected to a taser—99.7%—suffer no injury or only a mild injury. John H. Laub, Director, Nat'l Inst. of Justice, Study of Deaths Following Electro Muscular Disruption 31 (2011); see also Mattos, 661 F.3d at 454 (Kozinski, J., concurring in part and dissenting in part).” (highlighting emphasis added)


   a. “[T]he relative risk of CED deployments appears to be lower than other use-of-force options.” Page 3.
b. “The risks of cardiac arrhythmias or death remain low and make CEDs more favorable than other weapons.” Page 10.

c. “All evidence suggests that the use of CEDs carries with it a risk as low as or lower than most alternatives.” Page 24.

d. “CED use is associated with a significantly lower risk of injury than physical force, so it should be considered as an alternative in situations that would otherwise result in the application of physical force.” Page 31.


   a. “Electronic control device use in the area of law enforcement is reported to reduce the risk of harm to both police officers and suspects, even compared with physical restraint.”


   a. “Of an average annual 75,000 suspects treated for non-fatal legal intervention injuries, 11% had injuries that were associated with the use of a CED or [TASER ECD]. ... Most suspects with CED-related injuries (93.6%) were treated and released from the hospital ED.”

   b. “The estimated number of CED-related injuries treated in US hospitals increased substantially over the study period. This could be explained by the increased use of CEDs by police departments over this period and by officers following Police Executive Research Forum (PERF) guidelines to notify emergency medical service personnel and have the suspect medically evaluated after exposure to a CED discharge.”

   c. Rates of injury (ROI) per 100,000 population included:

      – CED ROI 2.8 per 100,000 (95% CI was “1.4 to 4.2”)
      – Physical contact w/officer ROI 17.6 per 100,000 (95% CI or 13.6 to 21.6)

   d. “The principal [CED injury] diagnoses were mostly puncture wounds (34.0%), contusions/abrasions (17.3%), foreign bodies (10.8%) and lacerations (6.8%).”

a. The NIJ study found that “in very rare cases, people have died after being pepper sprayed or shocked with a T[ASER ECD], although no clear evidence exists that the weapons themselves caused the deaths.” Even more significant, however, was the study’s conclusion that the odds of a suspect being injured decreased by almost 60 percent when an ECD was used instead of hands-on physical force:

(1) “Our findings clearly show that the use of physical force and hands-on control increase the risk of injury to officers and citizens. . . . This increased risk was not trivial. When controlling for the use of CEDs [synonymous with ECD] and OC spray in the multiagency analysis, using physical force increased the odds of injury to officers by more than 300 percent and to suspects by more than 50 percent.” Pg. 8–1.

(2) “The multiagency models also show a reduction in suspect injuries associated with CED use. Across 12 agencies and more than 24,000 use of force cases, the odds of a suspect being injured decreased by almost 60 percent when a CED was used. . . . Overall, the injury findings related to CEDs were robust across agencies and across time. Controlling for other types of force and resistance, the use of CEDs significantly reduced the probability of injuries.” Pg. 8–3.


a. “CEDs appear to be relatively safe when used on healthy individuals in clinically controlled research settings. Given the findings from this study, as well as those from previously published research, law enforcement agencies should encourage the use of OC spray or CEDs in place of impact weapons and should consider authorizing their use as a replacement for hands-on force tactics against physically resistant suspects. … Our findings suggest that the incidence of injuries from police use-of-force incidents can be reduced substantially when police officers use CEDs and OC spray responsibly and in lieu of physical force to control physically resistant suspects.”

a. Overall findings:

(1) “The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects.” Pg. 1.

(2) “All in all, our data suggest that we found consistently strong effects for CEDs on increasing officer and suspect safety. Not only are CED sites associated with improved safety outcomes compared to a matched group of non-CED sites, but also within CED agencies, in some cases the actual use of a CED by an officer is associated with improved safety outcomes compared to use of other less-lethal weapons.” Pg. 6.

(3) “For five of the eight comparisons, the cases where an officer uses a CED were associated with the lowest or second lowest rate of injury, injuries requiring medical attention, or injuries requiring hospitalization.” Pg. 6.

(4) “The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects. Similar results were obtained in a study by Smith et al. (2008), who recommended that CEDs should be authorized as a possible response in cases where suspects use defensive resistance (e.g., suspect struggles to escape physical control of officer) or higher levels of suspect resistance, in order to avoid up-close combative situations.” Pg. 6.

b. Officer injuries reduced:

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(4) “CEDs seem to have a neutral effect on the number of suspect deaths related to officer use-of-force cases.” Pg. 5.


a. “Despite the controversy surrounding [TASER ECD] use in North America, the question surrounding [TASER ECD] use should not be ‘Is it safe?’ but, rather, ‘Is it as safe as, or safer than, the alternatives?’”


a. “While TASERs are not injury free (puncture wounds from dart probes, or skin burns from drive stuns) the alternative (broken bones from batons, burning pain from pepper spray, and potential death from firearm) makes them a preferential choice. Clearly this research has shown that electric weapons are very effective at ending conflict situations quickly, this in turn leads to less injuries to both suspects and officers.” Pg. 93.
Other – Selected CEW Medical/Scientific Literature

Algorithmic Approach to Assessment of CEW-Associated Fatality:


   a. “An algorithmic approach to assessment of CED-associated fatality seems feasible. By these pharmacovigilance standards, some published case fatality rates attributable to CED exposure seem exaggerated. CED-attributable deaths have close similarity to Type-B SAEs. The latter are rare, unpredictable, and usually due to a patient idiosyncrasy. In the person being restrained, such idiosyncratic factors may be unavoidable by law enforcement officers (LEO) in the field. These are unlike predictable (Type-A) SAEs, which have their corollary amongst secondary CED-associated deaths, e.g., head injury among cyclists or ignition of an inflammable atmosphere by the CED, and are identifiable risk factors for which LEO can train. Regardless, absolute CED tolerability is obviously greater than that for firearms. A prospective registry of CED deployments would measure this more precisely.”

CEW Safety Margin:


   a. “Conclusion: The majority of current medical research could not find acute clinical relevant pathophysiological effects during or after professional use of CEWs on human subjects. However, since not every aspect of possible acute pathophysiological influences of conducted electrical weapons in humans has been evaluated yet, medical supervision of exposed patients is essential.”


   a. “The literature suggests a substantial safety margin with respect to the use of CEDs when they are used according to manufacturer’s instructions.” Page 24.

a. “CEDs appear to be relatively safe when used on healthy individuals in clinically controlled research settings. Given the findings from this study, as well as those from previously published research, law enforcement agencies should encourage the use of OC spray or CEDs in place of impact weapons and should consider authorizing their use as a replacement for hands-on force tactics against physically resistant suspects. … Our findings suggest that the incidence of injuries from police use-of-force incidents can be reduced substantially when police officers use CEDs and OC spray responsibly and in lieu of physical force to control physically resistant suspects.”


a. “Overall, we found that the CED sites were associated with improved safety outcomes when compared to a group of matched non-CED sites on six of nine safety measures, including reductions in (1) officer injuries, (2-3) suspect injuries and severe injuries, (4-5) officers and suspects receiving injuries requiring medical attention, and (6) suspects receiving an injury that resulted in the suspect being taken to a hospital or other medical facility. Also within CED agencies, in some cases the actual use of a CED by an officer is associated with improved safety outcomes compared to other less-lethal weapons. The evidence from our study suggests that CEDs can be an effective weapon in helping prevent or minimize physical struggles in use-of-force cases. LEAs should consider the utility of the CED as a way to avoid up-close combative situations and reduce injuries to officers and suspects.”


a. “If deployed according to an appropriate use-of-force policy, and used in conjunction with a medically driven quality assurance process, Taser use by law enforcement officers appears to be a safe and effective tool to place uncooperative or combative subjects into custody.”

   a. “Collectively, these data are broadly reassuring and constitute the current best understanding of the human physiologic effects of conducted electrical weapons.”


   a. “Law enforcement professionals are able to comply with CED policies of their agencies. Rational and supported CED policies allow for decreased uses of lethal force. … Police were compliant with policy in all cases, and, in addition to avoiding the use of lethal force in a significant number of circumstances [23 of 426 incidents, or 5.4%], the safety of CED use was demonstrated despite one death subsequently attributed to lethal toxic hyperthermia.”


   a. “Ventricular fibrillation: In an attempt to evoke ventricular fibrillation, trains of simulated M26 or X26 Taser waveforms (designed to mimic the discharge patterns of the respective Taser devices) were applied to the ventricular muscle. When the simulated waveforms were applied in this way, neither the M26 nor X26 waveforms elicited ventricular fibrillation at peak current densities up to the maximum output available from the laboratory electrical stimulation system. The threshold peak current density for generation of ventricular fibrillation for the simulated M26 waveform was greater than 70-fold the modeled current density predicted to occur at the heart during Taser discharge. In the case of the simulated X26 waveform, the threshold peak current density was greater than 240-fold the modeled current density. That this failure of the simulated M26 and X26 Taser waveforms to induce ventricular fibrillation was not a function of the biological test system was demonstrated in each experiment by the generation of VF using the rectangular stimulation pulses.”
Risk of Injury:

   a. “There is no evidence in animals that indicates a high risk of injury from a single discharge lasting less than 15 seconds from a TASER® X26™.” Page 2

   a. “TASERs play an important role in law enforcement. This research and this report show that electric weapons are deployed more frequently than other less-lethal weapons and tactics, but they also appear to enjoy higher success rates in conflict resolution. This success in bringing officer/suspect confrontations to an end is invaluable as it has the effect of reducing injuries to all persons in the conflict. ... The fact that TASERs offer society the best “set phasers on stun” solution currently available makes them extremely appealing to police in use-of-force situations. Added to this are the many safeguards implemented by TASER International to identify when and where a TASER has been discharged. These electronic and physical tracking safeguards highly discourage improper use. In a police use of force confrontation, the most humane weapon or tactic would be one in which the resultant injury would be the least severe. While TASERs are not injury free (puncture wounds from dart probes, or skin burns from drive stuns), the alternative (broken bones from batons, burning pain from pepper spray, and potential death from firearm) makes them a preferential choice. Clearly this research has shown that electric weapons are very effective at ending conflict situations quickly, this in turn leads to less injuries to both suspects and officers.”

Risk of Death from CEW:

   a. “[T]he risk of human death due directly or primarily to the electrical effects of CED application has not been conclusively demonstrated.” Page viii.
   b. “The risks of ... death remain low and make CEDs more favorable than other weapons.” Page viii.
   c. “The risks of ... death remain low and make CEDs more favorable than other
weapons.” Page 10.

d. “Unlike the risk of secondary injury due to falling or puncture, the risk of human death due directly or primarily to the electrical effects of CED application has not been conclusively demonstrated.” Page 23.

e. “The medical risks of repeated or continuous CED exposure beyond the durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.


a. “[T]he role of electronic control device in mortality remains speculative.”


a. “Exposure to CEW application causes minimal effect on different organs. Decrease in overall mortality and morbidity is the main benefit of these devices in comparison to firearms, batons, pepper spray and wrestling. Also, ‘[t]here is no report of life threatening arrhythmia induction during application of these devices on healthy subjects. Based on these findings, CEW is considered safe from a cardiovascular stand-point.’”


a. “Across 12 agencies and more than 25,000 use of force cases, the odds of a suspect being injured decreased by 70 percent when a CED was used. Controlling for other types of force and resistance, the use of CEDs significantly reduced the probability of injuries. In very rare cases, people have died after being pepper sprayed or shocked with a Taser, although no clear evidence exists that the weapons themselves caused the deaths.”


a. “CEDs are used in circumstances of elevated risk of injury to both suspects and officers, including situations of persons armed during the confrontation.
Deaths proximate to CED use appear to fit a narrow suspect profile.”

   a. “No study has demonstrated a pathophysiologic mechanism or effect that would account for delayed deaths minutes to hours after conducted electrical weapon exposure.”

   a. “While to date there has been no medical research to establish a causal relationship between CED use and mortality, the panel notes that the science regarding the impact of CEDs is still evolving. ... To date in Canada, no report of a coroner or medical examiner has listed the CED as a cause of death or a contributory factor.”

CEW Discharge Duration Temporal to Arrest Related Death (“ARD”):

   a. “The medical risks of repeated or continuous CED exposure beyond the [45 second] durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.
   b. “Studies examining the effects of extended exposure in humans to CEDs are limited to humans exposed to less than 45 seconds.” Page 27.
   c. “... [E]xperiments using healthy human volunteers have found no cardiac dysrhythmias\textsuperscript{9,10} or respiratory dysfunction\textsuperscript{11} following exposures less than 45 seconds.”

   a. “The duration of total CED exposure was reported based on downloads off of the CED device itself. It should be noted that if the probes were dislodged or if energy was not being effectively transferred to the subject, the CED would not be able to differentiate and the total time would include these CED “failures.”
The median exposure was 17 seconds (IQR = 10–32, range, 2–64) for drive stun mode only, 20 seconds (IQR = 10–30, range, 4–130) for projectile probe mode only, and 25 seconds (IQR = 19–63, range, 7–176) when both projectile probe mode and drive stun were used.” Page 24.


a. 292 CEW temporal ARD incidents analyzed:

(1) Over 75% of the 292 deaths involved only 1 or 2 CEW exposures.

(2) 85% of fatalities were preceded by 3 CEW exposures or less.

b. “24.2 Are Multiple Exposures More Dangerous? ... A total of 267 autopsies were obtained, and police records or media accounts were analyzed for the remaining 25 cases. The results are shown in Fig. 24.4. It can be seen that 85% of fatalities were preceded by three exposures or less. Over 75% of the deaths involved only one or two exposures. The distribution of the number of CEW exposures was then compared to the exposure distribution for 3200 CEW exposures of the Royal Canadian Mounted Police (RCMP) [6]. These distributions were fitted to a Gumbel-Gompertz model and then were compared. Main and secondary distribution lobes, including the tail, showed no differences (log-rank p=0.48). We concluded that there appeared to be no correlation between the number of exposures and the mortality rate. ...These conclusions are supported by the recent human data with exposures out to 45 seconds [7] and animal data with exposures out to 30 minutes [8].” Pages 289–290.
c. **“24.5 Conclusions.”** About 1,400,000 human beings have received CEW exposures as of July 2008. Statistical analysis showed that many of the urban myths surrounding the use of CEW were false. The adoption of these devices has demonstrated a reduction in both suspect and officer injuries. **There was no evidence that longer exposures were more dangerous.** Presently, medical examiners rarely suggest a link between a CEW exposure and the death of a suspect.” Page 296.

**CEW Effectiveness:**


   a. “If deployed according to an appropriate use-of-force policy, and used in conjunction with a medically driven quality assurance process, Taser use by law enforcement officers appears to be a safe and effective tool to place uncooperative or combative subjects into custody.”

a. “TASERs play an important role in law enforcement. This research and this report show that electric weapons are deployed more frequently than other less-lethal weapons and tactics, but they also appear to enjoy higher success rates in conflict resolution. This success in bringing officer/suspect confrontations to an end is invaluable as it has the effect of reducing injuries to all persons in the conflict. ... The fact that TASERs offer society the best ‘set phasers on stun’ solution currently available makes them extremely appealing to police in use-of-force situations. Added to this are the many safeguards implemented by TASER International to identify when and where a TASER has been discharged. These electronic and physical tracking safeguards highly discourage improper use. In a police use of force confrontation, the most humane weapon or tactic would be one in which the resultant injury would be the least severe. While TASERs are not injury free (puncture wounds from dart probes, or skin burns from drive stuns), the alternative (broken bones from batons, burning pain from pepper spray, and potential death from firearm) makes them a preferential choice. Clearly this research has shown that electric weapons are very effective at ending conflict situations quickly, this in turn leads to less injuries to both suspects and officers.”

CEW Research Produces Consistent Findings (TASER versus others):

   a. “Findings from independent investigations have been concordant with those performed with industry support.”

   a. “It is important to note that TASER International [,Inc.] is the leader in the development and manufacture of CEDs. The ILEF recognizes that this vendor has invested in and conducted exhaustive research in order to increase device effectiveness as a tool for law enforcement while minimizing injury to subjects. Additionally, they have cooperated with and supported both government and independent researchers to continue to grow the body of knowledge on these systems. The ILEF views this open and responsible approach to research and testing as a model for other manufacturers to emulate.” Page 38.
CEW Use on Members of Specific Populations

CEW Use in Hospital Setting:


   a. Abstract. The author, who has trained thousands of police and civilians in use-of-force, tackles the controversy over the use of CEW technology (TASERS) in healthcare settings. In this article he provides the latest technical developments for such weapons, dispels three common myths about them, and provides fresh perspective for further discussion and consideration of their use in healthcare security.

   a. “Conclusion: CEW introduction into a health care setting demonstrated the ability to avert and control situations that could result in further injury to subjects, patients, and personnel. This correlates with a decrease in injury for hospital personnel. Further study is recommended for validation.”

CEW Use Medically Vulnerable or At-Risk Displaying Violent Behaviour:

   a. The majority of multiple or prolonged Taser incidents involved people from one or more “medically vulnerable or at-risk” groups:
      (1) More than 80 per cent of the people were reportedly affected by drugs and/or alcohol.
      (2) Indigenous people comprised 16 per cent of all people who were the subject of a multiple or prolonged deployment.
      (3) Over 40 per cent of the people were believed to have an underlying mental health condition.
CEW Use on Mentally Ill Subjects:


   a. Regarding or “involving persons with actual or perceived mental illness.” See generally entire document, especially: Use of Force (pages 16–28) and Electronic Control Weapons (pages 18–19).


   a. "Conclusion: The mentally ill represents a significant portion of subjects upon whom CEWs are used. These data suggest frequent use of CEWs in situations where deadly force would otherwise be justified and in situations where subjects exhibit imminent danger to themselves. These data also suggest that escalation to deadly force was avoided in many mental illness and suicidal situations by the presence of a CEW."


   a. Using CEW in 35 incidents on mentally ill patients resulted in no serious harm to the individuals in crisis or officers. Based on this report, CEW has been used on 16 suicidal, 1 homicidal, and 8 psychotic subjects. 10 subjects possessed weapons and 16 crises were judged to be potentially life threatening. CEW was not considered as cause of but was helpful in decreasing mortality.

CEW Use on Children:

Table 31 CEW Use on Children

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<th>No.</th>
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<tbody>
<tr>
<td>3</td>
<td>Jan. 2012</td>
<td>Statement on the Medical Implications of Use of the Taser X26 and M26 Less-Lethal Systems on Children and Vulnerable Adults, United Kingdom Defence Scientific Advisory Council. DSAC Sub-Committee on the Medical Implications of Less-lethal</td>
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Abstract

OBJECTIVE: Conducted electrical weapons (CEWs) such as the TASER are often used by law enforcement (LE) personnel during suspect apprehension. Previous studies have reported an excellent safety profile and few adverse outcomes with CEW use in adults. We analyzed the safety and injury profile of CEWs when used during LE apprehension of children and adolescents, a potentially vulnerable population.

METHODS: Consecutive CEW uses by LE officers against criminal suspects were tracked at 10 LE agencies and entered into a database as part of an ongoing multicenter injury surveillance program. All CEW uses against minors younger than 18 years were retrieved for analysis. Primary outcomes included the incidence and type of mild, moderate, and severe CEW-related injury, as assessed by physician reviewers in each case. Ultimate outcomes, suspect demographics, and circumstances surrounding LE involvement are reported secondarily.

RESULTS: Of 2026 consecutive CEW uses, 100 (4.9%) were uses against minor suspects. Suspects ranged from 13 to 17 years, with a mean age of 16.1 (SD, 0.99) years (median, 16 years). There were no significant (moderate or severe) injuries reported (0%; 97.5% confidence interval, 0.0%-3.6%). Twenty suspects (20%; 95% confidence interval, 12.7%-29.1%) were noted to sustain 34 mild injuries. The majority of these injuries (67.6%) were expected superficial punctures from CEW probes. Other mild injuries included superficial abrasions and contusions in 7 cases (7%).

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CONCLUSIONS: None of the minor suspects studied sustained significant injury, and only 20% reported minor injuries, mostly from the expected probe puncture sites. These data suggest that adolescents are not at a substantially higher risk than adults for serious injuries after CEW use.


CEW Use on Pregnant Woman:

Table 32 CEW Use on Pregnant Woman

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a. “Box 6.1, CEWs and Risk of Fetal Death:

1 “Although most of the published case reports describing fetal death following electric shocks involve exposures to higher amounts of electricity
than those delivered by CEWs, risk factors for fetal injury following electrocution include the magnitude of the current, the pathway along which the current travels, the duration of the current in the body, the body weight, and whether or not the mother was proximal to water at the time of exposure. High-voltage currents, and those that pass from hand to foot through the uterus, increase the risk of fetal death (Goldman et al., 2003). In one of the only prospective studies following women who received an electric shock during pregnancy, most received electric shocks of 110 volts or 220 volts while using home appliances. Of the 31 pregnant women, 28 delivered healthy newborns. One spontaneous abortion may have been related to the electric shock injury; however, the study concluded that low-voltage electric shock “does not pose a major risk to the fetus (Einarson et al., 1997).” (Page 48).

(2) “The Panel's review of the literature identified one case report of a pregnant woman who was exposed to a CEW, with the path of the current travelling through the uterus. She began spotting after one day, and received medical attention after seven days, when an incomplete spontaneous abortion was diagnosed. The conclusion was that because the uterus and amniotic fluid are excellent conductors of electric current, the fetus may have been vulnerable, depending on the contact points of the CEW probes (Mehl, 1992). Contact points that facilitate the passage of current through the fetus may, therefore, increase the risk for adverse outcomes. Since no studies have explored this question to date, the risk remains unknown.” [emphasis added] (Page 48).


a. “5. DOMILL"s principal findings, based on the evidence presented in the main body of this statement, are as follows: … (c) Risks to the pregnant woman and fetus from Taser discharge are incompletely understood. While there is no evidence that abdominal application of Taser discharge is able directly to induce uterine muscle contraction, Taser-induced muscle contraction commonly leads to falls. Fall injuries in general have been associated with an increased probability of delivery by caesarian section and low birth weight.” (Page 2).

b. “Spontaneous abortion and other implications for fetal well-being
29. The risks to the pregnant woman and fetus from Taser discharge are poorly understood.

30. A case report describes spontaneous abortion in an 11-week pregnant, 32-year-old woman seven days after being subjected to discharge from a conducted energy device. One of the device's barbs had lodged in the abdominal skin overlying the uterus, while the second barb had lodged in the left thigh. Spotting occurred one day after exposure to discharge and the woman miscarried six days later.

31. Amnesty International report a second case in which fetal death was diagnosed some 12 hours after exposure to Taser discharge.

32. In both of the above cases, the contribution of the Taser discharge (or of any other force used at the time) to the reported adverse outcomes is uncertain.

33. It has been suggested that Taser-induced muscle contractions in pregnant women may lead to induction of labour or other obstetric complications. DOMILL is unaware of any evidence either to substantiate or alleviate these concerns.

34. Fall injuries have been associated with a significantly increased probability of delivery by caesarian section and low birth weight, and these may be additional factors to consider when planning to use a Taser on a woman who is known to be pregnant or in the post-incident medical management of a pregnant woman who has been subjected to Taser discharge.

35. No pregnancy-associated adverse outcomes in the UK have emerged during DOMILL's on-going review of injury data from Taser incidents.


a. “Case reports of fetal death due to exposure to electrical current exist, all involving exposure significantly more severe than that associated with CED exposure. In contrast, one study of 31 pregnant women subjected to electric shock, not from CED deployment, but including 12 V (telephone line), 110 to
220 V (home appliance), and 2000 and 8000 V (electric fence) current, found no adverse effects to the pregnancies.\(^3\) There has been no research or field study demonstrating a significantly higher or lower risk for CED use with any particular group.\(^4\)–\(^7\)" (Page 23).


a. “There are no studies demonstrating the effects on pregnant women, so physicians will need to make clinical decisions on the need for fetal assessment and monitoring based on the type of CEW use, location, and patient presentation.” (Page 601).


a. “RESULTS: Thirty-one women were followed up after delivery: 26 had been exposed to 110 V, 2 to 220 V, 2 to high voltage, and 1 to 12 V. Twenty-eight women gave birth to healthy normal infants, one had a child with a ventricular septal defect, and two had spontaneous abortions. In the control group there were 30 healthy babies; one woman had a spontaneous abortion. There were no differences between the groups in pregnancy outcome, birth weight, gestational age, type of delivery, or rates of neonatal distress.”

b. “CONCLUSION: In most cases accidental electric shock occurring during day-to-day life during pregnancy does not pose a major fetal risk.”


a. “A case report is presented of a woman who was "Tasered" by law enforcement personnel while 12 weeks pregnant. The Taser (Thomas A. Swift's Electric Rifle) is an electronic immobilization and defense weapon that has been commercially available since 1974. The Taser was developed as an alternative to the .38 special handgun. The patient was hit with Taser probes in the abdomen and the leg. She began to spontaneously miscarry 7 days later and received a dilatation and curettage procedure 14 days later for incomplete abortion. The world's literature on electrical and lightning injury to pregnant women is reviewed, and the mechanism of action of Taser injury is discussed. As use of the Taser becomes more common, obstetrical clinicians may encounter complications from the Taser more often.” [emphasis added]
## CEW Use on Excited Delirium Syndrome (ExDS) Subjects:

Table 33 CEW Use on Excited Delirium Syndrome (ExDS) Subjects

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   a. “… In the pre-hospital setting, the basic principles used by law enforcement to control a patient in ExDS revolve around rapid physical restraint, minimalization of the patient's exertional activity, and safety for all. The use of a taser electronic control device (ECD) is felt by many experts to be preferable to the more traditional physical wrestling for control, because fighting or heavy physical exertion has a more deleterious effect on a patient's acid-base status [34–36]. …” Page 127.

   a. “Tactics used in the prehospital setting to control a patient in ExDS should revolve around patient and provider safety with rapid control and minimisation
of the patient’s exertional activity. The use of an electronic control device, such as a TASER® ECD, to gain control of a patient appears preferable to the more traditional and drawn out approach of going ‘hands on’, as fighting or heavy physical exertion has more of a deleterious effect on a patient’s already tenuous acid-base status. Thus, heavy exertion may make the patient more acidic and contribute to a greater risk for sudden death compared with a short burst of electrical control and rapid restraint. Judicious restraint of the patient will prevent ongoing use of the large thigh and arm muscles, which consume oxygen and contribute to acid-base disturbances. Containment and de-escalation where possible will minimise both stress and exertion.”


   a. “A conducted energy device is a fast way to restrain an individual with ExDS, pointed out Lenexa and Seattle police officers. While the TASER [CEW] is cycling, have somebody restrain him and deliver him to medics, if medics are present,” stated Officer Myers.


   a. “CED exposure may contribute to “stress,” and stress may be an issue related to cause-of-death determination. All aspects of an altercation (including verbal altercation, physical struggle or physical restraint) constitute stress that may heighten the risk of sudden death in individuals who are intoxicated or who have pre-existing cardiac or other significant disease. Medical research suggests that CED deployment during restraint or subdual is not a contributor to stress of a magnitude that separates it from the other stress-inducing components of restraint or subdual.” Id. at 19.


a. (page 7) “In addition, seven inquest juries from Ontario during the period from 2005 to early 2009 recommended all front-line/primary response officers be authorized to use CEWs. The rationale for these recommendations stems from an acknowledgement that front-line officers may be in a position to facilitate a rapid resolution of violent situations without the use of lethal force and the situations in which a CEW is required are most often encountered by front-line/primary response officers. The presiding coroner of one of the inquests commented that:

‘Particularly where ED (excited delirium) may be involved, early control and restraint of the agitated subject will prevent possible serious consequences, and allow for earlier medical intervention and treatment…Use of a Taser, particularly in full deployment (probe) mode, has proven highly effective in gaining rapid control of subjects, avoiding prolonged and potentially dangerous physical confrontations.’”


a. “CED technology may be a contributor to “stress” when stress is an issue related to cause of death determination. All aspects of an altercation (including verbal altercation, physical struggle or physical restraint) constitute stress that may represent a heightened risk in individuals who have pre-existing cardiac or other significant disease. Current medical research suggests that CED deployment is not a stress of a magnitude that separates it from the other components of subdual.” Id, at 3.

CEW Use on Subjects Under Influence of Alcohol/Ethanol:


a. “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.”
CEW Use on Subjects Under Influence of Cocaine (VFT) (animal)


   a. “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.”


   a. “Cocaine did not significantly decrease VFT, but actually increased it (i.e., reduced ventricular vulnerability to fibrillation) compared with placebo (84.6 ± 10.4 vs 55.8 ± 7.2 mA, respectively; at 150 minutes, p=0.04). Cocaine prolonged ERP and PR, QRS, QT, QTc, JT, and JTc intervals. Cocaine does not increase ventricular vulnerability to fibrillation in anesthetized dogs with normal intact hearts. Its electrophysiologic effects are similar to those of class I antiarrhythmic agents in this model.”

CEW Use on Subjects Under Influence of Methamphetamine (animal)


   a. “Conclusions: In smaller animals (32 kg or less), ECD exposure exacerbated atrial and ventricular irritability induced by methamphetamine intoxication, but this effect was not seen in larger, adult-sized animals. There were no episodes of ventricular fibrillation after exposure associated with ECD exposure in methamphetamine-intoxicated sheep.”
TASER CEW Operational Information

Graphic – TASER X26 CEW Basic Components:

Figure 13 TASER X26 CEW Basic Components
Graphic – Necessity of Completed Circuit to Deliver Electrical Charge:

Figure 14 Necessity of Completed Intact Electrical Circuit to Deliver Charge

The New York Conducted Energy Device Course, Student Guide, includes.  

Figure 15 (NY) Illustration of Circular Current Flow to Complete Electrical Circuit. In order for electricity to have an effect, it must flow in a circular pattern between a positive and negative conductor to complete a circuit.

Targeting (lower center mass):

Figure 16 CEW Pre-Probe Deployment LASER Aiming (targeting lower center mass).

---

X26 CEW Sound Levels (Open Circuit Arcing versus Delivered Charge):

The TASER X26 ECD is fairly quiet (51 decibels (dBA) at 1 m (meter)) when it is making an intact, completed circuit, good connection capable of delivering an electrical charge. The X26 ECD is significantly louder when it is not completing a circuit (79 dBA at 1 m) – when it is arcing in the air across the electrodes. This is similar to many types of equipment that are quiet when they are working properly and loud when they are not. This can be put into context with the sound levels from a sampling of ordinary sources as seen in Table 1. All examples are given with a one-meter distance from the source to the listener.

Table 34 Sampling of sound levels from various sources.

<table>
<thead>
<tr>
<th>Sound level (dBA at 1 m)</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>95</td>
<td>screaming</td>
</tr>
<tr>
<td>79</td>
<td>X26 ECD open-circuit crackling</td>
</tr>
<tr>
<td>70</td>
<td>vacuum cleaner</td>
</tr>
<tr>
<td>60</td>
<td>polite conversational speech</td>
</tr>
<tr>
<td>51</td>
<td>X26 ECD closed-circuit clicking</td>
</tr>
<tr>
<td>50</td>
<td>average home volume, normal refrigerator</td>
</tr>
<tr>
<td>40</td>
<td>quiet library</td>
</tr>
<tr>
<td>30</td>
<td>quiet bedroom at night</td>
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</tbody>
</table>

The scientific basis of the crackling sound emitted from an electrical arc has been well studied.

There is indeed a dramatic difference between the open circuit and intact circuit completed connected sound level from a TASER X26 ECD. When the X26 ECD is deployed with a completed intact circuit (such as making contact with a body sufficient to deliver an electrical charge) it makes a relatively soft clicking noise which is softer than normal conversation and on the order of the sound from a well operating refrigerator. However, in the open circuit mode when the circuit is broken or not completed — such as when a wire is broken, a probe misses, there is a clothing or other distance disconnect (cumulative distance of approximately four centimeters (cm) (or 1.6 inches), or a probe is dislodged — the sound level is 79 dBA which is well above that of a vacuum cleaner. The difference between 51 dBA and 79 dBA is logarithmic and actually corresponds to a ratio of:

\[
\text{Ratio} = 10^{((79-51)/10)} = 102.8 = 631
\]

Thus the X26 ECD, very similar in M26 ECD, in arcing (open circuit, no completed circuit) mode has 631 times the sound intensity in watts per meter squared (W/m²). This is the same arcing sound heard when a law enforcement officer performs a spark test on the X26 or M26 ECD. With a closed circuit (good connection, intact completed circuit capable of delivering an electrical
charge) the sound cannot be heard over loud conversation and certainly not over yelling and shouting.

The arcing (open-circuit) sound is not only much louder but has a different sound. It is often described as a “crackling” sound as opposed to a “clicking” sound when connected with an intact completed circuit. The “crackling” sound is so different that it can be differentiated by simply zooming in on a volume tracing to show the instantaneous sound level.

**CEW Cartridge/Probe Wires are Very Thin and are Easily Broken:**

The loaded X26 or M26 ECD has a cartridge affixed (snapped in place) on the front that contains two metal probes drawing thin insulated wires. When deployed, the two probes are propelled forward with the bottom probe moving at an eight-degree downward angle, which causes the probes to separate a foot for roughly every seven feet they travel from the ECD. Based on optical microscopy and testing, the wires connecting the probes to the cartridge have been measured as extremely thin (127 microns (millionths of a meter) or approximately 0.005 inches) in diameter—smaller than some human hair. Since the wires only have a tensile strength of 1.5-2.0 pounds, they can be easily broken in force encounters.

**CEW Probe Spread and Incapacitation:**


   a. “Incapacitation by all measures was found to be a function of spread; generally increasing in effectiveness up to spreads between 9 and 12 in. There were notable differences between front and back exposures, with front exposures not leading to full incapacitation of the upper extremities regardless of probe spread.”

   a. “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."

**Graphic - CEW Probe Spread – Distance from CEW to Subject:**

*Figure 17 CEW Probe Spread – Distance from CEW to Subject*

---

**Probe Spread**

*For 15, 21 & 25 Foot Cartridges*

- Aim like a standard firearm at center of mass
- Use sights and/or laser
- Observe standard firearm safety guidelines
- Rule of thumb: ~1 foot (.3 m) spread for every 7 feet (2.1 m) of travel

<table>
<thead>
<tr>
<th>Target Distance (ft)</th>
<th>Spread (in)</th>
<th>Spread (cm)</th>
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</thead>
<tbody>
<tr>
<td>2'</td>
<td>4&quot;</td>
<td>10cm</td>
</tr>
<tr>
<td>5'</td>
<td>9&quot;</td>
<td>23cm</td>
</tr>
<tr>
<td>7'</td>
<td>13&quot;</td>
<td>33cm</td>
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<tr>
<td>10'</td>
<td>18&quot;</td>
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<tr>
<td>15'</td>
<td>26&quot;</td>
<td>66cm</td>
</tr>
<tr>
<td>21'</td>
<td>36&quot;</td>
<td>91cm</td>
</tr>
<tr>
<td>25'</td>
<td>38&quot;</td>
<td>109cm</td>
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*Figure 18 CEW Cartridge Showing Probe Discharge and Eight Degree Discharge Downward Angle.*
X26 CEW Log Shows Only Discharges Not Delivered Charge:


   a. “The record shows that an ‘activation’ of the T[TASER ECD] does not mean that the T[ASER ECD] actually touched or stunned Allen.” *Hoyt*, 672 F.3d at 976.


   a. “[TASER ECD] log shows only device activation; it does not represent that a shock was actually delivered to a body nor does it distinguish between probe deployment and drive stun.”

50,000 Volts Delivered to Body Myth:


   a. “Results: For the eight subjects, the mean spread between top and bottom probes was 12.1 inches (30.7 cm). The mean resistance was 602.3 Ω with a range of 470.5–691.4 Ω. The resistance decreased slightly over the 5-second discharge with a mean decrease of 8.0%. The mean rectified charge per pulse was 123.0 μC. The mean main phase charge per pulse was 110.5 μC. The mean pulse width was 126.9 μs. The mean voltage per pulse was 580.1 V. The mean current per pulse was 0.97 A. The average peak main phase voltage was 1899.2 V and the average peak main phase current was 3.10 A.”


   a. Page 7: “FN 8. Imp misunderstands voltage. First, voltage is a measure of electric potential per unit charge and is only meaningful in the context of current. While “50,000 volts” may sound frightening, any child whose hair stands on end while touching a low-current Van de Graff generator observes that an electric potential of even hundreds of thousands of volts does not necessarily cause shock or injury. Moreover, voltage is not additive with each taser contact: applying the taser ten times does not mean that Imp had “500,000 volts of electricity being shot into him.” Pl.'s Mem. Opp’n 2–3. Lastly,
even if relevant, the record and video support two taser deployments, not ten."
M26/X26/X26P CEW Drive-Stun Effects:

Figure 19 Arrows Pointing to Electrodes on Front of CEW with No Expended Cartridge in Place.

Figure 20 Illustrating CEW Drive-Stun Discharge Across Front Electrodes and LASER.

Figure 21 X26 CEW Front Electrodes – No Cartridge in Place on CEW.

Figure 22 X26 CEW Cartridge Showing Front Electrodes Recessed on Cartridge.

Drive-Stun: Medical Studies:


   a. “In drive stun mode, the device is pressed directly against the subject, causing localized pain.” (Page viii).
b. “In drive stun (also known as touch stun) mode, the device is pressed directly against the subject like a traditional stun gun. The electrical current is delivered across a more localized area than in a probe mode deployment (NSDOJ, 2008a). As a result, the main effect of drive stun mode is localized pain, and muscle immobilization is likely to be localized, due primarily to direct stimulation of skeletal muscle fibres adjacent to the point of contact with the electrodes.” (Page 21).

   a. “Risk of ventricular dysrhythmias is exceedingly low in the drive-stun mode of CEDs because the density of the current in the tissue is much lower in this mode.” Page 10.
   b. “Conclusions and Recommendations: The “drive-stun” or contact mode of CED use is a pain compliance procedure, and does not cause muscular incapacitation enabling restraint. Some sources indicate that people suffering from excited delirium are relatively insensitive to pain as a result of their condition. Some reports from law enforcement reinforce this view, because there are individuals who do not appear to be affected by the pain associated with CED exposure. Thus, “drive-stun” mode and other pain compliance methods should not be repeated in these individuals if they are found to have little or no initial effect.” Page 22.

   a. “The gun can also be used as a contact device whereby the darts are not fired, but rather the 2 metal darts make direct contact with a person’s body, in what police call a “drive stun.” With this method, the shock is delivered directly to the subject and the main effect is therefore not neuromuscular incapacitation, but a painful stimulus.17,21”

   a. Recommendation 3: Evaluation after Use of CEW in Drive Stun or Touch Stun Mode Level of recommendation: Class B. For patients who have undergone drive stun or touch stun CEW exposure, medical screening should focus on local skin effects at the exposure site, which may include local skin
irritation or minor contact burns. This recommendation is based on a literature review in which thousands of volunteers and individuals in police custody have had drive stun CEWs used with no untoward effects beyond local skin effects.

b. “Conclusions ... Among patients who had a CEW activation in drive stun or touch stun mode, evaluation should focus on skin manifestations, which are typically limited to surface burns, also called signature marks.”


a. Establishing that CEW use actually reduces stress markers compared to other force options and restraint alternatives).


a. CEW drive-stun applications have no effect over human phrenic nerves—nerves that control breathing.


a. No medically worrisome changes in human physiology found from two consecutive 5 second drive-stuns or one continuous 15 second drive-stun.

**Drive-Stun: Legal Cases:**


a. CEW in drive-stun mode “becomes a pain compliance tool with limited threat reduction.”


a. X26 CEW drive-stun mode graphic illustration depicting path and depth of delivered electrical charge based upon finite-element modeling. [Graphic was mentioned in Glowczenski v. TASER International, Inc., 2012 WL 976050,
2012 U.S. Dist. Lexis 39438 (E.D.N.Y. March 22, 2012). “After viewing an exhibit showing the flow of electrical charge from a T[ASER X26 ECD] in drive stun mode, which showed that the charge does not penetrate the dermal fat layer into the skeletal muscle of the recipient, and which [Dr. William] Manion [forensic pathologist and attorney] agreed was a “fair representation,” ...” Id. pg. 14.]


a. “Cooks said that he had stunned Allen once with the probes and two times in dry stun mode, although his T[ASER X26 ECD’s] data download showed that the device had been activated twelve times. Harkleroad said that he had stunned Allen three times in dry stun mode, but his T[ASER X26 ECD’s] data download showed that it had been activated six times. The record shows that an “activation” of the T[ASER ECD] does not mean that the T[ASER ECD] actually touched or stunned Allen. In any event, the more significant fact is that Allen was tased only once in the prong mode, and that all subsequent tasings were in the dry stun mode.” [Hoyt, at 976].

b. FN4. “Dry stun mode” is also known as “drive stun mode.” Plaintiffs’ expert described the difference between the probes and dry stun:

The [TASER CEW] was classified as an electro-muscular disruptor when used to fire small probes attached to the
weapon with thin wires because, in that mode, it overrides the central nervous system and makes muscle control impossible. The TASER can also be used as a pain compliance weapon in what is called the “drive stun” mode. In the “drive stun” mode, the weapon is pressed against a person's body and the trigger is pulled resulting in pain (a burning sensation) but the “drive stun” mode does not disrupt muscle control. [Hoyt, at 976].

c. “FN5. As discussed below, the record in this case reveals a stark contrast between the prong mode (which overrides the central nervous system and disrupts muscle control) and the much less serious [drive] stun mode (which results merely in pain, a burning sensation).” [Hoyt, at 976].


a. EN 9.”Most tasers have two modes: dart mode and drive-stun mode.” *Thomas v. Plummer*, 486 F. App’x 116, 126 n. 10 (6th Cir.2012). “A drive stun is performed after the probes are removed from the taser [and] reduces the amount of force employed on a person in close range.” *Flowers v. City of Melbourne*, 2014 WL 715609, at *3 n. 6 (11th Cir. Feb.26, 2014); see *Rossevelt–Hennix v. Prickett*, 717 F.3d 751, 756 (10th Cir.2013) (in drive stun mode, “the taser delivers an electric shock, but does not cause an override of an individual’s central nervous system as does a taser in dart probe mode”).


(1) “When a [TASER X26 ECD] is used in drivestun mode, the operator removes the dart cartridge and pushes two electrode contacts located on the front of the [TASER ECD] directly against the victim. In this mode, the [ECD] delivers an electric shock to the victim, but it does not cause an override of the victim’s central nervous system as it does in dart-mode.” *Mattos*, 661 F.3d at 443.

(2) The Ninth Circuit declined to determine what level of force specifically is used when a [TASER X26 ECD] is used in drive-stun mode. *Mattos*, 661 F.3d at 443.

1018 (C.A.9 (Wash) March 26, 2010) which stated in part (since it was superseded this is NOT good law):

(1) Drive-stun quantum of force less than “intermediate” Brooks, 599 F.3d at 1028.

(2) “The [CEW]’s use in ‘touch’ or ‘drive-stun’ mode—as the Officers used it here— involves touching the [CEW] to the body and causes temporary, localized pain only.” Id. at 1026.

(3) “The use of the [CEW] in drive-stun mode is painful, certainly, but also temporary and localized, without incapacitating muscle contractions or significant lasting injury.” Id. at 1027.

6. General Description of CEW firing modes: The CEW can be used primarily in one of two ways. In probe or dart mode, it fires two projectiles that are designed to penetrate the suspect’s skin and deliver a continuous charge of electricity across the area between the probes, capturing the muscle nerves and causing some degree of neuromuscular incapacitation. See, e.g., Neal-Lomax v. Las Vegas Metro. Police Dept., 574 F. Supp. 2d 1170, 1176 (D. Nev. 2008) aff’d, 371 F. App’x 752 (C.A.9 (Nev.) 2010) (explaining mechanics of the TASER X26 CEW). In its other capacity, however, when the probe or dart cartridge is removed, or an expended cartridge is in place the ECD becomes a simple stun gun. Id. This is often referred to as using the ECD in “drive-stun” mode. Id.; Neal-Lomax, 574 F. Supp. 2d at 1176. “Drive stunning does not incapacitate or damage a suspect, but it does cause pain . . . .” Ellis v. Columbus City Police Dept., CIVA 1:07CV124SASAA, 2009 WL 3347300, n. 2 (N.D. Miss. Oct. 14, 2009). In drive-stun mode, the ECD must be “physically placed in contact with the person and discharged. . . . . The drive stun mode is used for pain compliance and works only on the area of the body to which the [ECD] is applied.” Neal-Lomax, 574 F. Supp. 2d at 1176. When applied in drive-stun mode, the ECD does not typically remain in contact with the subject during the entire duration of the discharge due to the subject already struggling against the officers and his reaction to the ECD, causing it to bounce in and out of contact with him.


826 (9th Cir. 2010) (Wardlaw, J., concurring in denial of rehearing en banc). In dart mode, a taser penetrates the skin and causes neuro-muscular interruption (NMI). See Baker Aff. Ex. C, at 20; see McKenney, 635 F.3d at 364. NMI causes the subject to lose control of his muscles, which can lead to injuries from falling while paralyzed. See McKenney, 635 F.3d at 364; Bryan, 630 F.3d at 824. In contrast, drive-stun mode causes a painful stimulus but does not lead to NMI. Baker Aff. Ex. C, at 20; McKenney, 635 F.3d at 364. As a result, a taser in drive-stun mode is more than trivial force, but it is a less intrusive — and less risk-laden — use of force than a taser in dart mode.

**Drive Stun: Movement, Multiple Locations:**

   
   a. “The record shows that an ‘activation’ of the T[ASER ECD] does not mean that the T[ASER ECD] actually touched or stunned Allen.” *Hoyt*, 672 F.3d at 976.

   
   a. “According to [TASER], each ECD trigger pull activates a 5 second cycle, but when in drive stun mode, it delivers an electrical charge only for the time that it is in direct contact with the skin.”

   
   a. When applied in drive-stun mode, the ECD does not typically remain in contact with the subject during the entire duration of the discharge due to the subject already struggling against the officers and his reaction to the ECD, causing it to bounce in and out of contact with him. *Neal-Lomax*, 574 F. Supp. 2d at 1176.

   
   a. “In Green’s case, the electrodes skipped along the skin-causing the [TASER ECD] to come in contact with the body more than once during the same drive stun. The contact marks (these are not true “burns”) shown in the photographs attached to Green’s complaint are consistently normal with the use of a [TASER ECD] in the drive stun mode. Often an officer does not have a choice in the location of the electrodes’ contact with the attacker’s body.”

a. See video of incident showing three (3) X26 ECD drive stun cycles with each five (5) second cycle delivered with intermittent body contact and to different parts of the body. Thus, multiple ECD application locations per five (5) second cycle.
CEW Three-Point Deployment Mode:

1. CEW three-point deployment mode is utilized to attempt to gain NMI when for whatever reason a deployed probe mode is not succeeding in achieving the desired NMI effect. Three-point deployment is a combination of use of the CEW in both probe-deployment mode followed up by a simultaneous drive stun. Use of the CEW in three-point deployment mode is intended to create a wide electrode spread or separation in order to significantly increase the probability of achieving NMI.

2. Research has shown that “[n]umerical modeling estimated that TASER CEWs were expected to be safe when deployed in 3-point mode. In drive-stun, probe-mode or 3-point deployments, the CEWs had high theoretically approximated safety margins for cardiac capture, VF, phrenic or vagus nerve capture and skeletal muscle damage by electroporation.”89

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M26 CEW Operational Information (TASER Training Version 11):

1. TASER M26 CEW (TASER Training Version 11 (January 2004)):

   Figure 24 M26 CEW. TASER Training Version 11, M26 User Program, Slide 36.

![Advanced TASER M26 Diagram]

2. CEW Field Statistics (TASER Training Version 11 (January 2004)):

   Figure 25 CEW Field Success by Level of Use: TASER Training Version 11, M26 User, Slide 79.

![Field Success by Level of Use Table]
3. M26 CEW Drive-Stun (TASER Training Version 11 (January 2004)):

Figure 26 M26 CEW Drive-Stun Mode, TASER Training Version 11, M26 User, Slide 104.

![Drive Stun Mode Diagram]

For maximum effectiveness in stun mode, aggressively drive the M26 into the highlighted areas.

- Carotid
- Brachial plexus tie-in
- Radial
- Pelvic triangle
- Common peronial
- Tibial

Drive stun field use success: 94%

Use care when applying drive stun to neck or groin. These areas are sensitive to mechanical injury (such as crushing to the trachea or testicles if applied forcefully). However, these areas have proven highly effective targets. Refer to your department’s policy regarding drive stuns in these and other sensitive areas.
Selected Cardiac Issues and Concepts

VFT for Swine, Canine, and Human (Electrode on Heart):

Table 35 VFT for Swine, Canine, and Human (Electrode on Heart)

<table>
<thead>
<tr>
<th>Species</th>
<th>Year</th>
<th>VFT (µC)</th>
<th>Calculation (time x current)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig 90</td>
<td>2013</td>
<td>RV VFT</td>
<td>38.8 ± 8.4</td>
</tr>
<tr>
<td>Dog 91</td>
<td>1977</td>
<td>LV epicardium</td>
<td>43.2 ± 25</td>
</tr>
<tr>
<td>Human 92</td>
<td>1979</td>
<td>RV VFT</td>
<td>85 ± 21</td>
</tr>
</tbody>
</table>

Typical Electrical Charges Required for Human Cardiac Effects:

Table 36 Typical Electrical Charges Required for Human Cardiac Effects

<table>
<thead>
<tr>
<th>Intracardiac Electrode</th>
<th>Transcutaneous Electrodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low rate cardiac pacing</td>
<td>1 µC = 1 mA • 1 ms</td>
</tr>
<tr>
<td>Burst cardiac pacing</td>
<td>2400 µC</td>
</tr>
<tr>
<td>VF from single pulse</td>
<td>85 µC 94</td>
</tr>
<tr>
<td></td>
<td>Not reported</td>
</tr>
<tr>
<td></td>
<td>100,000 µC 95</td>
</tr>
</tbody>
</table>

Human VFT: Electrodes Applied to Epicardial Surface of Ventricle:


   a. “SUMMARY The ventricular fibrillation threshold (VFT) was measured in 28 patients at the time of cardiac surgery. The VFT was measured with a 100 Hz train of 24 rectangular pulses positioned across the ST segment and T wave. Current was applied to the epicardial surface of either ventricle with a bipolar electrode probe.”

   b. “This study shows that the VFT can be measured in man and that coronary artery disease reduces this parameter.”

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90 Personal communication.
### Table 37 1979 Horowitz VF thresholds

<table>
<thead>
<tr>
<th>Normal Heart</th>
<th>VFT (mA)</th>
<th>VFT Range (mA)</th>
<th>VFT (µC)</th>
<th>VFT Range (µC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Ventricle</td>
<td>24.3 ± 5.2 mA</td>
<td>19.1 – 29.5 mA</td>
<td>97.2 ± 20.8 µC</td>
<td>76.4 – 118.0 µC</td>
</tr>
<tr>
<td>Left Ventricle</td>
<td>33.6 ± 9.5 mA</td>
<td>24.1 – 43.1 mA</td>
<td>134.4 ± 38.0 µC</td>
<td>96.4 – 172.4 µC</td>
</tr>
</tbody>
</table>

Human Heart Requires 3X More Current to Go Into VF Compared to Swine:

   a. “Swine are exquisitely sensitive to the electrical induction of VF and a human being requires 3 times as much ventricular epicardial current in order to induce VF.” (pg 6)
   b. “swine are 3 times more sensitive — for the induction of VF” (pg 6)

   a. “Swine heart needs 35% less current to go to ventricular fibrillation in comparison to human heart from external stimulation.”

   a. “Because they have a heart-body weight ratio and general cardiac anatomy similar to that of humans, swine have been used in the testing and development of pacemakers and implantable cardiac defibrillators. However, swine have a relatively low threshold for ventricular fibrillation, in part, because their Purkinje fibers cross the entire ventricular wall, in contrast to human hearts in which these fibers are largely confined to a thin layer in the endocardium. Additionally, the cardiac impulse proceeds from the epicardium to the endocardium in swine, potentially increasing their sensitivity to externally applied electrical currents compared with humans. These differences diminish the relevance of this model for evaluating the safety of CED exposure in humans.” Pg. 4.


**Accuracy of Subject’s Pulse Detection by Responder:**

1. It is sometimes argued that pulse detection is inaccurate:

   a. However, the inaccuracy lies in the inability of responders to quickly find a pulse. For example, if a responder is pushed to find a pulse in 10 seconds or less, about 50% of the responders will fail to find one.\(^{97}\)

   (1) Given a full minute, responder will find the pulse with 97% accuracy.\(^{98}\)

   b. False positives concern, i.e. what are the chances that a responder will detect a pulse that is not there? A pulse is detected with 95% accuracy.\(^{99}\)

**Medical Device Litigation:**\(^{100}\)

1. “Conclusions. Medical device litigation is a large industry in the United States. In many cases, there was no true product defect behind the litigation. Beyond designing high-quality devices, the biomedical engineer must understand the realities of this litigation environment and be cautious with the use of humor or irony in e-mails.”

2. “The 100 μC charge per pulse (which is what determines the potential to affect the heart) can be compared to electric fence energizers that can provide an output up to 1.1 mC, or 11 times more charge.”

3. "The ECD takes advantage of two primary natural protections against electrocution that arise from the difference between skeletal and cardiac muscle."


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The Stability of Electrically Induced Ventricular Fibrillation:101

1. Abstract:

The first recorded heart rhythm for cardiac arrest patients can either be ventricular fibrillation (VF) which is treatable with a defibrillator, or asystole or pulseless electrical activity (PEA) which are not. The time course for the deterioration of VF to either asystole or PEA is not well understood.

Knowing the time course of this deterioration may allow for improvements in emergency service delivery. In addition, this may improve the diagnosis of possible electrocutions from various electrical sources including utility power, electric fences, or electronic control devices (ECDs) such as a TASER® ECD.

We induced VF in 6 ventilated swine by electrically maintaining rapid cardiac capture, with resulting hypotension, for 90 seconds. No circulatory assistance was provided. They were then monitored for 40 minutes via an electrode in the right ventricle. Only 2 swine remained in VF; 3 progressed to asystole; 1 progressed to PEA. These results were used in a logistic regression model. The results are then compared to published animal and human data.

The median time for the deterioration of electrically induced VF in the swine was 35 minutes. At 24 minutes VF was still maintained in all of the animals. We conclude that electrically induced VF is long-lived—even in the absence of chest compressions.

2. CONCLUSIONS:

a. We have studied the time for electrically-induced ventricular fibrillation to deteriorate into asystole or PEA in ventilated animals. The median time was 35 minutes. No animals deteriorated in less than 24 minutes.

b. Although occasional instances, in humans—of more rapid VF to asystole deterioration—have been noted, the median time for deterioration to asystole or PEA is estimated at 31 minutes. However, the point at which 90% of the cases have not degraded to asystole is approximately 12 minutes. The shorter duration is most likely due to the myocardial ischemic acidosis developing before the cardiac arrest.

c. Based on the existing data, we estimate that it requires about 21-30 minutes for electrically-induced VF to deteriorate to asystole with a 10% probability assuming some chest compressions. We estimate the median time to be 49–

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Defibrillation Success Rates for Electrically-Induced Fibrillation:102

1. ABSTRACT

Accidental electrocutions kill about 1000 individuals annually in the USA alone. There has not been a systematic review or modeling of elapsed time duration defibrillation success rates following electrically-induced VF. With such a model, there may be an opportunity to improve the outcomes for industrial electrocutions and further understand arrest-related-deaths where a TASER® electrical weapon was involved. We searched for MedLine indexed papers dealing with defibrillation success following electrically induced VF with time durations of 1 minute or greater post VF induction. We found 10 studies covering a total of 191 experiments for defibrillation of electrically-induced VF for post-induction durations out to 16 minutes including 0–9 minutes of pre-shock chest compressions.

The results were fitted to a logistic regression model. Total minutes of VF and use of pre-shock chest compressions were significant predictors of success (p < .00005 and p = .003 respectively). The number of minutes of chest compressions was not a predictor of success. With no compressions, the 90% confidence of successful defibrillation is reached at 6 minutes and the median time limit for success is 9.5 minutes. However, with pre-shock chest compressions, the modeled data suggest a 90% success rate at 10 minutes and a 50% rate at 14 minutes.*

Essentials of Low-Power Electrocution: Established and Speculated Mechanisms:103

1. Abstract – Even though electrocution has been recognized—and studied—for over a century, there remain several common misconceptions among medical professional as well as lay persons. This review focuses on “low-power” electrocutions rather than on the “high-power” electrocutions such as from lightning and power lines. Low-power electrocution induces ventricular fibrillation (VF).

2. We review the 3 established mechanisms for electrocution:
   a. shock on cardiac T wave,
b. direct induction of VF, and

c. long-term high-rate cardiac capture reducing the VF threshold until VF is induced.

3. There are several electrocution myths addressed, including the concept—often taught in medical school—

a. that direct current causes asystole instead of VF, and

b. that electrical exposure can lead to a delayed cardiac arrest by inducing a subclinical ventricular tachycardia (VT).

c. Other misunderstandings are also discussed.

i. respiratory arrest,

ii. asystole from direct current,

iii. induction of an intermediate ventricular tachycardia (VT), and accommodation of the VERP (ventricular effective refractory period).
CEW Latency Signs and Symptoms Checklists

Latency for Signs and Symptoms of Electrocution:

Table 38 Latency for Signs and Symptoms of Electrocution

<table>
<thead>
<tr>
<th>Sign</th>
<th>Time from shock</th>
</tr>
</thead>
</table>

### Necessary, but not Sufficient, CEW Electrocution Diagnostic Criteria:

<table>
<thead>
<tr>
<th>Criteria (all must be satisfied)</th>
<th>Cutoff Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  CEW deployed in probe mode</td>
<td>Must be present</td>
</tr>
<tr>
<td>2  Successful delivery of electrical charge to person</td>
<td>Must be present</td>
</tr>
<tr>
<td>3  Conductive electrical path to the heart</td>
<td>Must be present</td>
</tr>
<tr>
<td>4  Lung not between electrode and heart</td>
<td>Must be present</td>
</tr>
<tr>
<td>5  Short DTH (Dart-to-Heart) distance</td>
<td>≤ 6 mm (millimeters) DTH</td>
</tr>
<tr>
<td>6  Cardiac capture ratio [BMP (beats per minute)]</td>
<td>2:1 capture ratio (550 BPM)</td>
</tr>
<tr>
<td>7  Immediate loss of pulse (no pulse after VF)</td>
<td>Any</td>
</tr>
<tr>
<td>8  Loss of consciousness (LOC)</td>
<td>≤ 20 seconds</td>
</tr>
<tr>
<td>9  Cessation of normal breathing</td>
<td>≤ 60 seconds</td>
</tr>
<tr>
<td>10 Presenting cardiac rhythm</td>
<td>Ventricular Fibrillation</td>
</tr>
<tr>
<td>11 Cessation of agonal breathing</td>
<td>&lt; 6 minutes</td>
</tr>
<tr>
<td>12 ≤3 Defibrillation attempts restoring rhythm</td>
<td>≤ 10 minutes</td>
</tr>
<tr>
<td>13 Deterioration of VF to asystole</td>
<td>≤ 21 minutes</td>
</tr>
</tbody>
</table>
## Transcutaneous Cardiac Pacing Thresholds and VF Safety Margins

### Adult Transcutaneous Cardiac Pacing Thresholds

<table>
<thead>
<tr>
<th>Source Information</th>
<th>Minimum (µC)</th>
<th>Minimum Range (in µC)</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TASER X26 CEW</td>
<td>–</td>
<td>–</td>
<td>Delivers ~100 µC</td>
</tr>
<tr>
<td>(1961) Zoll</td>
<td>100</td>
<td>100–600</td>
<td>Using &quot;long subcutaneous precordial needles&quot;</td>
</tr>
<tr>
<td>(1964) Zoll</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2009) Grimnes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1983) Falk</td>
<td>1680</td>
<td>1680–3200</td>
<td>–</td>
</tr>
<tr>
<td>(1984) White</td>
<td>3000</td>
<td>–</td>
<td>2 of 20 patients experienced capture at 150 milliamperes (mA) and 20 milliseconds (ms)</td>
</tr>
<tr>
<td>(1984) Geddes</td>
<td>4000</td>
<td>–</td>
<td>26 of 52 patients experienced capture at 200 mA and 20 ms</td>
</tr>
<tr>
<td>(1985) Dalsey</td>
<td>1000</td>
<td>1000–2000</td>
<td>There were no arrhythmias of any type, including ventricular fibrillation (VF), induced by transcutaneous pacing.</td>
</tr>
<tr>
<td>(1985) Berliner</td>
<td>800</td>
<td>800–5600</td>
<td>Most commonly ranged from 1600–2800 µC</td>
</tr>
<tr>
<td>(1985) Zoll</td>
<td>2000</td>
<td>2000–4000</td>
<td>52% of patients experienced electrical capture</td>
</tr>
</tbody>
</table>

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### Source Information

<table>
<thead>
<tr>
<th>Year</th>
<th>Author(s)</th>
<th>Minimum (µC)</th>
<th>Minimum Range (in µC)</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>Noe et al.</td>
<td>2000</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1987</td>
<td>Barold et al.</td>
<td>3200</td>
<td>–</td>
<td>1 patient. Termination of all 5 episodes of ventricular tachycardia (VT) was accomplished without rate acceleration or degeneration into VF.</td>
</tr>
<tr>
<td>1988</td>
<td>Klein, Zipes</td>
<td>1800</td>
<td>1800–4000</td>
<td>Mean of 2440 µC</td>
</tr>
<tr>
<td>1989</td>
<td>Heller et al.</td>
<td>2660 Zoll NTP</td>
<td>Mean capture thresholds of 1740–2660 µC</td>
<td>5 Transcutaneous pacing devices tested. Mean capture threshold of 5 different pacing units on 10 test subjects. Zoll NTP had a pulse with of 40 ms. All others had a pulse with of 20 ms.</td>
</tr>
<tr>
<td>1990</td>
<td>Luck</td>
<td>1600</td>
<td>1600–3200</td>
<td>Close “double” captures with max output (5600 µC = 140 mA * 40 ms). Researchers never had VF induced.</td>
</tr>
<tr>
<td>1993</td>
<td>Vukmir</td>
<td>25 mA ≥ 500 µC</td>
<td>25–107 mA ≥ 500–2140 µC</td>
<td>Pulse widths of 20 to 40 ms were used but were not correlated to specific mA outputs</td>
</tr>
</tbody>
</table>

1. The Grimnes treatise, citing the 1964 Zoll paper, states that cardiac capture can be achieved (in humans) with 100 µC, misstates the Zoll paper. The 1964 Zoll paper states that the researchers used "**long subcutaneous precordial needles**" to achieve capture (emphasis added).


2. The low rate cardiac pacing threshold in the 1983 Falk paper was 1,680 µC. With a (low rate) capture threshold range of 1,680–3,200 µC.

3. In the 1988 Klein paper the cardiac pacing threshold was 1,800 µC. With a (low rate) capture threshold range of 1,800–4,000 µC.

---


a. Also, the 1988 Klein paper (their Fig. 2) showed that it took another 20 mA (milliamperes) (= 800 µC) to get more rapid pacing similar to that attainable with an internal pacemaker. And, this was at a pacing rate still far slower than the rate required or necessary to induce ventricular fibrillation (VF).

4. It should be clear to anyone that an X26 CEW does not deliver its electrical charge to a person through "long subcutaneous precordial needles." While the Grimnes treatise citation is correct to a degree, it is incumbent upon an author to check the underlying references before quoting. It is obvious that in the 1961 Zoll paper the researchers used "long subcutaneous precordial needles" to get the lowest cardiac capture threshold of 100 µC. The capture threshold range was 100–600 µC. Obviously, the X26 CEW does not use "long subcutaneous precordial needles" to deliver an electrical charge to a person.

5. It is also important to note that these cardiac capture (pacing) thresholds are NOT the same as high-rate cardiac capture or cardiac capture rates sufficient to induce VF. Both the 1983 Falk and the 1988 Klein, where Zipes was a co-author, papers primarily discussed transcutaneous pacing thresholds, or low rate (or low beats-per-minute) cardiac capture. The 1988 Klein paper showed that an electrical charge of 1800–4000 µC was required (capture threshold) to externally capture the heart at a low capture rate. That same paper (their Fig. 2) showed that it took another 20 mA (milliamperes) (= 800 µC) to get more rapid pacing similar to that attainable with an internal pacemaker. And, this was at a cardiac pacing rate still far slower than the rate required or necessary to induce VF.

**Pediatric Transcutaneous Pacing Thresholds:**

<table>
<thead>
<tr>
<th>Source Information</th>
<th>Minimum (µC)</th>
<th>Minimum Range (in µC)</th>
<th>Pad Size</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Béland 1987(^{129})</td>
<td>1160 µC</td>
<td>1160–3280 µC</td>
<td>Small</td>
<td>53 of 56 patients (ages 0.9–17.9 years) resulted in successful capture</td>
</tr>
<tr>
<td></td>
<td>1440 µC</td>
<td>1440–3680 µC</td>
<td>Med</td>
<td>No complications of NTP were noted.</td>
</tr>
<tr>
<td></td>
<td>1580 µC</td>
<td>1680–3920 µC</td>
<td>Large</td>
<td>No arrhythmias were produced.</td>
</tr>
</tbody>
</table>

Transcutaneous Pacing Threshold to VF Safety Margins:

<table>
<thead>
<tr>
<th>Source Information</th>
<th>Safety Factor (mean)</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984 Voorhees(^{130})</td>
<td>12.6 ± 2.9 (x)</td>
<td>No significant difference between the safety factors for different stimulus durations (1–50 ms) was observed. The threshold pacing strength for rectangular current pulses having durations of 1, 2, 5, 10, 20, and 50 ms, The current for transcutaneous pacing was approximately 70 mA. The current for VF with the same electrode arrangement was approximately 1000 mA.</td>
</tr>
<tr>
<td>09/2007 Ideker(^{131})</td>
<td>12.6–28 (x)</td>
<td>In animals, the strength of a stimulus given during the vulnerable period of the cardiac cycle required to induce ventricular fibrillation has been found to be approximately 12.6 times the minimum pacing threshold. [Voorhees] Since the fundamental law of electrostimulation estimates that the average minimum pacing threshold is 2.33 times the size of the TASER X26 pulse, the ventricular fibrillation threshold should be approximately 29 times the magnitude of the TASER pulse. This estimate is in good agreement with the experimental study of McDaniel et al, who found that the size of the pulses needed to induce ventricular fibrillation in pigs is a mean of 28 times the size of the TASER pulse. Again, these results are for electrodes located in small regions on the anterior chest; the stimulus strength required to initiate ventricular fibrillation with electrodes at other sites on the body surface should be much higher.</td>
</tr>
<tr>
<td>1964 Zoll(^{132})</td>
<td>12x</td>
<td>“The current required to produce fibrillation was 12 times the stimulating threshold at 1 millisecond and about 25 fold at 2 to 3 milliseconds.”</td>
</tr>
</tbody>
</table>

(Swine) TASER CEW Capture, no VF Safety Margins:

   a. “a total of 354 … [CEW] exposures [in 84–85 lb swine] with no recorded cases of VF.”

---


b. “Among [CEW] exposures with [electrical cardiac] capture, the probability of VF is no more than 0.59 % (95 % CI 0.014–3.3 %).”

Cao: Human Pacemaker Patient Experiencing Capture with CEW Discharge:


i. (12/2007) The Cao case report authors stated: “We agree that these data do not speak to the potential for [TASER CEW] application to induce ventricular arrhythmias [affect the heartbeat] in the absence of an implantable device.”

Stability of Pacing Threshold, Impedance, and R Wave Amplitude at Rest and During Exercise:


a. “Conclusions. … Our study points out that pacemaker programming at rest for voltage threshold, impedance, and R wave amplitude remains reliable and safe also during exercise.”

![Figure 2. Strength-duration curves. There were no significant differences in pacing thresholds between rest and exercise for either the steroid lead or Elgiboy leads.](image-url)
b. “... None of the investigated parameters showed a significant difference between rest and exercise, neither for the steroid eluting lead nor for the Elgilo lead. The data suggest that the individual programming of a pacemaker adapted to the measurements at rest is also reliable and safe during exercise.”

c. “Our data do not confirm previous reports of an exercise-induced decrease of cardiac stimulation threshold.”
Modeling and Other Studies

   b. “Conclusion — In humans, the charge required for single response cardiac capture using transthoracic electrodes and 0.1 ms pulses is at least 0.5 mC. The transthoracic charge required to trigger repetitive ventricular responses in humans is at least several times higher than that for single responses. Hence, in adult humans, the transthoracic charge threshold required to induce repetitive ventricular responses, tachycardia, or fibrillation, with 0.1 ms pulses is expected to be significantly greater than 1 mC.”

   b. “Conclusion — Animal studies can play a role in conservatively evaluating cardiac safety. However, while still abiding by the precautionary principle, animal study design has to take into account the significant anatomical and electrophysiological differences between humans and other mammals. Data from multiple animal models may offer broader perspectives. If attempts are made to extrapolate animal results to humans then appropriate numerical correction factors should be applied, such as some of those discussed in this article.”

b. “Conclusion — The sternum offers significant ‘shielding’ effect and protects the tissues posterior to it against effects of electrical current flow from anteriorly-placed CEW electrodes.”


a. "Conclusion. This simulation study indicates a VF safety margin of up to five fold for a single ECD pulse (similar to the one of TASER X26) based on the resulting values of electric field strength, current density, and charge density in the heart tissues. ..."

b. "...no medical research has yet demonstrated pathophysiological cardiac effects arising from ECD application ...

c. "... we believe that when a series of pulses is used, the effects of each pulse have gone away by the time the next one is applied."


### UL, IEC, Au/NZ, BS, EN, Webster Proposed CEW Safety Tests

#### Electrical Standards Safety Summary:

Table 43 CEW-Related Electrical Safety Standards Primary References

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
</table>

**Conclusion:** The TASER X26 CEW meets relevant sections of the IEC, UL, EN, BSI, AUS/NZ applicable electrical safety standards as they pertain to cardiac safety and the delivered electrical charge is in the “no VF” range.

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133 Test Procedures for Conducted Energy Weapons, Version 1.1, dated July 31, 2010. Authors: Andy Adler (Carleton University), Dave Dawson (Carleton University), Ron Evans (Datrend Systems Inc), Laurin Garland (Vernac Ltd.), Mark Miller (Datrend Systems Inc.), and Ian Sinclair (MPB Technologies).
Table 44 Electrical Standards Safety Summary Table

<table>
<thead>
<tr>
<th>X26 CEW Meets 134</th>
<th>Electrical Safety Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>(IEC) Transitions, pulses and related waveforms - Terms, definitions and algorithms, IEC 60469 (Ed. 1.0), IEC Geneva, Switzerland, 2013 [Published April 23, 2013]</td>
</tr>
<tr>
<td>Yes</td>
<td>(AS/NZS) AS3S59+19131; IEC479-1 &amp; IEC479-2 Australian Standard [IEC title: Effects of current passing through the human body]</td>
</tr>
<tr>
<td>Yes</td>
<td>(BS) EN 60601-1:2006 Medical electrical equipment. General requirements for basic safety and essential performance. 2006 (including corrigenda up to March 2010).</td>
</tr>
<tr>
<td>Yes</td>
<td>Webster’s Proposed Safety Test Standard (01/2009).</td>
</tr>
</tbody>
</table>

(07/2013) Panescu, et. al. CEW Electrical Safety:


a. “Results and Conclusion: Our measurements and analyses confirmed that the nominal electrical outputs of TASER X26, X26P and X2 CEWs lie within safety bounds specified by relevant requirements of the above standards.”

b. “Concluding, the analyses above confirmed that the nominal electrical outputs of TASER X26, X26P and X2 CEWs lie within safety bounds specified by relevant requirements of UL, IEC, AS/NZS, EN, and BSI standards.”

(02/2013) Hughes, et. al. Ventricular Fibrillation Safety Margins:


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134 The TASER X26 CEW meets relevant sections of the IEC, UL, EN, BSI, AUS/NZ applicable electrical safety standards as they pertain to cardiac safety and the delivered electrical charge is in the “no VF” range.

X26 CEW Meets Dr. Webster’s 2009 Proposed Safety Test:

1. TASER X26 CEW Meets Dr. John Webster’s 2009 Proposed Safety Test

As Dr. John Webster, a recurring anti-TASER expert, stated in his 2009 paper (Nimunkar AJ, Webster JG. Safety of pulsed electric devices. Physiol Meas. Jan 2009;30(1):101–114.), the X26 CEW meets the Underwriter’s Laboratories (UL), International, Electrotechnical Commission (IEC) [also see Joint Australian/New Zealand (AS/NZS) Standards which use the same relevant criteria as the IEC standards], and his proposed safety test standards. In confirming this, on September 24, 2012, in Russell v. Denney Wright, et. al., U.S.D.C W.D.Va., Case No. 3:11-cv-00075-GEC, Dr. Webster, a plaintiff’s expert, testified:

111

19   Q … “Hence if the X26 Taser were to be
20          assessed according to IEC 2006 and UL 2003 standards for electric fence energizers it
21          would pass the safety test,” is that correct?
22   A    That’s correct.
23   Q    Was that correct when you wrote it?

---


   a. TASER X26 CEW meets UL, IEC, and Webster’s proposed safety standards.

   b. In his 2009 paper138, “Safety of pulsed electric devices,” Dr. Webster proposed a new electrical standard for testing the safety of pulsed electric devices. Dr. Webster stated: “If the maximum voltage does not exceed 0.5 V [volts] [using Dr. Webster’s proposed test fixture], the device is not as harmful and passes the test.” According to the test data in Table 1, the TASER X26 CEW meets Dr. Webster’s proposed standard safety threshold. The voltage developed over the proposed test circuit, when a TASER X26 CEW was used, had a value of 0.469 V, less than the 0.5 V limit.

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Note that two of the commercially available electric fences tested by Dr. Webster failed to pass his proposed safety standard.

**X26 CEW Meets Australian/New Zealand Standards:**

1. **Australian/New Zealand Standards™ (AS/NZS):**
   c. AS3S59•19131; IEC479-I & IEC479-2 Australian Standard. Effects of current passing through the human body

As noted, these standards have requirements which are consistent with those of IEC 60479-1 and IEC 60479-2. For a discussion of TASER X26 CEW electrical output with respect to requirements of IEC 60479 -1 and -2 see Section 1 of this document.

As noted, these standards have requirements which are consistent with those of IEC 60479-1 and IEC 60479-2. For a discussion of TASER X26 CEW electrical output with respect to requirements of IEC 60479 -1 and -2 see Section 6 of this document.

d. “The conclusion reached is that the current output of the X-26 [CEW] is significantly below the fibrillation threshold set out in the Standard.” Pg. 2.

e. “The short pulse length of the [TASER X26 CEW] output makes cardiac and breathing arrest very unlikely. Respiratory arrest difficulties are reduced by the automatic 1-second de-activation after 7.5 seconds, which is then repeated for each subsequent 6.5 seconds of use. No reports were found of cardiac arrest or breathing arrest solely from pulsed high frequency current at the levels produced by the [TASER X26 CEW].” Pg 7.

f. “Results were compared with limits specified by Australian Standard AS3859 – 1991 –‘Effects of current flowing through the human body’”. Pg. 2.

g. “The measured X·26 [CEW] results were compared with recognised Australian/New Zealand and the International Electro-technical Commission (IEC) electrical safety standards for the application of electric current to the human body. Both M-26 and X-26 [TASER] outputs were then compared with some typical medical and domestic equipment. As shown in the table (section 3.5), the M-26 Taser output is less than 2% of the normalised current likely to produce ventricular fibrillation. The X-26 improves this figure even more to less than 1% of normalised current likely to cause ventricular fibrillation.” Pg. 24.

h. “The conclusion reached is that the output of the X-26 [TASER] is below the fibrillation threshold set out in the Standard. Our testing showed that the X-26 design is improved over the M-26 providing greater pulse power output with lower total energy outlet. This provides greater electrical safety and better performance than the M-26. From an electrical safety viewpoint the device presents an acceptable risk when used by trained law enforcement officers in accordance with the manufacturers directions for use.” Pg. 25.

X26 CEW Meets British Safety Standards:

1. BSI British Standards\textsuperscript{139} BS EN\textsuperscript{140} 60601-1:2006 Medical electrical equipment. General requirements for basic safety and essential performance. 2006 (including corrigenda up to March 2010).

The overall VF risk profile of TASER CEWs is significantly lower than VF probabilities accepted by EN (European Norm), for the European Committee for Standardization (CEN), EN60601-1, a widely used international standard for general safety requirements to be met by electrical medical devices, including those devices in direct contact with the heart (known as Type CF parts).

The (European Norm) EN 60601-1 international standard stipulates accepted regulatory requirements for the safety of electrical medical devices\textsuperscript{141}. Particularly, this standard sets the allowed threshold for the patient leakage current for medical devices that have direct contact to patients' heart. Citing from the standard, we learn that\textsuperscript{3}:

“The allowable value of PATIENT LEAKAGE CURRENT for TYPE CF APPLIED PARTS in NORMAL CONDITION is 10 [microamperes] µA which has a probability of 0.002 for causing ventricular fibrillation or pump failure when applied through small areas to an intracardiac site.

Even with zero current, it has been observed that mechanical irritation can produce ventricular fibrillation. A limit of 10 µA is readily achievable and does not significantly increase the risk of ventricular fibrillation during intracardiac procedures.”

This implies that under normal medical device operation, the allowed maximum patient leakage current is 10 µA\textsubscript{rms} for safety to a lead inserted directly inside the heart. While the 10 µA\textsubscript{rms} limit does not apply to TASER X26 devices, as they are

\textsuperscript{139} British Standard EN 60601-1:2006. Medical electrical equipment — Part 1: General requirements for basic safety and essential performance. This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2006.

This British Standard is the United Kingdom (“UK”) implementation of EN 60601-1:2006, incorporating corrigendum March 2010. It is identical with IEC 60601-1:2005, incorporating corrigenda December 2006 and December 2007. It supersedes BS EN 60601-1:1990 and BS EN 60601-1-4:1997 which were declared obsolescent and withdrawn on 1 June 2012. It also supersedes BS EN 60601-1-1:2001 which has been withdrawn.

\textsuperscript{140} European standard are approved by the CENELEC (French: Comité Européen de Normalisation Electrotechnique; English: European Committee for Electrotechnical Standardization). CENELEC members are bound to comply with the CEN (French: Comité Européen de Normalisation; English: European Committee for Standardization) /CENELEC Internal Regulations which stipulate the conditions for giving a European Standard the status of a national standard without any alteration.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

\textsuperscript{141} BSI British Standards. BS EN 60601-1:2006 Medical electrical equipment. General requirements for basic safety and essential performance. 2006.
not indicated for direct contact with a patient’s heart, the rationale behind the 0.002 VF induction probability is relevant to CEW applications. Although under these circumstances a 10-µArms patient leakage current has a 0.002-probability (1 out of 500) of causing VF or pump failure in humans, the standards accepts this value as being safe. Regulatory bodies, such as the US FDA or the Germany-based Technischer Überwachungs-Verein (TUV), certify electrical medical devices as being safe for use in intracardiac clinical procedures if they comply with the patient leakage current limit above. Intracardiac procedures carry the highest risk for patients. Therefore, by accepting requirements of EN60601-1, these conservative regulatory bodies, including the US FDA, accept that a probability of causing VF of 0.002, or 1 in 500 cases, represents an extremely low risk. This FDA-accepted VF risk probability level of 0.002 is more than 5500 times higher than the probability estimates for TASER CEW-induced VF risk.

**X26 CEW Meets International Electrotechnical Safety Standards:**

1. International Electrotechnical Commission (IEC) Standards:\(^{142}\):
   
   a. Specific IEC Standards:


   b. Review of TASER X26 CEW delivered electrical output with respect to requirements of standard IEC 60479-1 and -2

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\(^{142}\) International Electrotechnical Commission (IEC) (French: Commission électrotechnique internationale (CEI))

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies. The IEC manages three global conformity assessment systems that certify whether equipment, system or components conform to its International standards.

The IEC is the world's leading international organization in its field, and its standards are adopted as national standards by its 82 member countries. The work is done by some 10,000 electrical and electronics experts from industry, government, academia, test labs and others with an interest in the subject. There are currently 82 country IEC members with another 82 counties participating in the IEC Affiliate Country Programme, which is not a form of membership but is designed to help industrializing countries get involved with the IEC.

The 60000 series of IEC standards are also found preceded by EN (European Norm) to indicate the IEC standards harmonized as European standards; for example IEC 60601-1 would be EN 60601-1.

IEC standards are also being adopted as harmonized standards by other certifying bodies such as BSI (Great Britain), CSA (Canada), UL and ANSI/INCITS (USA), SABS (South Africa), SAI (Australia), SPC/GB (China) and DIN (Germany). IEC standards harmonized by other certifying bodies generally have some noted differences from the original IEC standard.

The IEC 60479 standard deals with effects of electrical current on human beings and livestock\textsuperscript{144,145}. IEC 60479-1 describes the effects of sinusoidal alternating currents with frequencies between 15 hertz (Hz) and 100 Hz and of direct currents passing through the human body, respectively. The effects of non-sinusoidal currents of higher frequencies are covered by IEC 60479-2. Section 11.4 describes the thresholds of VF for impulses of short duration\textsuperscript{2}. It states that “for 50% probability of fibrillation, $F_q$ is of the order of 0.005 As.” $F_q$ is defined as the charge of the impulse. By the definition of current, charge and time units of measurement, the quantity 0.005 As is equal to 5000 microcoulombs ($\mu$C). The first peak of the TASER X26 CEW current (and by far the largest) carries a charge of about 100 $\mu$C. This is at least 50 times less than the threshold indicated by IEC 60479-2 for a 50% probability of VF induction. Additionally, referring to Fig. 20 section 11.4, it is obvious that the electrical output parameters of a TASER X26 ECD fall in the C1 region of the graph, which the standard lists as ‘no fibrillation’. Section 11.2.2 and Fig. 18 of IEC 60479-2 define $I_{\text{rms}}$ as being $I_{\text{peak}}/\sqrt{6}$, for currents approximated as being mostly a unidirectional impulses of short durations. The X26 CEW active pulse is mostly unidirectional with a short duration of 126 microseconds (us), or 0.126 milliseconds (ms). Even if considering $I_{\text{rms}}$ equal to the average X26 CEW peak output current of 3.5 amperes (A), the output operating point would still fall within the ‘no fibrillation’ region C1. But, as explained in section 11.2 and Figs. 17 and 18 of the IEC 60479-2 standard, the actual $I_{\text{rms}}$ corresponding to a typical TASER X26 CEW can be approximated as 3.5 A/$\sqrt{6}$, or 1.4 A. At a pulse duration of 0.126 ms, the IEC 60479-2, Fig. 20, specifies the limit of the C1 region at approximately 6 amperes (A). The value of $I_{\text{rms}}$ corresponding to a typical TASER X26 CEW is, thus, much lower than 6A. Consequently, the electrical parameters of a typical TASER X26 CEW are well within the ‘no fibrillation’ region C1 specified by IEC 60479-2. Even the peak electrical current delivered by an X26 CEW, 3.5 A, would still be lower than 6A, the limit for the ‘no fibrillation’ region at 0.1 ms pulse duration. For clarification, the actual root-mean-squared (RMS) output current of a typical TASER X26 CEW measured into a 600 ohm resistor is 55 mA$_{\text{rms}}$, if calculated over the complete duration of one pulse, at the average 19 pulses per second (pps) rate.

Additionally, it is important to note that the X26 CEW peak current stays above 2A for approximately 0.0025 ms, and above 3 A for approximately 0.0012 msec. Consequently, the IEC 60479-2 standard strongly suggests that a single TASER X26 CEW has practically very remote chances, if any, of directly inducing VF in a human. With a sequence of pulses, the VF threshold may decrease (see section 9.2 of IEC 60479-2). However, if its 126 microsecond (µs) pulse duration and corresponding 0.2% duty cycle are taken into account and worked into IEC 60479-2 table 1, section 9.2, page 26.

in light of example 1, Fig. 14, the standard strongly suggests that a series of TASER X26 CEW pulses would not significantly decrease the applicable VF threshold (VFT). Consequently, the electrical output of a typical TASER X26 CEW is well within the 'no fibrillation' region, as defined by IEC 60479-2, even for an application with a hypothetical duration extending over several seconds.


This International Standard deals with the safety of electric fence energizers. In section 3.118, the standard defines 'standard load: load consisting of a non-inductive resistor of 500 +/- 2.5 ohm resistor.' In section 22.108, the standard calls out that an energizer output characteristic shall be such that:

- the impulse repetition rate shall not exceed 1 hertz (Hz);
- the duration of the impulse shall not exceed 10 ms;
- for energy-limited energizers, the energy/impulse in the 500 ohm component of the standard load shall not exceed 5 J/pulse;
- for current-limited energizers the output current in the standard load shall not exceed 15,700 mA\text{rms} for an impulse duration of not greater than 0.1 ms;

Compared to above requirements, a typical TASER X26 CEW delivers 0.1 J/pulse, significantly below the 5 J/pulse limit. The RMS value of the output current of a typical TASER X26 CEW is 55 mA\text{rms}. This value is much lower than the 15,700 mA\text{rms} limit offered by the standard. Computing the X26 CEW output current RMS just over duration of the impulse itself (which is about 0.1 ms wide) yields a typical value of 1543 mA\text{rms}. This value is still more than ten times lower than the 15,700 mA\text{rms} standard limit.

The average impulse repetition rate of a TASER X26 CEW is 19 pps. This exceeds the 1 Hz limit stipulated by the standard. However, section 19.13 of the standard defines conditions for abnormal operation and provides requirements for impulse energy limits under increased repetition rates:

- If the impulse repetition rate becomes greater than 1.34 Hz, the discharge energy per second into a load consisting of a non-inductive resistor of 500 ohms (Ω) shall not exceed 2.5 J/s [2.5 watts] for a period not exceeding 3 min;

A typical TASER X26 CEW delivers: 0.1 J/pulse * 19 pulse/s = 1.9 J/s < 2.5 J/s [watts]. According to its specifications, the maximum impulse repetition rate for TASER X26 CEW is 20 pps. Even when considering its maximum impulse repetition rate, the energy per second of a TASER X26 CEW falls below the limit required by the standard. Thus, the electrical output
characteristics of TASER X26 CEWs fall within the limits required by IEC 60335-2-76.

X26 CEW Meets Underwriters Laboratories Safety Standards:


Review of TASER X26 CEW delivered electrical output with respect to requirements of standard UL 69: 2009.

The UL 69 requirements cover electric-fence controllers used only for the control of animals. UL 69 also covers portable and permanently mounted electric-fence controllers with peak-discharge or sinusoidal-discharge output for indoor or outdoor use, including battery-operated controllers intended to operate from battery circuits of 42.4 V or less, line-operated controllers intended to operate from circuits of 125 V or less, combination controllers intended to operate from either a battery or a line circuit, and photovoltaic module battery operated controllers. These requirements do not cover electric-fence controllers for the continuous (uninterrupted) current type or intermediate equipment, such as a converter, a rectifier, or the like, that is sometimes used between the primary source of supply and an electric-fence controller and that is investigated only as part of a complete controller.

UL 69 standard load consists of a non-inductive resistor of 500 ohm resistor with a parallel capacitor of less than 2 microfarads (uFs). Based on such load, the UL 69 standard requires that the energizer output characteristics shall be such that:

- Figure 22.1 of the standard shows the relationship between current (mA) versus time (ms) for the safe levels of current. The equation indicating this relationship is:

\[
\text{current (mA)} = 2000 \times (\text{pulse duration (ms)})^{-0.7}. 
\]

For a single impulse with a duration of 0.1 ms, the equation yields:

\[
I_{\text{single\_pulse\_UL\_limit}} = 10023 \text{ mA}_{\text{rms}}
\]

Abnormal operation restrictions are specified as:

- \[
\text{current (mA)} = 2000 \times (\text{pulse duration (ms)})^{-0.7} \times (\text{pps})^{-0.5}
\]

- For an impulse with a duration of 0.1 ms and a repetition rate of 19 pps, \( I_{\text{repetitive\_UL\_limit}} = 2300 \text{ mA}_{\text{rms}} \)

A typical TASER X26 CEW impulse duration is 0.126 ms. UL 69 defines the pulse duration as the interval of time which contains 95% of the overall energy.
Based on this definition, the TASER X26 CEW pulse duration is approximately 0.1 ms. The RMS value of the output current of a typical TASER X26 CEW is 55 mA\textsubscript{rms}. This value is much lower than the 10,023 mA\textsubscript{rms} and than the 2300 mA\textsubscript{rms} limits offered by the standard. Computing the X26 CEW output current RMS just over duration of the impulse itself (about 0.1 ms, according to UL 69 duration definition) yields a typical value of 1543 mA\textsubscript{rms}. This value is still much lower than the 10,023 mA\textsubscript{rms} standard limit for single pulses and lower than the 2300 mA\textsubscript{rms} limit stipulated for repetitive pulses. Thus, the electrical output characteristics of TASER X26 CEWs fall within the limits required by UL 69.

**Additional Papers that Discuss or Reference Electrical Safety Standards:**

   a. **(07/31/2010 Adler)** See also: Test Procedures for Conducted Energy Weapons, Version 1.1, dated July 31, 2010. Authors: Andy Adler (Carleton University), Dave Dawson (Carleton University), Ron Evans (Datrend Systems Inc), Laurin Garland (Vernac Ltd.), Mark Miller (Datrend Systems Inc.), and Ian Sinclair (MPB Technologies).

   a. “This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”
   b. “The value of 20 mC [millicoulombs] is also what the IEC (International Electrotechnical Commission) considers to be in the VF risk range for chest exposures.1 Note that the 20 mC value is 200 times that of the typical 100 μC of a CEW and thus there is no risk from a single CEW pulse falling on a T-wave.” Page 257.


Amnesty International:

1. (May 2013) The Amnesty International website states, “[a]t least 42 people across 20 states died after being struck by police Tasers, bringing the total number of such deaths since 2001 to 540.” (emphasis added).  

2. Amnesty International report has been deemed inadmissible and unreliable. See:

Dziekanski / Braidwood / Williams Timeline:

Table 46 Dziekanski / Braidwood / Williams Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 14, 2007</td>
<td>Date of Death: Robert Dziekanski</td>
</tr>
<tr>
<td>Jan. 29, 2008</td>
<td>Dziekanski autopsy report received by Ministry of Solicitor General</td>
</tr>
<tr>
<td>Feb. 15, 2008</td>
<td>Braidwood was appointed as sole Commissioner</td>
</tr>
<tr>
<td>May–June 2008</td>
<td>Braidwood convened for 15 days of informal, non-adversarial public forums</td>
</tr>
<tr>
<td>Dec. 12, 2008</td>
<td>Canadian public statements regarding Dziekanski death</td>
</tr>
<tr>
<td>June 18, 2009</td>
<td>Braidwood 1 released</td>
</tr>
<tr>
<td>June 2012</td>
<td>Williams' Paper147</td>
</tr>
</tbody>
</table>

   a. Autopsy: Cause of Death:
      
      Part 1. Principal Cause of Death:
      a. Sudden Death During Restraint

      Part 2. Contributory Factors:
      a. Chronic Alcoholism

      b. The TASER CEW was not implicated in the Autopsy Report as a cause or contributor to Dziekanki’s death.

   a. “Findings – Evidence from the existing literature does not support the Commission’s findings regarding the medical risks of the use of TASER technology. Recommendations to restrict the use of TASER devices are unlikely to reduce arrest-related deaths, but they are likely to result in increased injuries to officers and suspects. Other recommendations, including training standards, testing requirements, reporting requirements, medical assistance, and research and review, are consistent with other reviews on the use of TASER technology and are necessary and appropriate to restore public confidence in police use-of-force.” (emphasis added)

Temporal Association and Proximate Causation:

1. “Temporal” is not “causal.”

2. *McClain v. Metabolife Int'l, Inc.*, 401 F.3d 1233, 1243 (11th Cir. 2005) (Any effort to establish cause-and-effect merely based on a chronological relationship, i.e., “*post hoc ergo propter hoc*,” after this, therefore because of this, should fail); *Hasler v. U.S.*, 718 F.2d 202, 205 (6th Cir. 1983) (“Without more, [a] proximate temporal relationship will not support a finding of causation”).
### Medical Examiner Sudden Cardiac Death (SCD) Undetermined:

<table>
<thead>
<tr>
<th>Date</th>
<th>% of Deaths Undetermined or Sudden Unexplained Death (“SUD”)</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 2014</td>
<td>31% SUD</td>
<td>Risgaard(^{148}), Sudden cardiac death in person aged 1–49 years</td>
</tr>
<tr>
<td>Apr. 2014</td>
<td>28% SUD</td>
<td>Winkel(^{149}), Sudden cardiac death in children (1-18 years)</td>
</tr>
<tr>
<td>Mar. 2014</td>
<td>20% undetermined</td>
<td>Harmon(^{150}), Etiologies of SCD in NCAA Athletes</td>
</tr>
<tr>
<td>Feb. 2014</td>
<td>9% unresolved</td>
<td>Maron(^{151}), U.S. college athletes</td>
</tr>
<tr>
<td>Sep. 2011</td>
<td>20.7% unresolved</td>
<td>Eckart(^{152}), young athletes</td>
</tr>
<tr>
<td>Dec. 2004</td>
<td>35% undetermined</td>
<td>Eckart(^{153}), military 25 year study</td>
</tr>
<tr>
<td>1995</td>
<td>5% undetermined</td>
<td>Van Camp(^{154}), Nontraumatic sports death high school/college athletes</td>
</tr>
</tbody>
</table>


   a. 20% the cause could not be determined


   a. **METHODS:** A prospective observational study of 2149 US high schools participating in the National Registry for AED Use in Sports was conducted from August 2009 to July 2011. Schools were contacted quarterly to collect and review SCA cases occurring on school campus. Ninety-five percent (2045) of the schools confirmed participation for the entire 2-year period.

---


b. **RESULTS:** The average numbers of total students and student athletes per school were 963 and 367, respectively, providing more than 4.1 million total student-years and more than 1.5 million student athlete-years of surveillance. Twenty-six cases of SCA occurred in students, including 18 cases in student athletes—all during exercise. The incidence of SCA in all students was 0.63 per 100,000; in student athletes, 1.14 per 100,000; and in student nonathletes, 0.31 per 100,000. The relative risk of SCA in student athletes vs nonathletes was 3.65 (95% confidence interval 1.6-8.4; P < .01). Sixteen of 18 (89%) student athletes with SCA were boys, resulting in an incidence of 1.73 per 100,000 in boys and 0.31 per 100,000 in girls and a relative risk in male compared with female student athletes of 5.65 (95% confidence interval 1.3-24.6; P < .01).

c. **CONCLUSION:** The incidence of SCA in high school student athletes is higher than previous estimates and may justify more advanced cardiac screening and improved emergency planning in schools.


a. Cardiovascular Mortality Rates: “confirmed cardiovascular disease (n = 47; 4/year; 1.2/100,000); combined confirmed or presumed cardiovascular disease (n = 64; 6/year; 1.6/100,000).”

b. “cardiovascular deaths were 5-fold more common in African-American athletes than whites (3.8 vs. 0.7/100,000; p <0.01), but did not differ from the general population of the same age and race (p = 0.6).”

c. “In 17 of the 64 athletes, collapse occurred virtually instantaneously following physical activity during competition or practices,”

**Objectives.** Reliably define the incidence and causes of sudden death in college student-athletes.

**Background.** Frequency with which cardiovascular-related sudden death (SD) occurs in competitive athletes importantly impacts considerations for preparticipation screening strategies.

**Methods.** We assessed databases (including autopsy reports) from both the U.S. National Sudden Death in Athletes Registry and National Collegiate Athletic Association (NCAA) (2002-2011).
Results. Over the 10 year period, 182 SDs occurred (ages 20 ± 1.7; 85% males; 64% white): 52 resulting from suicide (n = 31) or drug abuse (n = 21), and 64 probably or likely attributable to cardiovascular causes (6/year). Of the 64 athletes, 47 had a confirmed post-mortem diagnosis (4/year), most commonly hypertrophic cardiomyopathy in 21, and congenital coronary anomalies in 8. The 4,052,369 athlete participations (in 30 sports over 10 years) incurred mortality risks of: suicide and drugs combined, 1.3/100,000 athlete-participation-years (5 deaths/year); and documented cardiovascular disease, 1.2/100,000 (4 deaths/year). Notably, cardiovascular deaths were 5-fold more common in African-American athletes than whites (3.8 vs. 0.7/100,000; p <0.01), but did not differ from the general population of the same age and race (p = 0.6).

Conclusions. In college student-athletes, SD risk due to cardiovascular disease is relatively low, with mortality rates similar to suicide and drug abuse, and less than expected in the general population, although highest in African-Americans. A substantial minority of confirmed cardiovascular deaths would not likely have been reliably detected by preparticipation screening with 12-lead ECGs.


Abstract

BACKGROUND: Sudden cardiac arrest (SCA) is the leading cause of death in athletes during exercise. The effectiveness of school-based automated external defibrillator (AED) programmes has not been established through a prospective study.

METHODS: A total of 2149 high schools participated in a prospective observational study beginning 1 August 2009, through 31 July 2011. Schools were contacted quarterly and reported all cases of SCA. Of these 95% of schools confirmed their participation for the entire 2-year study period. Cases of SCA were reviewed to confirm the details of the resuscitation. The primary outcome was survival to hospital discharge.

RESULTS: School-based AED programmes were present in 87% of participating schools and in all but one of the schools reporting a case of SCA. Fifty nine cases of SCA were confirmed during the study period including 26 (44%) cases in students and 33 (56%) in adults; 39 (66%) cases occurred at an athletic facility during training or competition; 55 (93%) cases were witnessed and 54 (92%) received prompt cardiopulmonary resuscitation. A defibrillator was applied in 50
(85%) cases and a shock delivered onsite in 39 (66%). Overall, 42 of 59 (71%) SCA victims survived to hospital discharge, including 22 of 26 (85%) students and 20 of 33 (61%) adults. Of 18 student-athletes 16 (89%) and 8 of 9 (89%) adults who arrested during physical activity survived to hospital discharge.

**CONCLUSIONS:** High school AED programmes demonstrate a high survival rate for students and adults who suffer SCA on school campus. School-based AED programmes are strongly encouraged.


   a. "an estimated 30% of these causes of death cannot be identified reliably by preparticipation screening, even with ECG. Page 1090.


   a. 35% of deaths unexplained.

   b. “sudden nontraumatic death occurred at a rate of 13.0 per 100 000 recruit-years."

   c. “Among 6.3 million military recruits age 18 to 35 years, sudden nontraumatic death occurred at a rate of 13.0 per 100 000 recruit-years. Over half of the 126 autopsied decedents had an identifiable cardiac abnormality; one third had an anomalous coronary artery. More than one third of deaths had no explanation.”
Zipes’ 2012 “Case Series” and Selected Related Documents

January 2014 Kroll and Zipes Controversies in Cardiovascular Medicine:


   a. (pg 98) “Discussion” The main findings of the study are as follows:

      (1) The demonstrated incidence of ECD-induced cardiac arrest is extremely low, if not zero.

      (2) Conclusions of a connection between ECD use and cardiac arrest are speculative at best.

      (3) The role of several non-ECD confounding factors explaining cardiac arrests are not accounted for in published case reports.


October 15, 2013 Canada Study Quote:

“...In the field, there has not been a conclusive case of fatal ventricular fibrillation caused solely by the electrical effects of a CEW (NIJ, 2011). A small number of human cases have found a temporal relationship between CEWs and fatal cardiac arrhythmias (Swerdlow et al., 2009; Zipes, 2012) but they do not allow for confirmation or exclusion of a clear causal link. The study by Zipes (2012) is particularly questionable since the author had a potential conflict of interest and used eight isolated and controversial cases as part of the analysis (Myerburg & Junttila, 2012). In addition, both studies examined individual cases of CEW proximal deaths without any corresponding data from control cases where death was not the outcome (Swerdlow et al., 2009; Zipes, 2012).” (emphasis added) (pg 36)

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October 2013 (Canada) Hall RESTRAINT Quote:156

“In [sic 2012] Zipes published a case series of 7 highly selected cases of subject death following CEW deployment and suggested that there is a direct association between probe deployment to the chest and the generation of ventricular fibrillation in the subjects.157 While this retrospective case series study of a very small number of highly selected cases can offer the hypothesis that there may be an association between probe/dart deployment to the chest and subsequent ventricular fibrillation, the nature and strength of that association requires evaluation through rigorous methodology that includes specific documentation of the location of conducted energy weapons deployment on the subject in those who have lived as well as those who have died. Determination of the relative risks of CEW and other modalities will not come from the isolated evaluation of subjects who have died. For CEW, locations of darts/deployments and the pairing of those darts both in subjects who have lived and in subjects who have died is pivotal in understanding the effects of transcardiac and deployments. Bozeman et al have documented that the risk of death following CEW deployment is very low and have now begun to evaluate dart location in their studies.158

It is unknown what characteristics of CEW use, if any, are predictive of poor outcome in the situations in which they are used by police officers. In some circumstances, utilization of conducted energy weapon probe/dart applications is carried out after other control mechanisms have failed.159 Whether such combination functions as a marker for the severity of the agitation or as a causative factor is unstudied.” (Page 15-16).

Zipes’ (2012) Paper is a “Case Series”

Zipes’ paper is a “case series.”

Dr. Douglas P. Zipes' paper is a “case series.” “Case series generally provide weak evidence of causality because they are particularly prone to bias and confounding.” In the hierarchy of scientific evidence a case series, such as Zipes’, has very important weaknesses, including: "lack of comparison group markedly limits conclusions about causality" and "risk, incidence, prevalence cannot be ascertained." (emphasis added)

AHA did not endorse or warrant accuracy or reliability of Zipes’ case series.

Some have incorrectly stated that the American Heart Association (“AHA”) that published Circulation supported Zipes’ case series or conclusions. This is incorrect. As Circulation clearly states:

“Statements, opinions, and results of studies published in Circulation are those of the authors and do not reflect the policy or position of the American Heart Association, and the American Heart Association provides no warranty as to their accuracy or reliability.”

Zipes’ "Case Series" Related Documents:


a. “Conclusion: ECD stimulation can cause cardiac electrical capture and provoke cardiac arrest resulting from ventricular tachycardia/ventricular fibrillation. After prolonged ventricular tachycardia/ventricular fibrillation without resuscitation, asystole develops.”

b. The case series premise is that an X26 CEW delivered sufficient electrical charge stimulating the hearts of eight individuals to induce cardiac arrest. Seven of the eight subjects died. None of the seven forensic pathologists (medical doctors) involved in the autopsies agreed with Zipes' conclusion.


161 http://circ.ahajournals.org/site/misc/about.xhtml. (accessed September 22, 2013).

   a. “The source of the data leads to some concerns about distortions and biases that can develop during the adversarial litigation process, but overall there is enough objective data to support reasonable judgments in the individual cases, if not definitive conclusions generalizable to all cases. Based on the circumstances, timing, and rhythm strips provided, and the pathological data provided, it seems reasonable to conclude that some finite number of these cases, >0, but likely <8, demonstrates a direct association between delivery of an ECD shock and the onset of cardiac arrest in an individual in whom other possible causes are not present.” (emphasis added).

   i. “One of the problems in interpreting the data is that there were undisputed pathological findings of a normal heart in only 2 of the 7 autopsied fatal cases, with a mildly elevated heart weight and a blood alcohol level of 0.25 g/100 mL in 1 of these 2. In both of these cases, the descriptions of the incidents and supporting data lend credence to the likelihood of an association that is strong enough to demonstrate a cause-and-effect relationship.”


162 (June 11, 2013 - Correction) "In the article by Zipes, “Sudden Cardiac Arrest and Death Following Application of Shocks From a TASER Electronic Control Device,” which appeared in the May 22, 2012 issue of the journal (Circulation. 2012;125:2417-2422), Dr Zipes did not acknowledge the contributions of Atty. John Burton, Dr Kamaraswamy Nanthakumar, Dr John Miller, and Ms Joan Zipes. The current online version of the letter has been corrected."


Zipes: (1975) Epinephrine Initially ↓ Then ↑ VFT:

   a. Epinephrine initially decreased VFT, then increased VFT. (Figure 1).

\[\text{June 11, 2013 – Correction}^{163}\] In the article by Nanthakumar and Waxman, “Letter by Nanthakumar and Waxman Regarding Article, “Sudden Cardiac Arrest and Death Following Application of Shocks From a TASER Electronic Control Device”, which was published in the January 1/8, 2013 issue of the journal (Circulation. 2013;127:e257), Dr. Waxman neglected to disclose that he served as an expert witness in litigation relevant to the topic of the article. The current online version of the letter has been corrected. The authors apologize for the oversight.
Some Factors that Alter Refractory Period Dispersion or Ventricular Fibrillation Threshold

<table>
<thead>
<tr>
<th>Increased RPD or decreased VFT</th>
<th>Decreased RPD or increased VFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial ischemia(^{12-22})</td>
<td>Epinephrine (initial ↓ VFT) (^{22-46})</td>
</tr>
<tr>
<td>Slower heart rates without ischemia(^{21})</td>
<td>Slower heart rates with ischemia(^{27})</td>
</tr>
<tr>
<td>Faster heart rates with ischemia(^{28})</td>
<td>Faster heart rates without ischemia(^{27})</td>
</tr>
<tr>
<td>Sympathetic nerve stimulation(^{19})</td>
<td>Vagal stimulation(^{16-42})</td>
</tr>
<tr>
<td>Ventricular premature systoles(^{19})</td>
<td>Drugs: lidocaine,(^\text{a}) bretyllium,(^\text{a}) procainamide,(^\text{a}) phenytoin,(^\text{a}) propranolol,(^\text{a}) quinidine,(^\text{a}) nitroglycerin,(^\text{a}) edrophonium(^\text{a})</td>
</tr>
<tr>
<td>Acidosis(^{17-47})</td>
<td>Aminophylline(^\text{a}) (after first 30 min following i.v. administration)</td>
</tr>
<tr>
<td>Ouabain toxicity(^{43})</td>
<td>Digitalis in intact dog or after stellate stimulation(^{45-49})</td>
</tr>
<tr>
<td>(for first 30 min after i.v. administration)</td>
<td>Respiratory acidosis with hypoxia(^{55})</td>
</tr>
<tr>
<td>Digoxin with autonomic denervation or propranolol(^{44})</td>
<td></td>
</tr>
<tr>
<td>Hypothermia(^\text{a})</td>
<td></td>
</tr>
<tr>
<td>Quinidine (high doses)(^{48})</td>
<td></td>
</tr>
<tr>
<td>Chloroform(^{49})</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: RPD = refractory period dispersion; VFT = ventricular fibrillation threshold.


   a. Cardiac Pacing Thresholds:
      
      i. Minimum cardiac pacing threshold: 1800 microcoulombs (µC).
      
      ii. Minimum range cardiac pacing threshold: 1800–4000 µC.
      
      iii. Mean cardiac pacing threshold: 2440 µC.

   b. Also, the 1988 Klein paper (their Fig. 2) showed that it took another 20 mA (milliamperes) (= 800 µC) to get more rapid pacing similar to that attainable with an internal pacemaker. And, this was at a pacing rate still far slower than the rate required or necessary to induce ventricular fibrillation (VF).

Zipes: (1977) VFT in Dogs (mean: 43.2 ± 25 µC):


   a. Mean ventricular fibrillation threshold (VFT): 43.2 ± 25 µC. (4 ms times 10.8 mA)

   b. “Ventricular fibrillation threshold was initially measured repeatedly at the same site in 11 dogs using an electrode sutured to the left ventricular
epicardium. In five of these dogs, after four to six determinations, the ventricular fibrillation threshold increased from 10.8 ± 6.2 to 21.5 ± 8.5 ma (mean).” Page 930. (emphasis added).

c. “Ventricular fibrillation threshold: This was determined by delivering in the T wave of every 10th regularly paced beat a 200 msec train of stimuli that spanned the T wave but did not extend into the T wave of the first premature ventricular beat.” Page 930.
Selected CEW Deployment and Use Guidance Information

CEW Policy Studies:


   Abstract:
   “Law enforcement agencies across the United States, partly in response to public outcries over fatalities associated with police use of lethal force, have adopted numerous less lethal technologies, including conducted energy devices (CEOs). Although the device was intended to reduce citizen deaths resulting from police use of force, various human rights groups have linked its usage to increased fatalities. The present study adds to the literature on CEOs by examining (a) the relationship between the restrictiveness of CEO-related policies and CEO deployments and (b) the relationship between these policies and fatal police shootings. Using data from a nationally representative sample of American law enforcement agencies, this study estimates a series of count regression models to examine the influence of departmental policies on CEO usage and fatal shootings by police. Findings illustrate that less restrictive CEO policies are associated with increased CEO usage and fewer fatal shootings by police. Although design limitations preclude causal arguments, these results suggest that police departments should at least consider adopting more liberal policies regarding the application of this less lethal technology. Future studies on this issue using more rigorous designs are warranted.” (highlighting emphasis added)

Initial 5-Second CEW Cycle:


   a. “1. Electronic Control Weapons. [Para.] 68. ... e. After one standard ECW cycle (5 seconds), the officer shall reevaluate the situation to determine if subsequent cycles are necessary, including waiting for a reasonable amount of time to allow the subject to comply with the warning. Officers shall describe and explain the reasonableness of each ECW cycle in their use of force reports;” Page 19.

   a. “21. Personnel should use an ECW for one standard cycle (five seconds) and then evaluate the situation to determine if subsequent cycles are necessary. Personnel should consider that exposure to the ECW for longer than 15 seconds (whether due to multiple applications or continuous cycling) may increase the risk of death or serious injury. Any subsequent applications should be independently justifiable, and the risks should be weighed against other force options.” Page 20.

15-Second CEW Discharge Restrictions (or Advice):


   a. “1. Electronic Control Weapons. [Para.] 68. ... f. Officers shall make every reasonable effort to attempt handcuffing during and between each ECW cycle. Officers should avoid deployments of more than three ECW cycles unless exigent circumstances warrant use;” Page 19.

   i. “II. Definitions. ... [Para.] 29. “Exigent circumstances” means circumstances in which a reasonable person would believe that imminent and serious bodily harm to a person or persons is about to occur.” Page 10.

   ii. “II. Definitions. ... [Para.] 58. “Serious Use of Force” means: ... (7) more than two applications of an ECW on an individual during a single interaction, regardless of the mode or duration of the application, regardless of whether the applications are by the same or different officers, and regardless of whether the ECW application is longer than 15 seconds, whether continuous or consecutive; (8) any ... ECW application ... against a handcuffed, otherwise restrained, under control, or in custody subject with or without injury; and (9) any use of force referred by an officer’s supervisor to IA that IA deems serious.” Page 14.

a. “Because the physiologic effects of prolonged or repeated CED exposure are not fully understood, law enforcement officers should refrain, when possible, from continuous activations of greater than 15 seconds, as few studies have reported on longer time frames.” Page viii.

b. “The medical risks of repeated or continuous CED exposure beyond the [45 second] durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.

c. “Studies examining the effects of extended exposure in humans to CEDs are limited to humans exposed to less than 45 seconds.” Page 27.

d. “… [E]xperiments using healthy human volunteers have found no cardiac dysrhythmias9,10 or respiratory dysfunction11 following exposures less than 45 seconds.” Page 27.


a. Reviewed studies did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after exposure to CEW electrical discharges of up to 15 seconds.


a. “21. Personnel should use an ECW for one standard cycle (five seconds) and then evaluate the situation to determine if subsequent cycles are necessary. Personnel should consider that exposure to the ECW for longer than 15 seconds (whether due to multiple applications or continuous cycling) may increase the risk of death or serious injury. Any subsequent applications should be independently justifiable, and the risks should be weighed against other force options.” Page 20.


“IV. PROCEDURES …
D. Post-Deployment Considerations …
2. Personnel shall request EMT response, or the person shall be transported to a medical facility for examination if any of the following occur: …
   f. he or she has been exposed to more than three ECW cycles,
   g. he or she has been exposed to the effects of more than one ECW device, …"
Selected Scientific Literature Criteria

Case Series Not Reliable for Determining Causation:

   
a. “Case series generally provide weak evidence of causality because they are particularly prone to bias and confounding.”
   
b. In the hierarchy of scientific evidence a case series has important weaknesses, including: “[l]ack of comparison group markedly limits conclusions about causality” and “[r]isk, incidence, prevalence cannot be ascertained.”

Case Reports Not Reliable for Determining Causation:

   
a. “Case reports are incomplete, uncontrolled, retrospective, lack operational criteria for identifying when an adverse event has actually occurred, and resemble nothing so much as hearsay evidence, a type of evidence that is prohibited in all courts in all of industrialized societies;”

Selected Scientific Logical Fallacies:

1. Scientific logical error of the “residue fallacy.” Simply put, conspiracy fans often go to the rare residues while scientists reject them as lacking in statistical significance and contradicting the larger body of evidence. Conspiratorialist things: “After all the bad data, fakes, and errors are weeded out, there are still a few unexplained cases that indicate a real phenomenon. Scientific thinking: if 99% of the data is contrary to the conspiracy theory, what makes you think the residue isn’t as well?”

2. Logical error of the “Argument from Ignorance fallacy.” An argument is fallacious when it maintains that a proposition is true because it has not been proved false or false because it has not been proved true. As an example, in some cases plaintiffs try to suggest that the TASER CEW provably caused a cardiac arrest in a certain individual, and unless TASER can prove an alternative causation. Over 1000 human beings suffer a cardiac arrest every day in the USA and about 3 people suffer an arrest-related-death (ARD) every day in the USA. By selecting rare cases where an ARD was not prevented by a TASER CEW, the plaintiffs may attempt to argue that that somehow proves that the CEW actually
caused an ARD or cardiac arrest. Plaintiffs might as well “prove” that the handcuffs caused a cardiac arrest by phrasing the allegations slightly differently.
Quantum of Force:

1. Possible Quantum of Force Probe versus Drive Stun Table (many variables to determine quantum of force for each CEW exposure):

<table>
<thead>
<tr>
<th>Probe Deployment (Bryan v. MacPherson&lt;sup&gt;164&lt;/sup&gt;)</th>
<th>Drive–Stun (single set of electrodes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;[TASER CEW], in general, is more than a non-serious or trivial use of force but less than deadly force,”</td>
<td>Factors:</td>
</tr>
<tr>
<td>• Intermediate quantum of force</td>
<td>• painful, only transitory, localized pain</td>
</tr>
<tr>
<td>• Significant quantum of force</td>
<td>• non-incapacitating effect</td>
</tr>
<tr>
<td>• Justified by a strong government interest</td>
<td>• without incapacitating muscle contractions</td>
</tr>
<tr>
<td>Factors:</td>
<td>• without significant lasting injury</td>
</tr>
<tr>
<td>• Pain was intense, felt throughout the body,</td>
<td>• has markedly different physiological effects</td>
</tr>
<tr>
<td>• CEW effectively commandeered the person's muscles and nerves</td>
<td>Basics:</td>
</tr>
<tr>
<td>Holding:</td>
<td>• Less-than-intermediate quantum of force</td>
</tr>
<tr>
<td>• X26 CEW is “an intermediate or medium, though not insignificant, quantum of force.”</td>
<td>• Amount of force more on par with pain compliance techniques</td>
</tr>
<tr>
<td>• use of a [TASER X26 CEW], in a manner equivalent to dart mode, “constitute[s] an intermediate, significant level of force that must be justified by a strong government interest that compels the employment of such force.”</td>
<td></td>
</tr>
<tr>
<td>Injuries in Bryan (as stated in Brooks v. Seattle):</td>
<td></td>
</tr>
<tr>
<td>• excruciating pain throughout his entire body,</td>
<td></td>
</tr>
<tr>
<td>• temporary paralysis, [resulting in fall to hard surface]</td>
<td></td>
</tr>
<tr>
<td>• facial abrasions,</td>
<td></td>
</tr>
<tr>
<td>• shattered teeth, and</td>
<td></td>
</tr>
<tr>
<td>• a sharp barb lodged into his flesh.</td>
<td></td>
</tr>
</tbody>
</table>

<sup>164</sup> “We recognize the important role controlled electric devices like the [TASER X26 CEW] can play in law enforcement. The ability to defuse a dangerous situation from a distance can obviate the need for more severe, or even deadly, force and thus can help protect police officers, bystanders, and suspects alike. We hold only that the X26 and similar devices constitute an intermediate, significant level of force that must be justified by “a strong government interest [that] compels the employment of such force.”
Selected Court Cases Regarding CEWs as a Level of Force

Selected General Force Statements:

  
  o “The question presented here is whether it was clearly established in June 2008 that using a taser on a suspect disobeying repeated orders amounted to excessive force.”

  o “It is clearly established that suspects have the right to be free from tasing where they are fully compliant with officers’ orders, not resisting arrest, or immobilized and posing no threat of danger. Hagans v. Franklin Cnty. Sheriff’s Office, 695 F.3d 505, 509 (6th Cir.2012).”

  o “Although the case at bar does not present facts which fall neatly into this category, cases of like circumstances have found no clearly established right of a suspect to be free from tasing where he or she disobeys police orders and may be in possession of a weapon. See McGee v. City of Cincinnati Police Dep’t, No. 1:06–CV–726, 2007 WL 1169374, at *5 (S.D.Ohio Apr.18, 2007).”

- **Meyers v. Baltimore County, Md.**, 713 F.3d 723 (C.A.4 (Md.) Feb 01, 2013):

  o “It is an excessive and unreasonable use of force for a police officer repeatedly to administer electrical shocks with a [CEW] on an individual who no longer is armed, has been brought to the ground, has been restrained physically by several other officers, and no longer is actively resisting arrest.”

  o “…‘officers using unnecessary, gratuitous, and disproportionate force to seize a secured, unarmed citizen, do not act in an objectively reasonable manner and, thus, are not entitled to qualified immunity.’” Bailey v. Kennedy, 349 F.3d 731, 744–45 (4th Cir.2003)(quoting Jones v. Buchanan, 325 F.3d 520, 531–32 (4th Cir.2003)).

Attempt to Use Physical Skill, Negotiation, or Commands:


  o “If [plaintiff’s] allegations are true, the officers immediately resorted to [CEW] and nightstick without attempting to use physical skill, negotiation, or even commands. Viewing the summary-judgment facts in a light most favorable to [plaintiff], we conclude that the use of force was objectively unreasonable.” [referencing Deville v. Marcantel, 567 F.3d 156 (C.A.5 (La.), May 1, 2009)]
“Although officers may need to use “physical force ... to effectuate [a]
suspect’s compliance” when he refuses to comply with commands during a
traffic stop, Deville, 567 F.3d at 167, the officers still must assess “the
relationship between the need and the amount of force used,” id. In Deville,
we held that a reasonable jury could find that the degree of force used was
not justified where the officer “engaged in very little, if any, negotiation” with
the suspect and “instead quickly resorted to breaking her driver’s side window
and dragging her out of the vehicle.” Id. at 168.”

**Failure to Train: Constitutional Limitations of Excessive Force:**

- *Alusa et al v. Salt Lake County, Utah et al*, 2013 WL 3946574, 2:11-cv-00184-RJS-EJF (D. Utah, August 1, 2013) [*Alusa settled for $90,000 (October 2013).*]:

  Addressing the first prong [(1) the training was in fact inadequate], the Plaintiffs
argue that the County does not correctly instruct its officers whether the law uses
an objective or subjective standard to determine whether the use of force is
reasonable. According to Deputy Broos, the standard is a subjective one:

  Q: [D]oes your department . . . give you the freedom to subjectively
decide how long and how often you tase somebody; yes or no?

  Broos: Based on the circumstances?

  Q: Yes.

  Broos: Yes.

  (Broos Dep. 87.) Nick Roberts, the range master for Salt Lake County who is
responsible for firearm and taser training, also appeared confused during his
deposition about the use of an objective or subjective standard to determine
reasonable force. (Roberts Dep. 33–34 (“Q: I just want to know whether [the law
uses an] objective or subjective standard. Do you know? Roberts: I don’t.”).)

  The Defendants argue that, even if Deputy Broos and Rangemaster
Roberts get the legal standard wrong, they are still applying it correctly because
they both believe that an officer must use reasonable force as determined by the
facts and circumstances of the situation. But the failure to be clear on this issue
has led at least one other Utah judge to allow a failure to train claim to survive
summary judgment in an excessive force case involving the use of a taser. In
Cavanaugh v. Woods Cross City, the Honorable Tena Campbell noted that the
police chief “consistently and repeatedly testified that officers were told in their
training that the decision to use force is a solely subjective analysis.” 2009 WL
judgment to the municipality on the failure to train claim, 21 holding:
If true that a policy existed in which officers were trained to use only their own subjective judgment when firing a Taser, such a policy would be in violation of the constitutional standards for use of force. Therefore, provided it was the moving force behind the violation, the policy would subject the municipality to liability. *Id.*

The court agrees with Judge Campbell’s analysis and finds that the Alusas have demonstrated that there are disputed issues of material fact regarding what training standards were used by Salt Lake County regarding the use of force and whether the training was inadequate as a result. While the Alusas still have to prove that the County was deliberately indifferent and that the inadequate training was the cause of Mr. Alusa’s constitutional deprivation, a reasonable jury could answer these questions in favor of the Alusas. Accordingly, the Defendants’ Motion for Summary Judgment is DENIED as it pertains to the Alusas’ failure to train claim.

  
  In denying law enforcement defendant’s motion for summary judgment on failure to train on use of force the Court stated “…although the officers were trained on the proper use of the [TASER CEW], there is no indication that the officers were trained on the constitutional limitations of excessive force.” 913 F.Supp. at 680.

- **Cavanaugh v. Woods Cross City**, Not Reported in F.Supp.2d, 2009 WL 4981591 (D.Utah, December 14, 2009); *aff'd*, 625 F.3d 661 (10th Cir. (Utah) Nov 03, 2010); jury’s defense verdict *aff'd*, 718 F.3d 1244 (10th Cir. (Utah) Jun 12, 2013):
  
  Specifically, Plaintiffs allege that Woods Cross's unwritten policy, established by Chief Howard, allowed for use of a Taser in the sole discretion of the officer without reference to warnings, violence of the offender, or danger to others. FN6 Chief Howard clearly testified that he ordered trainers to abandon the written use of force policy and replace it with a “reasonably necessary” policy. Although Chief Howard’s deposition is somewhat confused, he also consistently and repeatedly testified that officers were told in their training that the decision to use force is a solely subjective analysis. FN7

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FN6. Plaintiffs are alleging Woods Cross has adopted an unconstitutional policy as the official position of the City, they are not alleging a failure to train or some other facially lawful action. Defendants argue that Plaintiffs must show the municipal action was taken with “deliberate indifference,” but this standard applies only to facially lawful actions that lead an employee to violate a plaintiff's rights. See *Bd. of County Comm’rs of Bryan County v. Brown*, 520 U.S. 397, 404 (1997). Adoption of an unconstitutional policy or custom does not require any such showing.
FN7. Toward the end of Chief Howard’s deposition, after consulting with counsel, he did indicate that he was unclear as to the difference between “objective” and “subjective.” But taking the evidence in the light most favorable to the nonmoving party, this testimony cannot overcome the extensive previous testimony on this topic.

If true that a policy existed in which officers were trained to use only their own subjective judgment when firing a Taser, such a policy would be in violation of the constitutional standards for use of force. See *Graham*, 490 U.S. at 396. Therefore, provided it was the moving force behind the violation, the policy would subject the municipality to liability. *Jiron*, 392 F.3d at 419. In this case the Plaintiffs have shown that there are disputed issues of material fact regarding what policy was implemented in Woods Cross regarding use force. Accordingly, the City of Woods Cross's motion for summary judgment is DENIED.

**Failure to Train: Dealing With Mentally Ill:**

  - “In sum, the jury concluded that the City of Bainbridge Island failed to provide any training to its officers on how to deal with the mentally ill. That failure led Officers Benkert and Portrey to confront Douglas Ostling without any pressing need and without any forethought as to how the schizophrenic man might react. The jury was entitled to believe that just such a confrontation was foreseeable, avoidable, and ultimately caused the deprivation of William and Joyce Ostling's substantive due process right to the society of their son.”

- “III. CONCLUSION. Defendants’ remaining arguments follow mainly from their erroneous premise—that the City and Chief Fehlman cannot be liable absent a determination that Officer Benkert was individually liable. (See Defs.’ Mot. for J. at 16–23). The Court must reject these arguments en masse. As the foregoing discussion indicates, the evidence presented at trial was sufficient to permit the jury to find that the City and Chief Fehlman failed to train their officers in their own policies on confronting the mentally ill. That failure led Officers Benkert and Portrey to forcibly and needlessly confront a schizophrenic man, creating a situation in which they were forced to shoot him. Defendants' Renewed Motion for Judgment (Dkt.# '148) is DENIED.”
Failure to Train: Use of Force on Injured Suspects:

  - Court denied law enforcement motion for summary judgment on plaintiff’s failure to train theory of: “the Court finds that the Department did not offer any training on injured subjects as part of its in-service trainings; nor did the department issue guidelines on handling injured persons in its general orders dealing with use of force.”
  - Officer had been POST certified and department trained, but, not on guidelines or use of force on handling injured persons.

Targeting:

- Forrest v. Prine, 620 F.3d 739 (C.A.7 (Ill.) August 31, 2010):
  - “No reasonable jury could believe that a police officer, although trained in the use of tasers, always hits precisely his target when the target is moving.” Forrest, 620 F.3d. at 746.

TASER Ventricular Fibrillation (VF) Research:

- Rosa v. TASER International, Inc., 684 F.3d 941 (9th Cir. (Cal.) July 10, 2012):
  - Before August 29, 2004, “the perceived cardiac risk associated with the [electronic control] device was immediate ventricular fibrillation, and TASER expended considerable resources testing its products for that risk.” Rosa, 684 F.3d, at 950.
  - Both pepper spray and baton blows are forms of force capable of inflicting significant pain and causing serious injury. As such, both are regarded as "intermediate force" that, while less severe than deadly force, nonetheless present a significant intrusion upon an individual's liberty interests. See Smith v. City of Hemet, 394 F.3d 689, 701-02 (9th Cir.2005); *1162United States v. Mohr, 318 F.3d 613, 623 (4th Cir.2003).

OC (Pepper Spray)/Batons – Significant Level of Force:

- Young v. County of Los Angeles, 655 F.3d 1156 (C.A.9 (Cal.), August 26, 2011):
  - “Pepper spray "is designed to cause intense pain," and inflicts "a burning sensation that causes mucus to come out of the nose, an involuntary closing of the eyes, a gagging reflex, and temporary paralysis of the larynx," as well as
"disorientation, anxiety, and panic." Headwaters Forest Defense v. County of Humboldt, 240 F.3d 1185, 1199-1200 (9th Cir.2000), vacated and remanded on other grounds, 534 U.S. 801, 122 S.Ct. 24, 151 L.Ed.2d 1 (2001); see also United States v. Neill, 166 F.3d 943, 949-50 (9th Cir.1999) (affirming district court finding that pepper spray is a "dangerous weapon" under the U.S. Sentencing Guidelines and describing trial evidence that pepper spray causes "extreme pain" and is "capable of causing 'protracted impairment of a function of a bodily organ' as well as lifelong health problems such as asthma). The evidence includes a declaration by a retired Los Angeles County Sheriff's Department lieutenant who testified as a police practices expert and stated that the basic curriculum of the California Commission on Peace Officer Standards and Training [FN7] (POST) instructs officers that "the use of pepper spray can have very serious and debilitating consequences," and that "[a]s such, it should only be generally used as a defensive weapon and must never be used to intimidate a person or retaliate against an individual."


A police officer's use of baton blows, too, presents a significant use of force that is capable of causing pain and bodily injury, and therefore, baton blows, like pepper spray, are considered a form of "intermediate force." Mohr, 318 F.3d at 623. Young's evidence shows that California law enforcement officers are taught that a baton is a deadly weapon that can cause deep bruising as well as blood clots capable of precipitating deadly strokes, and that batons should therefore be used "only as a response to aggressive or combative acts."

(Alleged) Many (37, 11) CEW Discharges Found to be Reasonable:

  - In Turner, where plaintiff was tased five times, the court found that there was no excessive force because he was resisting throughout the entire encounter.

  - "Mr. Hughes received an electrical current from the responding officers' tasers a total of twelve separate times."
  
  o “… the Estate contends that the officers used too much force after Jackson’s collision with the dumpster arm, when they allegedly tased him 11 times, as well as punched and kicked him repeatedly. The Estate concedes, however, that Jackson was the “strongest” and the “most physical” person the officers had ever fought. So the officers had to use a significant amount of force to subdue him. Moreover, we give a “measure of deference to the officer’s on-the-spot judgment about the level of force necessary in light of the circumstances of the particular case.” Green, 640 F.3d at 153 (quotation marks omitted). And the officers used less force here than we have found reasonable elsewhere. For example, in **Williams v. Sandel**, 433 F. App’x 353, 362 (6th Cir.2011), we held that it was reasonable for officers to tase a suspect 37 times, in addition to using their batons and pepper spray, because the suspect “remained unsecured and unwilling to comply with the officers' attempts to secure him[.]” Id. Blaskie and Wilkins acted similarly—they stopped applying force the moment Jackson stopped resisting them.

  In sum, Jackson’s Estate cannot prove to a jury that Blaskie and Wilkins used excessive force during the arrest, or that they violated clearly established law. They are therefore en-titled to qualified immunity.”

• **Williams v. Sandel**, 433 F. App’x 353, 362 (6th Cir. (Ky.) July 13, 2011):
  
  o held that it was reasonable for officers to tase a suspect 37 [actually 38] times, in addition to using their batons and pepper spray, because the suspect “remained unsecured and unwilling to comply with the officers' attempts to secure him[.]”

• **Cyrus v. Town of Mukwonago**, 624 F.3d 856 (7th Cir.2010):
  
  o “There are material facts in dispute about the extent to which Cyrus attempted to evade the officers and the actual amount of force Czarnecki used to bring about his arrest. The evidence conflicts, most importantly, on how many times Cyrus was Tasered. Czarnecki testified that he deployed his Taser five or six times, and the autopsy report describes marks on Cyrus's back consistent with roughly six Taser shocks. But the Taser's internal computer registered twelve trigger pulls, suggesting that more than six shocks may have been used. On a Fourth Amendment excessive-force claim, these are key factual disputes not susceptible of resolution on summary judgment.”

  o In **Cyrus**, the United States Court of Appeals for the Seventh Circuit found that, while the subject arrestee would not allow his hands to be handcuffed when officers attempted to arrest him, he had not violently resisted and that “once
Cyrus was on the ground, unarmed, and apparently unable to stand up on his own, the risk calculus changed.” 624 F.3d at 862–63.

What is “Deadly Force” – Generally:

- Common household items have the potential for death. And, every force option available to law enforcement has the potential to cause death. Deaths have been attributed to police canines, OC spray, impact weapons, prone positioning, hands-on physical control, control holds, takedowns, and restraint techniques.

- Pencil as deadly force:
  - State v. Doss, 2007 WL 3071034 (N.J. Super. App. Div. Oct. 23, 2007) (“although . . . a pencil commonly is used to write or sketch, and not to hurt other people, a pencil surely has the capacity to be used to inflict serious bodily injury when it is jabbed into a mouth, an eye or a blood vessel”);
  - U.S. v. Vahovick, 160 F.3d 395, 397 (7th Cir. 1998) (holding that several sharpened pencils bound together with tape in prisoner’s possession constituted a deadly weapon); and

Everything has the “Potential” to be “Lethal:”

- Peanuts have the potential to be lethal to someone with peanut allergies.

- Acetaminophen, the active ingredient in Tylenol and Nyquil is responsible for over 33,000 hospitalizations each year and 1,567 deaths in the last decade.

- Highchairs have labels warning of the risk of death, as do household fans.

- Pencils can be lethal.

Deadly vs. Non-Deadly Under Fourth Amendment:

  - “Although respondent’s attempt **1778 to craft an easy-to-apply legal test in the Fourth Amendment context is admirable, in the end we must still slosh our way through the fact bound morass of “reasonableness.” Whether or not Scott’s actions constituted application of “deadly force,” all that matters is whether Scott’s actions were reasonable.”
TASER CEW is not “deadly” force:


- *Marquez v. City of Phoenix*, 693 F.3d 1167, 1176 (9th Cir. (Ariz.) 2012), *as amended on denial of reh’g* (Oct. 4, 2012), cert. denied, 133 S. Ct. 1468 (U.S. 2013) (“We are not convinced that the use of an X26 involves deadly force.”).

TASER CEW is a “non-deadly weapon”:

- *Fils v. City of Aventura*, 647 F.3d 1272 (11th Cir. (Fla.) July 28, 2011)

- *Jackson v. Johnson*, 797 F. Supp. 2d 1057, 1067 (D. Mont. 2011) (“unlike a firearm, a taser does not constitute deadly force”)


- *Steen v. City of Pensacola*, 809 F. Supp. 2d 1342, 1350 (N.D. Fla. 2011) (citing *Fils v. City of Aventura*) (taser is a non-deadly weapon)


TASER CEW is “non-deadly force”:


TASER CEW is “less-than-lethal” force:

  
  - “deployed the less-than-lethal taser in probe mode”
  
  - “In *Bryan*, the United States Court of Appeals for the Ninth Circuit indicated that arresting officers have a duty to consider all less intrusive alternatives prior to utilizing more intrusive ones. 630 F.3d 805. While Sheffey cites this case and argues generally that the officers failed to consider such less intrusive
alternatives, it seems that the officers did just that in choosing to take Mr. Hughes to the ground and to tase him, rather than allowing the situation to reach a level that would have required obviously lethal force. At oral argument, Sheffey argued that the officers could have simply wrestled with Mr. Hughes until they brought him into compliance rather than tasing him after he was brought to the ground. However, Sheffey does not offer any evidence or argument regarding the effectiveness of this option, nor does she respond to the aggravating circumstances present here, including the level of Mr. Hughes’s resistance after he was taken to the ground, and the fact that he was reasonably considered to be in possession of, and actively reaching for, a firearm."


- FN10. All circuits that have considered the question, including the Ninth Circuit, designate taser use generally as non-lethal or less-than-lethal force. See *Bryan*, 630 F.3d at 825 (citing similar findings from other circuits). There nevertheless have been numerous cases in Ninth Circuit courts in which a suspect died after being tased by police officers, though the connection between the use of force and the suspect's death is a subject of ongoing debate and ambiguity. See, e.g., *Rosa v. Taser Int'l Inc.*, 684 F.3d 941 (9th Cir.2012); *Marquez v. City of Phoenix*, 693 F.3d 1167 (9th Cir.2012); *Sanders, 551 F.Supp.2d at 1168*; *Neal–Lomax v. Las Vegas Metro. Police Dep't*, 574 F.Supp.2d 1170 (D.Nev.2008); *Heston v. Taser Int'l, Inc.*, 431 Fed.Appx. 586, 589 (9th Cir.2011); *LeBlanc v. City of Los Angeles*, No. 04 CV 8250, 2006 WL 4752614, at *13 (C.D.Cal. Aug. 16, 2006); *Tolosko–Parker v. Cnty. of Sonoma*, Nos. 06 CV 06841, 06 CV 06907, 2009 WL 498099 (N.D.Cal. Feb. 26, 2009); *Salinas v. City of San Jose*, No. 09 CV 04410, 2012 WL 2906052 (N.D.Cal. July 13, 2012); *Gillson v. City of Sparks*, No. 06 CV 00325, 2007 WL 839252 (D.Nev. Mar. 19, 2007); *Teran v. Cnty. of Monterey*, No. 06 CV 06947, 2009 WL 1424470 (N.D.Cal. May 20, 2009).

**TASER CEW is “less than deadly force”:**


- *Mattos v. Agarano*, 590 F.3d 1082, 1087 (9th Cir. (Haw.) January 12, 2010), superseded by *Mattos v. Agarano*, 661 F.3d 433 (9th Cir. (Haw.), Oct. 17, 2011)

TASER CEW is “non-lethal”:

Figure 28 TASER Training Version 12 (11/04), X26 CEW User Certification PowerPoint Slide

- The U.S. Department of Defense policy defines non-lethal weapons as “weapon systems that are explicitly designed and primarily employed so as to incapacitate personnel or material, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment. . .” It is important to note that Department of Defense policy does not require or expect non-lethal weapons “to have a zero probability of producing fatalities or permanent injuries.” Rather, non-lethal weapons are intended to significantly reduce the probability of such fatalities or injuries as compared with traditional military weapons which achieve their effects through the physical destruction of targets.

- Joint Concept for Non-lethal Weapons
  United States Marine Corps

The purpose of this slide is to set expectations that non-lethal weapons are not risk-free, and the term “non-lethal” is not a guarantee that injuries and fatalities will be zero.

• The U.S. Department of Defense policy defines non-lethal weapons as “weapon systems that are explicitly designed and primarily employed so as to incapacitate personnel or material, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment. . .” It is important to note that Department of Defense policy does not require or expect non-lethal weapons “to have a zero probability of producing fatalities or permanent injuries.” Rather, non-lethal weapons are intended to significantly reduce the probability of such fatalities or injuries as compared with traditional military weapons which achieve their effects through the physical destruction of targets.

- State v. Herr, 346 Wis.2d 603, 828 N.W.2d 896 (Wis.App., February 6, 2013)
  - FN10. All circuits that have considered the question, including the Ninth Circuit, designate taser use generally as non-lethal or less-than-lethal force. See Bryan, 630 F.3d at 825 (citing similar findings from other circuits). There nevertheless have been numerous cases in Ninth Circuit courts in which a suspect died after being tased by police officers, though the connection between the use of force and the suspect’s death is a subject of ongoing debate and ambiguity. See, e.g.,


  • In Batiste no one (medical examiner or plaintiff’s expert) opined that the CEW caused the death. In fact, the Batiste court described the TASER CEW as a “non-lethal weapon” and declined to find that the CEW amounted to deadly force.

  • “Plaintiffs claim that because the taser was discharged while the officer was running, while the suspect was running, or because the taser hit the suspect in the head, the use of the taser amounts to deadly force. If the taser was used while the discharging officer was running, it was in violation of Sheriff's department training and outside the manufacturers' guidelines for taser use. However, Plaintiffs did not demonstrate that the use of the taser in the manner they described created an unreasonable risk of death. Even if Plaintiffs accurately describe the tasing, they have not shown that the use of a non-lethal weapon in a less than optimal manner necessarily equates to the use of a loaded firearm as was the case in Garner.” (emphasis added)

• Lewis v. Downey, 581 F.3d 467, 476 (C.A.7 (Ill.) September 4, 2009), cert. denied, 130 S.Ct. 1936, 176 L.Ed.2d 366 (U.S. 2010)

• Bryan v. MacPherson, 630 F.3d 805, 825 (C.A.9 (Cal.) November 30, 2010)


• Sanders v. City of Fresno, 551 F.Supp.2d 1149, 1168 (E.D.Cal., Apr. 3, 2008)
• Plaintiff implies without citation that the use of a Taser represents the use of “deadly force.” The Ninth Circuit defines deadly force as force that creates a substantial risk of causing death or serious bodily injury.\textsuperscript{FN32} \textit{Blanford v. Sacramento County, 406 F.3d 1110, 1115 n. 2 (9th Cir.2005)}. However, case law indicates that Tasers are generally considered non-lethal or less lethal force. See \textit{Ewolski v. City of Brunswick, 287 F.3d 492, 508 (6th Cir.2002); Matta–Ballesteros v. Henman, 896 F.2d 255, 256 n. 2 (7th Cir.1990); Montgomery v. Morgan County, 2008 WL 596068, *11, 2008 U.S. Dist. LEXIS 15846, *32 (S.D.Ind.2008); Fuller v. Cuyahoga Metro. Hous. Auth., 2008 WL 339464, *18 n. 25, 2008 U.S. Dist. LEXIS 8730, *57 n. 25 (N.D.Ohio 2008); McDonald v. Pon, 2007 WL 4420936, *2–3, 2007 U.S. Dist. LEXIS 92356, *6–7 (W.D.Wash.2007); see also \textit{San Jose Charter of the Hells Angels Motorcycle Club v. City of San Jose, 402 F.3d 962, 969 n. 8 (9th Cir.2005); cf. Draper v. Reynolds, 369 F.3d 1270, 1278 (11th Cir.2004)}. Tasers have been described as “a non-lethal device commonly used to subdue individuals resisting arrest. It sends an electric pulse through the body of the victim causing immobilization, disorientation, loss of balance, and weakness. It leaves few, if any, marks on the body of the victim.” \textit{Matta–Ballesteros, 896 F.2d at 256 n. 2}. Similarly, another court has explained that a Taser “works by causing involuntary muscle contractions, similar to muscle cramps, that preclude the suspect from engaging in the type of coordinated motion necessary to fight or flee.” \textit{McDonald, 2007 WL 4420936 at *3, 2007 U.S. Dist. LEXIS 92356 at *7}. Further, one court has noted that pain is a necessary byproduct of the Taser, pain is not the primary motivator, the Taser is considered to inflict considerably less pain than other forms of force, and the effects of the Taser are generally temporary. See \textit{Beaver v. City of Federal Way, 507 F.Supp.2d 1137, 1142–43 (W.D.Wash.2007)}. No evidence has been presented that Tasers constitute force that creates a substantial risk of death. It is true that Michael died following a struggle in which multiple Taser applications were used, but Michael clearly did not die immediately, he was able to breathe and converse with the officers and Henrickson, and the coroner’s report indicates that he died due to complications associated with cocaine ingestion. The Court will view the use of a Taser as an intermediate or medium, though not insignificant, quantum of force that causes temporary pain and immobilization. See \textit{Matta–Ballesteros, 896 F.2d at 256 n. 2; Beaver, 507 F.Supp.2d at 1142–43; McDonald, 2007 WL 4420936 at *2–3, 2007 U.S. Dist. LEXIS 92356 at *6–7; see also Draper, 369 F.3d at 1278}.

• \textit{Buckley v. Haddock}, 292 F.Appx. 791 (C.A.11 (Fla.) September 9, 2008)

• \textit{United States v. Fore}, 507 F.3d 412, 413 (C.A.6 (Ky.) November 8, 2007)
• “The officers warned defendant that a Taser, a non-lethal weapon that emits an electrical charge to incapacitate a subject, would be used if he did not comply with their instructions.” Fore, at 413.


• San Jose Charter of Hells Angels Motorcycle Club v. City of San Jose, 402 F.3d 962, 969 n. 8 (C.A.9 (Cal.) April 4, 2005)

• When Does Use of T[ASER ECD] Constitute Violation of Constitutional Rights, 45 A.L.R.6th 1 (Originally published in 2009)

TASER CEW is not “lethal” force:


• Rocha v. Schroeder, 283 F.App’x 305 (C.A.5 (Tex.) June 27, 2008)

TASER CEW is “less-lethal” weapon:

  o “Other courts of appeals have observed that baton launchers and similar ‘impact weapons’ employ a substantially greater degree of force than other weapons categorized as ‘less lethal,’ such as pepper spray, [TASER CEWs], or pain compliance techniques.” Page 521.

• Glenn v. Washington County, 673 F.3d 864 (C.A.9 (Or.) December 27, 2011):
  o TASER X26 CEW is “a less intrusive [force] alternative to the beanbag shotgun.” Glenn, 673 F.3d at 878, fn 10.
  o [Definition of “less-lethal weapon”] “First we consider the quantum of force used when officers shot Lukus with the beanbag shotgun. A beanbag shotgun is “a twelve-gauge shotgun loaded with ... ‘beanbag’ round[s],” which consist of “lead shot contained in a cloth sack.” Deorle v. Rutherford, 272 F.3d 1272, 1277 (9th Cir.2001). It is “intended to induce compliance by causing sudden, debilitating, localized pain, similar to a hard punch or baton strike.” “Although bean bag guns are not designed to cause serious injury or death, a bean bag gun is considered a ‘less-lethal’ weapon, as opposed to a non-lethal weapon, because the bean bags can cause serious injury or death” “if they hit a relatively sensitive area of
the body, such as [the] eyes, throat, temple or groin.” In Deorle, we observed that the euphemism “beanbag” “grossly underrates the dangerousness of this projectile,” which “can kill a person if it strikes his head or the left side of his chest at a range of under fifty feet.” Id. at 1279 & n. 13. Indeed, the plaintiff in Deorle suffered multiple cranial fractures *872 and the loss of an eye as a result of being shot with a beanbag gun from approximately 30 feet away. See id. at 1277–78 & n. 11. In light of this weapon’s dangerous capabilities, “[s]uch force, though less than deadly, ... is permissible only when a strong governmental interest compels the employment of such force.” Id. at 1280.”

- **Mercado v. City of Orlando**, 407 F.3d 1152, 1157 (C.A.11 (Fla.) April 29, 2005):
  - Under Florida law, “deadly force” means any “force that is likely to cause death or great bodily harm,” but does not include “the discharge of a firearm by a law enforcement officer or correctional officer during and within the scope of his or her official duties which is loaded with a ‘less lethal munition.’” Fla. Stat. § 776.06. “Less-lethal munition” is, in turn, defined as “a projectile that is designed to stun, temporarily incapacitate, or cause temporary discomfort to a person without penetrating the person’s body.”

- **Deorle v. Rutherford**, 272 F.3d 1272 (C.A.9 (Cal.), March 16, 2001)

**Cases Citing the May 24, 2011 NIJ CEW Study:**


- **Hagans v. Franklin County Sheriff’s Office**, 695 F.3d 505, 510 (C.A.6 (Ohio) August 23, 2012)

  “... The taser remains a relatively new technology, and courts and law enforcement agencies still grapple with the risks and benefits of the device. Even as of a year ago, however, it could be said that tasers carry “a significantly lower risk of injury than physical force” and that the vast majority of individuals subjected to a taser—99.7%—suffer no injury or only a mild injury. John H. Laub, Director, Nat’l Inst. of Justice, Study of Deaths Following Electro Muscular Disruption 31 (2011); see also Mattos, 661 F.3d at 454 (Kozinski, J., concurring in part and dissenting in part).”

- **Williams v. City of Cleveland, Miss.**, 2012 WL 3614418 (N.D.Miss. August 21, 2012)

“... [A] study by six university departments of emergency medicine found that 99.7 percent of those Tased by police suffer no injuries or, at most, mild ones.” Mattos, 661 F.3d at 454 (Kozinski, C.J., concurring in part and dissenting in part) (citing William P. Bozeman et al., Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Against Criminal Suspects, 53 Annals Emergency Med. 480, 484 (2009)). And “[t]he research division of the Department of Justice concluded that Taser deployment has a margin of safety as great or greater than most alternatives, and carries a significantly lower risk of injury than physical force.” Ibid. (citing John H. Laub, Director, Nat’l Inst. of Justice, Study of Deaths Following Electro Muscular Disruption 30–31 (2011)). Of course, the materials the district court cited focus specifically on suspects fleeing from law enforcement. But this does not diminish the force of arguments concerning tasers’ relative safety, as compared to other methods of detaining suspects—even suspects who are running from the police. See ibid. (discussing dangers of alternative methods of subduing suspects). Data from outside sources, then, confirms our analysis of taser-use case law: it is not clear that every reasonable officer would believe that Hall's actions violated Cockrell's right to be free from excessive force.”

This quote was included in Williams v. City of Cleveland, Miss., 2012 WL 3614418 (N.D.Miss. Aug 21, 2012).


“The Taser is a safe alternative: It’s effective at a range of fifteen to thirty-five feet, so officers can use it without engaging in personal combat. And a study by six university departments of emergency medicine found that 99.7 percent of those Tased by police suffer no injuries or, at most, mild ones. William P. Bozeman et al., Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Against Criminal Suspects, 53 Annals Emergency Med. 480, 484 (2009). The research division of the Department of Justice concluded that Taser deployment “has a margin of safety as great or greater than most alternatives,” and carries a “significantly lower risk of injury than physical force.” John H. Laub, Director, Nat’l Inst. of Justice, Study of Deaths Following Electro Muscular Disruption 30–31 (2011)."

PERF Guidelines/Policies Admissibility for Constitutional Violation:

1. Thompson v. City of Chicago, 472 F.3d 444 (C.A.7 (Ill.) December 19, 2006):
   a. The Seventh Circuit has stated that “the violation of police regulations or even a state law is completely immaterial as to the question of whether a violation of the federal constitution has been established.”


   (a) “However, while the [PERF] Guidelines and Sheriff’s Procedures may be inadmissible to show a constitutional violation has been established, that does not necessarily mean that information contained in these documents is irrelevant or inadmissible for other purposes.”
Lay/Expert Testimony: CEWs:

1. Officer’s lay witness testimony on TASER CEW download - *Claret v. Roberts*, 657 F.3d 664, 671 (7th Cir.2011):
   
   a. “[Lay witness Officer] Roberts did not give technical testimony about how the Taser’s internal memory operated or how data was uploaded from the Taser to the police department’s central computer—subjects that no doubt would have required some form of properly qualified expert testimony under Rule 702. Rather, his testimony was limited to his own experience in operating the Taser. He explained the steps required to fire the Taser in order to illustrate the incongruity of rapid, successive deployments only one second apart. Neither this testimony, nor his discussion of the Taser printout, was couched in terms of an expert opinion.”

   b. “[Lay witness Officer] Roberts testified that based on his experience and training, it would be physically impossible to discharge the Taser multiple times just one second apart. He also testified more generally about the Taser printout, which registered 585 separate deployments occurring over the span of more than a year. He also said that ‘[a]fter reviewing this printout, there does appear to be many different malfunctions in the printout.’"
Warnings:

1. Airbag Warning: Automobile airbags, which reduce injuries and save lives similar to the TASER CEW, contain the following warning:
Selected General Numbers and Mortality/Injury Statistics

Basic Selected TASER CEW Statistics:

- As of December 31, 2013:\footnote{165}
  - TASER has sold approximately 750,000 CEWs worldwide (does not include civilian TASER CEWs)
  - TASER has sold CEWs to 17,000 law enforcement and military agencies
    - 7,293 of these agencies deploy CEWs to all of their patrol officers
  - TASER has sold CEWs in 107 countries (195 recognized countries in world)
  - Approximately 260,000 civilian TASER CEWs have been sold to the general public since 1994

- Estimated CEW exposure numbers:
  - CEW Field Use/Suspect Applications: 2,140,000 ± 2% (as of May. 9, 2014)
  - CEW Training/Voluntary Applications: 1,351,891 ± 7% (as of Dec. 31, 2011)
  - Total TASER ECD Applications: 3.49 + million

\footnote{165} TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®), dated January 17, 2014. The most current Field Data and Risk Management PowerPoint and the most current International Field Data and Risk Management PowerPoint are both specifically included herein by reference in their entireties as though fully incorporated herein in totality, as well as all underlying foundational documents and information.
Law Enforcement-Person Contacts, Use of Force, Excessive Force, Deaths:

Law Enforcement Officer (LEO) Temporal Related Deaths per Category Table:

Table 49 Law Enforcement Officer (LEO) Temporal Related Deaths Per Category Summary Table

<table>
<thead>
<tr>
<th>Category of deaths (mortality)</th>
<th>Deaths per temporal factor</th>
<th>Deaths per 100,000 of specific incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEOs use of weapons deaths</td>
<td>1 death per 323 arrests using weapons</td>
<td></td>
</tr>
<tr>
<td>Pepper spray deaths per uses</td>
<td>1 death per 600 uses of pepper spray</td>
<td></td>
</tr>
<tr>
<td>Jail inmates deaths per year</td>
<td>1 death per 658–709 jail inmates</td>
<td>150 per 100,000 inmates</td>
</tr>
<tr>
<td>LEOs deaths per year</td>
<td>1 death per year for every 5,521 LEOs</td>
<td>18 per 100,000 LEOs</td>
</tr>
<tr>
<td>Arrests deaths per arrests</td>
<td>1 death per 15,384.6 arrests</td>
<td>6.5 per 100,000 arrests</td>
</tr>
</tbody>
</table>

Temporal Arrest–Related Deaths Per Uses of Force (estimates):

Table 50 Estimates: Temporal Arrest–Related Deaths per Uses of Force

<table>
<thead>
<tr>
<th># Uses of Force</th>
<th>Deaths</th>
<th>Ratio</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Hall</td>
<td>4,992</td>
<td>7</td>
<td>1:713</td>
</tr>
<tr>
<td>2012 Hall</td>
<td>1,269</td>
<td>1</td>
<td>1:1,269</td>
</tr>
<tr>
<td>2010 Strote</td>
<td>1,101</td>
<td>0</td>
<td>0:1,101</td>
</tr>
<tr>
<td>2009 Bozeman</td>
<td>1,201</td>
<td>2</td>
<td>1:600</td>
</tr>
<tr>
<td>2008 Eastman</td>
<td>426</td>
<td>1</td>
<td>1:426</td>
</tr>
<tr>
<td>2003 Koehler</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 51 Estimates: Law Enforcement Encounters, Arrests, Force, Deaths

<table>
<thead>
<tr>
<th>Event (estimates)</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Population (2010)</td>
<td>308,745,538</td>
<td>1:1</td>
<td>100%</td>
</tr>
<tr>
<td>Police-Public Face-to-Face (FTF) Contacts (total) (2008)</td>
<td>39,914,000</td>
<td>1:6</td>
<td>16.9%</td>
</tr>
<tr>
<td>Force Used or Threatened on those FTF Contacts (2008)</td>
<td>776,000</td>
<td>1:51</td>
<td>1.4%</td>
</tr>
<tr>
<td>Force Used Against Them Felt Force Excessive (2008)</td>
<td>447,000</td>
<td>1:1.74</td>
<td>74.3%</td>
</tr>
<tr>
<td>Force, Person Believed Excessive Filed Complaint</td>
<td>61,249</td>
<td>1:7.3</td>
<td>13.7%</td>
</tr>
<tr>
<td>Arrest – Force – Death Numbers (estimates)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US Population 2010</td>
<td>308,745,538</td>
<td>1:1</td>
<td>100%</td>
</tr>
<tr>
<td>Arrests (2010) (BJS FBI statistics and definitions)</td>
<td>13,122,000</td>
<td>1:23.5</td>
<td>4.2%</td>
</tr>
<tr>
<td>Force Used Per Arrests (calculated 1.5%)</td>
<td>196,830</td>
<td>1.5–2:100</td>
<td>1.4%</td>
</tr>
<tr>
<td>Deaths Per BJS/FBI Arrests (estimated)</td>
<td>600</td>
<td>1:3.28</td>
<td>0.003%</td>
</tr>
</tbody>
</table>

Police-Person Contacts, Use of Force, and Excessive Force (2008): 173

Table 52 Police-Person Contacts, Use of Force, and Excessive Force (2008)

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Face-to-Face (FTF) Contacts (total)</td>
<td>39,914,000</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Force Used or Threatened on those FTF Contacts</td>
<td>776,000</td>
<td>1:51</td>
<td>1.4%</td>
</tr>
<tr>
<td>Force Used Against Them Felt Force Excessive</td>
<td>447,000</td>
<td>1:1.74</td>
<td>74.3%</td>
</tr>
<tr>
<td>Force, Person Believed Excessive Filed Complaint</td>
<td>61,249</td>
<td>1:7.3</td>
<td>13.7%</td>
</tr>
</tbody>
</table>

- “A majority of the people who had force used or threatened against them said they felt it was excessive.”
- “More than half of police use-of-force incidents involved the police pushing or grabbing the individual.”
- “In 2008, 9.6% of persons who were suspected of wrongdoing by police experienced the use or threat of force.”
- “Of those who experienced the use or threat of force in 2008 and felt the police acted improperly, 13.7% filed a complaint against the police.”
- “As was the case in 2002 (90.1%) and 2005 (90.4%), the vast majority of residents (89.7%) with police contact during 2008 felt the officer or officers acted properly. In addition, about 9 out of 10 (91.8%) residents who experienced a contact in 2008 reported that the police were respectful.”
- “About 1 out of 10 searches conducted during traffic stops uncovered illegal items.”
- “Residents who experienced a police contact that involved force were asked if they felt any of the physical force used or threatened against them was excessive. The

---

PPCS did not define excessive for the respondent. Most (74.3% or about 417,000) people whose most recent contact with police in 2008 involved force or the threat of force thought those actions were excessive.”

Police-Person Contacts, Use of Force, and Excessive Force (2005): 174

Table 53 Police-Person Contacts, Use of Force, and Excessive Force (2005)

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Face-to-Face (FTF) Contacts</td>
<td>43500000</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Force Used or Threatened on those FTF Contacts</td>
<td>1:62.5</td>
<td></td>
<td>2.3%</td>
</tr>
<tr>
<td>Force Used Against Them Felt Force Excessive</td>
<td></td>
<td></td>
<td>83%</td>
</tr>
</tbody>
</table>

- “An estimated 19% [43.5 million] of U.S. residents age 16 or older had a face-to-face contact with a police officer in 2005.”
  - “Of the 43.5 million persons who had contact with police in 2005, an estimated 1.6% had force used or threatened against them during their most recent contact, a rate relatively unchanged from 2002 (1.5%).”
  - “Of persons who had force used against them in 2005, an estimated 83% felt the force was excessive.”

Hall (2013) Law Enforcement Officer (LEO) Interactions, Use of Force Deaths: 175

Table 54 Hall (2013): Police Interactions, Use of Force, Death Statistics

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Interactions (total)</td>
<td>3,594,812</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Police Use of Force Occurred (total)</td>
<td>4,992</td>
<td>1:720</td>
<td>0.14%</td>
</tr>
<tr>
<td>Deaths Per Use of Force (7 deaths)</td>
<td>7</td>
<td>1:713</td>
<td>0.14%</td>
</tr>
<tr>
<td>Sudden In Custody Death (1 death)</td>
<td>1</td>
<td>1:4.992</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

Hall (2012) Law Enforcement Officer (LEO) Interactions, Use of Force, Deaths: 176

Table 55 Hall (2012): Police Interactions, Use of Force, Death Statistics

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Interactions (total)</td>
<td>1566908</td>
<td>1:1 234</td>
<td>0.08%</td>
</tr>
<tr>
<td>Police Use of Force Occurred (total)</td>
<td>1 269</td>
<td>1:1 269</td>
<td>0.002%</td>
</tr>
</tbody>
</table>


  o "During the study interval, there were 1,566,908 total police-public interactions. Police use of force occurred in 1,269 of those 1,566,908 interactions (0.08% of all police–public interactions; 95% CI = 0.08%, 0.086%)."

    ▪ 1 use of force for every 1,234 police–public interactions
    ▪ 1 death for every 1,269 uses of force

  o "The sudden in-custody death rate following police use of force was low overall (0.08%, 95% confidence interval (CI) = 0.002, 0.44) and the difference in the proportion of subjects who died suddenly in either position was not significant at 0.14%, (95%CI = −0.8, 0.9). Our results indicate that prone positioning was common and was not associated with death in our cohort of consecutive subjects following police use of force."

**Basic Arrest–Related Death (“ARD”) Numbers:**

• **Pepper spray** – approximately 1 in 600 will die

  o “The study of in-custody deaths concluded that pepper spray contributed to death in two of the 63 cases, both involving people with asthma.”

  o “The [26 deaths] fatality total suggests that one person dies after being pepper sprayed for about every 600 times the spray is used by police.”

• **Positional asphyxia** – in a pepper spray study in 7 out of 63 "clear cut" cases of suspect death the death was attributed to positional asphyxia.

**Pre-Arrest/Arrest Risk of Death (no listing of CEW):**

• Pre-arrest/arrest risk of death is 6.5 deaths per 100,000 arrests or

• 1 death per 15,384.6 arrests

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177 The Effectiveness and Safety of Pepper Spray, NIJ Research for Practice, Office of Justice Programs, National Institute of Justice, Office of Justice Programs, U.S. Department of Justice, April 2003, NCJ 195739.
179 The Effectiveness and Safety of Pepper Spray, NIJ Research for Practice, Office of Justice Programs, National Institute of Justice, Office of Justice Programs, U.S. Department of Justice, April 2003, NCJ 195739.
Table 56 Pre-Arrest/Arrest risk of death

<table>
<thead>
<tr>
<th>Events Prior / During Arrest</th>
<th>No. of Deaths (n=77)</th>
<th>%</th>
<th>Risk of Death per 100,000 arrests</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police Pursuits or Chases</td>
<td>14 deaths</td>
<td>18.1%</td>
<td>6.5 per 100,000 arrests</td>
<td>1:15,384</td>
</tr>
<tr>
<td>Transport of Suspects</td>
<td>10 deaths</td>
<td>12.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>During Incarceration</td>
<td>2 deaths</td>
<td>2.6%</td>
<td>0.93 per 100,000 arrests</td>
<td>1:107,527</td>
</tr>
<tr>
<td></td>
<td>51 deaths</td>
<td>66.2%</td>
<td>268 per 100,000 inmates</td>
<td>1:323</td>
</tr>
</tbody>
</table>
Selected (US) Societal Problems Influencing Force Response:

<table>
<thead>
<tr>
<th>Societal Problem</th>
<th>Number</th>
<th>%</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Illicit Drug Abusers (2009)</td>
<td>21,800,000</td>
<td>8.7%</td>
<td>1:11</td>
</tr>
<tr>
<td>DSM-IV Substance Dependence (2009)</td>
<td>22,500,000</td>
<td>8.9%</td>
<td>1:11</td>
</tr>
<tr>
<td>Drug Caused Emergency Department Visits (2007)</td>
<td>1,900,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People in Serious Psychological Distress (2007)</td>
<td>23,400,000</td>
<td>10.9%</td>
<td>1:9</td>
</tr>
<tr>
<td>Drunk/Drugged Driving</td>
<td>10,200,000</td>
<td>13.2%</td>
<td>1:8</td>
</tr>
<tr>
<td>Mental Disorder: Children (13–20%) [up to 1 in 5]</td>
<td></td>
<td>13–20%</td>
<td>1:5–7</td>
</tr>
<tr>
<td>Suicide: Children (annually) (4.5 per 100,000)</td>
<td>1,926</td>
<td>0.0045%</td>
<td>1:22,222</td>
</tr>
</tbody>
</table>

Current Illicit Drug Abusers (“CIDA”):

- increasing annually (current drug use means use of an illicit drug during the month prior to the survey interview):
  
  o (2009) 21,800,000 CIDA age 12 and older (8.7% of population)\(^{181}\)
  o (2004) 19,100,000 CIDA age 12 and older (7.9% of population)\(^{182}\)

DSM-IV Substance Dependence:

- In 2009, an estimated 22.5 million persons (8.9% of the population aged 12 or older) were classified with substance dependence or abuse in the past year based on criteria specified in the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM-IV).\(^{183}\)

Drug caused hospital emergency department (“ED”) visits:

- (2007) “In 2007, hospitals in the United States delivered over 116 million ED visits, and DAWN estimates that about 1.9 million (1,883,272 [CI: 1,561,490 to 2,205,054]) were associated with drug misuse or abuse.”\(^{184}\)

People in serious psychological distress (“SPD”) annually in the U.S.:

- (2007) 23,400,000 SPD (10.9% of adults)\(^{185}\)
- (2004) 21,400,000 SPD (9.9% of adults)\(^{186}\)

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\(^{185}\) Serious Psychological Distress and Receipt of Mental Health Services. The NDSUH (National Survey on Drug Use and Health) Report, National Survey on Drug Use and Health, December 22, 2008.
Drunk or Drugged Driving (2006–2009):\textsuperscript{187}

- “Combined 2006 to 2009 data indicate that 13.2 percent of persons aged 16 or older (an estimated 30.6 million persons) drove under the influence of alcohol in the past year and 4.3 percent (an estimated 10.1 million persons) drove under the influence of illicit drugs in the same time period.”
  - Highest rate was in Wisconsin with 23.7\% of population
- “[I]n 2008, 32 percent of all traffic related deaths—nearly 12,000 deaths—were the result of alcohol-related crashes.”

Mental Health Surveillance Among Children – United States (2005–2011):\textsuperscript{188}

- A total of 13\% to 20\% of children living in the United States experience a mental disorder in a given year, and surveillance during 1994–2011 has shown the prevalence of these conditions to be increasing.
- The overall suicide rate for persons aged 10–19 years was 4.5 suicides per 100,000 persons in 2010 (a total of 1,926 deaths). (1 in 22,222 annual suicide rate.)
- Up to 1 out of 5 children experience a mental disorder in a given year and an estimated $247 billion is spent each year on childhood mental disorders.
- Data collected from a variety of data sources 2005–2011 show:
  - Children aged 3–17 years currently had:
    - ADHD (6.8\%)
    - Behavioral or conduct problems (3.5\%)
    - Anxiety (3.0\%)
    - Depression (2.1\%)
    - Autism spectrum disorders (1.1\%)
    - Tourette syndrome (0.2\%) (among children aged 6–17 years)
  - Adolescents aged 12–17 years had:
    - Illicit drug use disorder in the past year (4.7\%)
    - Alcohol use disorder in the past year (4.2\%)
    - Cigarette dependence in the past month (2.8\%)

Basic Selected Mortality Summary Numbers:

[“LEO” refers to “Law Enforcement Officer;” “SCD” refers to “sudden cardiac death”; “NCAA” refers to the “National Collegiate Athletic Association;” “CSP” refers to “competitive sports participants;” and “SUD” refers to “sudden unexplained death”]:

Abbreviated summary of selected approximate mortality numbers:

- 1.6 deaths per 100 hospital emergency room admissions (weekdays)
- 1.8 deaths per 100 hospital emergency room admissions (weekends)
- 1 death per 126 people in the U.S. population (annual 2009)
- 1 death per 323 LEOs’ uses of weapons
- 1 death per 600 LEOs’ uses of pepper spray
- 1 death per 700–800 persons jailed
- 1 death per 5,521 LEOs (annually)
- 1 death per 7,692 Military recruit-years (non-traumatic sudden death) (35% unexplained)
- 1 death per 15,385 law enforcement arrests

Sudden Cardiac Death (SCD): \(^{189}\)

- 1 SCD death per 14,925 males
- 1 SCD Sudden Unexplained Death (SUD) per 83,333 males (< 35 years of age)

Out of Hospital [Sudden] Cardiac Arrest (SCA) In Those <35 Years of Age: \(^{190}\)

- Overall incidence of 2.28 SCA per 100,000 person-years [1 in 43,859]:
  - 2.1 per 100,000 in those 0–2 years of age [1 in 47,619],
  - 0.61 per 100,000 in those 3–13 years of age [1 in 163,934]
  - 1.44 per 100,000 in those 14–24 years of age [1 in 69,444], and

---


\(^{190}\) Meyer, L, Stubbs, B., Fahrenbruch, C. Incidence, Causes, and Survival Trends From Cardiovascular-Related Sudden Cardiac Arrest in Children and Young Adults 0 to 35 Years of Age A 30-Year Review, Resuscitation Science, Circulation. 2012;126:1363–1372. Background—Sudden cardiac arrest is a leading cause of death in children and young adults. This study determined the incidence, cause, and outcomes of cardiovascular-related out-of-hospital cardiac arrest (OHCA) in individuals <35 years of age.
4.40 per 100,000 in those 25–35 years of age [1 in 22,727].

Sudden Cardiac Death (SCD) Minnesota (MN) High School CSP:
- 1 SCD death per 72,500 MN high school CSP over 3 years of high school
- 1 SCD death per 217,400 MN high school CSP per year

Sudden Deaths in Young Competitive Athletes in U.S.: 1980–2006:
- 1 sudden death per 163,934 young competitive athletes

Sudden Cardiac Death (SCD) Children:
- 1 SCD death per 12,438 children age 1–18 (in patient years)
- 1 SCD death per 15,698 children age 12–18 (in patient years)

Sudden Cardiac Death (SCD) NCAA Participants:
- 1 SCD death per 1,282 NCAA basketball black male athletes per year
- 1 SCD death per 3,126 NCAA basketball Division I male athletes per year
- 1 SCD death per 11,394 NCAA basketball athletes per year
- 1 SCD death per 12,990 NCAA black male athletes per year
- 1 SCD death per 21,293 NCAA swimming participants per year
- 1 SCD death per 23,397 NCAA lacrosse participants per year
- 1 SCD death per 38,497 NCAA football participants per year
- 1 SCD death per 41,695 NCAA cross-country participants per year
- 1 SCD death per 43,770 NCAA participants per year

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Probability, see, *Hirsch v. CSX Transp., Inc.*, 656 F.3d 359 (6th Cir. (Ohio) 2011):

- As referenced in *Hirsch*, at 364, see: National Safety Council, Injury Facts 37 (2011 ed.),\(^{195}\) and Harvard Center for Risk Analysis.\(^{196}\)

- Including, *Hirsch*, 656, at page 364:

  Beyond the uncertainty surrounding the Plaintiffs' exposure, there is still more reason to question Dr. Kornberg's assessment: a one-in-a-million chance is small. Indeed, it is proverbially small. If something has a one-in-a-million chance of causing cancer in an individual, then it will not cause cancer in 999,999. For some perspective, the National Safety Council estimates a person's lifetime risk of dying in a motor vehicle accident as 1 in 88. The lifetime risk of dying in "air and space transport accidents" is roughly 1 in 7,000. The risk of being killed by lightning is roughly 1 in 84,000, while the risk of being killed in a "fireworks discharge" stands at around 1 in 386,000. National Safety Council, Injury Facts 37 (2011 ed.), available at http://www.nsc.org/NSC%20Picture%20Library/News/web_graphics/Injury_Facts_37.pdf. These risks—of death, not disease—are all much smaller than what the Plaintiffs allege in this case: lifetime odds of developing cancer at 50% of 1 in 1,000,000. To even approach that number, we can look at the average person's risk of dying from bathtub drowning in any given year (1 in 840,000). Harvard Center for Risk Analysis, http://www.hcra.harvard.edu/quiz.html (last visited Sept. 6, 2011).

  In light of all of the above, Dr. Kornberg's statement is simply insufficient to establish a genuine issue of material fact regarding whether reasonable physicians would prescribe a medical monitoring regime for the Plaintiffs. Viewing the facts of this case together, the Plaintiffs have alleged only a risk that borders on legal insignificance, have failed to produce evidence establishing even this hypothetical risk with any degree of certainty, and have demanded a jury trial based upon their expert's review of this evidence and conclusory statement of the relevant legal standard. In this context, Dr. Kornberg's affidavit amounts to a "mere ... scintilla" of evidence. Shropshire, 550 F.3d at 576.


\(^{196}\) Available at http://www.hcra.harvard.edu/quiz.html.
- National Vital Statistics Reports ("NVSR"), National Center for Health Statistics ("NCHS"), Centers for Disease Control and Prevention ("CDC"), U.S. Department of Health and Human Services ("DHS").¹⁹⁷

Figure 29 US Deaths 2000–2010 Drugs, Suicide, Firearms, and Alcohol

![US Deaths 2000 through 2010](chart)

<table>
<thead>
<tr>
<th>Year</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>97,376</td>
</tr>
<tr>
<td>2001</td>
<td>102,014</td>
</tr>
<tr>
<td>2002</td>
<td>101,909</td>
</tr>
<tr>
<td>2003</td>
<td>108,031</td>
</tr>
<tr>
<td>2004</td>
<td>113,800</td>
</tr>
<tr>
<td>2005</td>
<td>118,506</td>
</tr>
<tr>
<td>2006</td>
<td>124,665</td>
</tr>
<tr>
<td>2007</td>
<td>127,392</td>
</tr>
<tr>
<td>2008</td>
<td>129,442</td>
</tr>
<tr>
<td>2009</td>
<td>129,523</td>
</tr>
<tr>
<td>2010</td>
<td>132,538</td>
</tr>
</tbody>
</table>

2009 – US Population Death/Mortality Numbers:

- In 2009 there was 1 death for every 126 people in the U.S. population:
  - 2009 U.S. population = 307,006,550
  - 2009 total U.S. deaths = 2,436,682
  - 307,006,550 population ÷ 2,436,682 deaths = (1 death per) 126 people

- In 2009, of those 2,436,682 who died in the U.S., there were 129,523 (132,538 in 2010) deaths from drugs, suicide, firearms, or alcohol.
  - 2009 U.S. deaths from:
    - Drugs – 37,485 or a rate of 12.2 per 100,000 people in population
    - Suicide – 36,547 or a rate of 11.9 per 100,000 people
    - Firearms – 31,228 or a rate of 10.2 per 100,000 people
    - Alcohol – 24,263 or a rate of 7.9 per 100,000 people
  - In 2009 for every 18.81 people who died, one of those 18.81 people died from drugs, suicide, firearms, or alcohol.
  - In 2009 for every 65 people who died, one of those 65 people died from drugs.

Table 58 Cause of death rates per 100,000 of general population

<table>
<thead>
<tr>
<th>Cause of Death (death rates per 100,000 of general population)</th>
<th>2010</th>
<th>2009</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>All causes of Death</td>
<td>798.7</td>
<td>793.7</td>
<td>813.2</td>
</tr>
<tr>
<td>Infant Death Rate All Causes</td>
<td>614.0</td>
<td>642.1</td>
<td>659.3</td>
</tr>
<tr>
<td>Major Cardiovascular Diseases</td>
<td>251.8</td>
<td>253.9</td>
<td>264.7</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>16.0</td>
<td>16.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Transport Accidents</td>
<td>12.2</td>
<td>12.7</td>
<td>14.1</td>
</tr>
<tr>
<td>Drugs</td>
<td>12.2</td>
<td>12.2</td>
<td>12.4</td>
</tr>
<tr>
<td>Suicide</td>
<td>12.2</td>
<td>11.9</td>
<td>11.8</td>
</tr>
<tr>
<td>Firearm</td>
<td>10.2</td>
<td>10.2</td>
<td>10.4</td>
</tr>
<tr>
<td>Alcohol</td>
<td>8.2</td>
<td>7.9</td>
<td>7.9</td>
</tr>
<tr>
<td>Falls</td>
<td>8.4</td>
<td>8.1</td>
<td>7.9</td>
</tr>
<tr>
<td>HIV</td>
<td>2.7</td>
<td>3.1</td>
<td>3.4</td>
</tr>
<tr>
<td>Injury at Work</td>
<td>1.6</td>
<td>1.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Peptic Ulcer</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Influenza</td>
<td>0.2</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Complications of Medical and Surgical Care</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Hernia</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Pregnancy, Childbirth, and the Puerperium</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>0.9</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Death Rate in Jails (no listing of ECD):

- Local U.S. Jails 2010 (BJS/OJP/DOJ¹⁹⁹):
  - Mortality rate:
    - 2010 – 918 deaths - 125 deaths per 100,000 jail inmates (1:800)
    - 2009 – 128 deaths per 100,000 jail inmates (1:781)
  - The number of inmates who died while in the custody of local jails declined in 2010, falling to 918 from the 951 deaths in 2009, representing the third consecutive annual decrease since the number of jail deaths peaked at 1,100 in 2007.
  - In 2010, males accounted for nearly 9 out of 10 jail inmate deaths (88%). In any single year between 2000 and 2010, males accounted for no less than 87% of jail


deaths.

- The number of jail inmate deaths from heart disease increased in 2010 to 240, up from 199 occurring in 2009. The annual average number of heart disease deaths was 222 over the past 10 years (excluding 2008 data as noted above).

- Jail inmates died of heart disease at a rate of 33 per 100,000 inmates in 2010, similar to rates between 2000 and 2006, but was slightly above the rate of 27 per 100,000 inmates in 2009.

- Local U.S. Jails (in-custody deaths) – 2008 and 2009 (NJ/BJS Report\textsuperscript{200}):
  - 2009 – 948 deaths, 127 deaths per 100,000 inmates (1 death per 787 detainees).
  - 2008 – 960 deaths, 123 deaths per 100,000 inmates (1 death per 813 detainees).

\textbf{Figure 31 Jail inmate deaths in custody, 2000–2009}

- Local U.S. Jails (in-custody deaths) – from 2000 through 2007 (NIJ/BJS Report\textsuperscript{201}):
o 8,110 persons died in local jails from 2000 through 2007
  - Approximately 1 death per 658–709 inmates (depending on year)

o Local jail in-custody rates of death for 2000 through 2007:
  - approximately 141–152 deaths per 100,000 inmates (depending on year)

- “Nevada’s rate of custody deaths of 247 per 100,000 inmates is similar to the national average (250 per 100,000 inmates), but is substantially higher than the average for other Western states (219 per 100,000 inmates).”\(^{202}\)

- In Ontario, Canada “[t]he crude rate of death among male inmates was 420.1 per 100 000 in federal institutions and 211.5 per 100 000 in provincial institutions.”\(^{203}\)

US ARDs, BJS, Deaths in Custody Reporting Act (“DICRA”):\(^{204}\)

Figure 32 US ARDs, BJS, Deaths in Custody Reporting Act (“DICRA”)

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• January 2003-December 2009 DICRA Report:205
  o A total of 4,813 deaths were reported to the Arrest-Related Deaths program from January 2003 through December 2009.
  o Of reported arrest-related deaths, 61% (2,931) were classified as homicides by law enforcement personnel, 11% (541) were suicides, 11% (525) were due to intoxication, 6% (272) were accidental injuries, and 5% (244) were attributed to natural causes.


• 2,000 Medical Examiner (“ME”) / Coroner (“C”) Offices in U.S.:
  o 7,320 ME/C full-time equivalent ME/C employees
  o $718,500,000.00 total ME/C annual budgets

• 2,398,000 human deaths:
  o 956,000 deaths referred to ME/C offices
    ▪ 487,000 deaths accepted for investigation
      - 677 Arrest Related Deaths (“ARDs”) (all causes)207
    • 9 ARDs involved the use of ECDs or other conducted-energy devices208

Additional Mortality Numbers:

Hospital Emergency Department Mortality Rates:209

• 1.8 out of 100 – hospital emergency department mortality rate on weekends

• 1.6 out of 100 – hospital emergency department mortality rate on weekdays

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“When all possible diagnoses (conditions accounting for the 3,789,917 admissions) were included in the analysis, there was a small increase in mortality among patients, admitted on a weekend (1.8 percent vs. 1.6 percent).”

Sudden Death in Young Adults:

Sudden Cardiac Death (SCD) mortality rate (person-years for the 1998–2008 study period comprising 15.2 million person-years of active surveillance):

- males: 6.7 per 100,000 [1:14,925]
- females: 1.4 per 100,000 [1:71,428]

SCD mortality incidence of sudden unexplained death (SUD) by age:

- < 35 years of age: 1.2 per 100,000 [1:83,333]
- ≥ 35 years of age: 2.0 per 100,000 [1:50,000]

Miscellaneous causes of exertional sudden cardiac death (SCD) included:
- moving furniture and/or equipment,
- mowing lawn,
- dancing,
- fighting, and
- sexual intercourse.

---

Table 59 Specific Activities Exertional and Sudden Cardiac Death

<table>
<thead>
<tr>
<th>Specific Activities at Time of Exertional Sudden Death</th>
<th>361 Young Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational sports</td>
<td>166 (51.9%)</td>
</tr>
<tr>
<td>Running</td>
<td>114 (31.6%)</td>
</tr>
<tr>
<td>Basketball</td>
<td>20 (5.5%)</td>
</tr>
<tr>
<td>Walking</td>
<td>14 (3.9%)</td>
</tr>
<tr>
<td>Swimming</td>
<td>11 (3.0%)</td>
</tr>
<tr>
<td>Weightlifting</td>
<td>6 (1.4%)</td>
</tr>
<tr>
<td>Baseball</td>
<td>4 (1.1%)</td>
</tr>
<tr>
<td>Biking</td>
<td>4 (1.1%)</td>
</tr>
<tr>
<td>Military training</td>
<td>150 (41.6%)</td>
</tr>
<tr>
<td>Organized physical training*</td>
<td>138 (38.2%)</td>
</tr>
<tr>
<td>Road march/land navigation</td>
<td>7 (2.0%)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5 (1.4%)</td>
</tr>
<tr>
<td>Not specified</td>
<td>17 (4.8%)</td>
</tr>
<tr>
<td>*(Organized physical training defined as group-level activity to include performance of physical fitness testing (pull-ups, push-ups, and timed distance running). Additional recreational sports representing 1% included football (n = 3), racquetball (n = 3), soccer (n = 3), volleyball (n = 3), tennis (n = 4), and combined (n = 1). Miscellaneous causes included moving furniture and other equipment (n = 8), moving law (n = 4), dancing (n = 2), fighting (n = 2), and sexual intercourse (n = 1).)</td>
<td></td>
</tr>
</tbody>
</table>

Sudden Cardiac Death (SCD) NCAA\textsuperscript{211} Athletes:\textsuperscript{212}

- SCD incidence (risk) of NCAA student-athlete – 1:43,770 participants per year
  - SCD incidence (risk) of NCAA male athletes – 33,134 participants per year
    - SCD incidence (risk) of NCAA white male athletes – 1:58,653 per year
    - SCD incidence (risk) in NCAA black male athletes – 1:12,990 per year
  - NCAA Basketball:
    - SCD Incidence (risk) of NCAA basketball participants – 1:11,394 per year
      - SCD Incidence (risk) of NCAA basketball participants by ethnicity:
        - SCD incidence (risk) in NCAA white male athletes – 1:21,824 per year
        - SCD incidence (risk) in NCAA black male athletes – 1:5,743 per year
    - SCD incidence (risk) of NCAA Division I male – 1:3,126 per year

\textsuperscript{211} NCAA – National Collegiate Athletic Association.
- SCD incidence (risk) in NCAA white male athletes – 1:3,947 per year
- SCD incidence (risk) in NCAA black male athletes – 1:1,282 per year

- NCAA Swimming SCD incidence (risk) – 1:21,293
- NCAA Football SCD incidence (risk) in Division I – 1:25,297
- NCAA Lacrosse SCD incidence (risk) – 1:23,357
- NCAA Football SCD incidence (risk) – 1:38,497
- NCAA Cross-country SCD incidence (risk) – 1:41,695
• NCAA SCD Athletes According to Sex, Ethnicity, and Division, 2004–2008:

Table 60 Incidence of SCD - NCAA Athletes 2004-2008

<table>
<thead>
<tr>
<th></th>
<th>No. of Athlete-Years</th>
<th>No. of Deaths</th>
<th>Death Rate (per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA athletes</td>
<td>1,969,663</td>
<td>45</td>
<td>1:43.770</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1,125,557</td>
<td>34</td>
<td>1:33.134</td>
</tr>
<tr>
<td>Female</td>
<td>843,106</td>
<td>11</td>
<td>1:76.646</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>300,835</td>
<td>17</td>
<td>1:17.093</td>
</tr>
<tr>
<td>White</td>
<td>1,583,635</td>
<td>27</td>
<td>1:58.053</td>
</tr>
<tr>
<td>By division</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division I</td>
<td>788,023</td>
<td>27</td>
<td>1:29.186</td>
</tr>
<tr>
<td>Division II</td>
<td>424,572</td>
<td>10</td>
<td>1:42.457</td>
</tr>
<tr>
<td>Division III</td>
<td>760,258</td>
<td>8</td>
<td>1:95.032</td>
</tr>
</tbody>
</table>

SCD indicates sudden cardiac death; NCAA, National Collegiate Athletic Association.

• Incidence of NCAA SCD by Sport, 2004–2008:

Table 61 Incidence of NCAA SCD by sport 2004–2008

<table>
<thead>
<tr>
<th>Sport</th>
<th>Number of Deaths</th>
<th>Overall Incidence*</th>
<th>Incidence in Males</th>
<th>Incidence in Females</th>
<th>Incidence in African Americans</th>
<th>Incidence in Caucasians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division I</td>
<td>9</td>
<td>1:5.451</td>
<td>1:3.126</td>
<td>1:23.901</td>
<td>1:5.284</td>
<td>1:6.135</td>
</tr>
<tr>
<td>Division III</td>
<td>2</td>
<td>1:24.681</td>
<td>1:13.646</td>
<td>†</td>
<td>1:6.952</td>
<td>†</td>
</tr>
<tr>
<td>Swimming</td>
<td>4</td>
<td>1:21.293</td>
<td>1:34.552</td>
<td>1:16.457</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>3</td>
<td>1:23.357</td>
<td>1:19.770</td>
<td>1:30.531</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>Football</td>
<td>8</td>
<td>1:38.497</td>
<td>1:38.497</td>
<td>†</td>
<td>1:59.814</td>
<td>1:14.401</td>
</tr>
<tr>
<td>Cross-country</td>
<td>3</td>
<td>1:41.695</td>
<td>1:59.484</td>
<td>1:32.301</td>
<td>1:12.043</td>
<td>1:51.033</td>
</tr>
</tbody>
</table>

NCAA indicates National Collegiate Athletic Association; SCD, sudden cardiac death.
*SCD incidence is expressed as number of athletes per year.
†No deaths for incidence calculation.
SCD During Competitive Sports Activities in Minnesota High School Athletes:\textsuperscript{213}

- “During the study period there were 1,453,280 overall sports participations and 651,695 student athlete participants among the 27 high school sports. The calculated risk for sudden death was 1:500,000 participations and 1:217,400 participants per academic year (or 0.46/100,000, annually). Over a 3-year high school career for a student athlete the estimated risk was 1:72,500.”
  - Calculated risk for sudden cardiac death (SCD) was:
    - 1:500,000 participations
    - 1:217,400 participants per academic year
    - 1:72,500 over a 3-year high school competitive sports career

Out-of-Hospital Non-traumatic Cardiac Arrest (OHCA): Children:\textsuperscript{214}

- The incidence of pediatric OHCA:
  - 8.04 per 100,000 person-years (1:12,438):
    - 72.71 in infants (1:1,375);
    - 3.73 in children (1:26,809); and
    - 6.37 in adolescents (1:15,698);
  - versus 126.52 per 100 000 person-years for adults (1:790).

- Survival for:
  - all pediatric OHCA was 6.4%:


- 3.3% for infants;
- 9.1% for children; and
- 8.9% for adolescents:
  - versus 4.5% for adults.

**Sudden Non-Traumatic Sudden Death in Military Recruits:**

- Non-traumatic sudden death rate: military recruit-years: 13.0/100,000 or 1 in 7,692
  - “a substantial number of deaths remained unexplained (44 of 126 recruits [35%])”
- No recruit was noted to have pre-entry cardiovascular disease, and postmortem toxicology reports showed no evidence of illicit drug use.
- Conclusions: Cardiac abnormalities are the leading identifiable cause of sudden death among military recruits; however, more than one third of sudden deaths remain unexplained after detailed medical investigation.

**Routine Cardiac Ablation Procedures Rates of Major Complications/Deaths:**

- Mortality rate – 1,000 deaths per million, or 1 in 1,000
- Major complications rate from routine cardiac ablation – 3.8 out of 100

**Severe Mental Illness Mortality Rates:**

- A 2–3 fold increased mortality rate
- “People with severe mental illnesses (SMI), such as schizophrenia, depression or bipolar disorder, have worse physical health and reduced life expectancy compared to the general population .... Evidence shows that they have a 2–3 fold increased mortality rate and that the mortality gap associated with mental illness compared to the general population has widened in recent decades.”

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216 Marius Bohnen, BSc, William G. Stevenson, MD, FHRS, Usha B. Tedrow, MD, MSc, FHRS, Gregory F. Michaud, MD, FHRS, Roy M. John, MD, PhD, FHRS, Laurence M. Epstein, MD, FHRS, Christine M. Albert, MD, MPH, Bruce A. Koplan, MD, MPH, FHRS, Incidence and predictors of major complications from contemporary catheter ablation to treat cardiac arrhythmias, o:10.1016/j.hrthm.2011.05.017.

Antipsychotics and the Risk of Sudden Cardiac Death:218

• Current use of antipsychotics was associated with a 3-fold increase in risk of sudden cardiac death.

• “Results: The study population comprised 554 cases of sudden cardiac death. Current use of antipsychotics was associated with a 3-fold increase in risk of sudden cardiac death. The risk of sudden cardiac death was highest among those using butyrophenone antipsychotics, those with a defined daily dose equivalent of more than 0.5 and short-term (≤90 days) users. The association with current antipsychotic use was higher for witnessed cases (n=334) than for unwitnessed cases.”

• “Conclusions: Current use of antipsychotics in a general population is associated with an increased risk of sudden cardiac death, even at a low dose and for indications other than schizophrenia. Risk of sudden cardiac death was highest among recent users but remained elevate during long-term use.”

SUDEP – Sudden Unexpected Death in Epilepsy Mortality:

• “Epilepsy is one of the most common neurologic diseases in the world, seen in 3% of the world’s population.”219

• “Approximately 2 million people in the United States have epilepsy.”220

• “Epilepsy patients are at an increased risk of mortality compared with the rest of the population. Standardized mortality rate in epilepsy patients is shown to be 1.6–9.3 times higher in this population.”221

• “SUDEP accounts for 8%–17% of deaths in people with epilepsy. The incidence is estimated to be 2–10 per 1,000 person years in population based studies.”222 [citation omitted]

• “People with epilepsy have a 2.6-fold increased risk of premature death compared with the general population.”223

218 Sabine M. J. M. Straus, MD; Gysel’te S. Bleumink, MD; Jeanne P. Dieleman, PhD; Johan van der Lei, MD, PhD; Geert W. ‘t Jong, PhD; J. Herre Kingma, MD, PhD; Miriam C. J. M. Sturkenboom, PhD; Bruno H. C. Stricker, PhD, Antipsychotics and the Risk of Sudden Cardiac Death, Arch Intern Med’Vol 164, June 28, 2004, 1293–1297, 1839.


220 Id.

221 Id.

222 Id.

• “The risk of sudden death in young adults with epilepsy is increased 24-fold.”224

• SUDEP “is the most frequent cause of epilepsy-related death with incidence rates of up to 9 per 1000 person-years in people with pharmaco-resistant epilepsy.”225

• “In children with epilepsy, the cumulative risk of dying suddenly is 7% within 40 years.”226

Law Enforcement Officer (LEO) Mortality, Assaults, and Injuries:227

• Averages over 2000–2009 decade:
  o 900,000 LEOs
  o 163 LEO deaths per year
  o 50,069 LEO assaults per year
  o 16,041 LEO injuries per year

• Thus, annually:
  o 1 LEO death per year per 5,521 officers
  o 1 LEO injured per year per 56 officers
  o 1 LEO assault per year per 18 officers

Other Numbers:

1. (Near Earth Object (NEO) Collision) According to NASA you have about one chance in 40,000 of dying as a result of a near earth object (“NEO”) [asteroid or comet] collision.228

224 Id.
225 Id.
Fatal and Nonfatal Acetaminophen Poisoning

Mary H. Dudley, MD, MS, RN, Jackson County Medical Examiner Office, Kansas City, Missouri, USA
Acetaminophen Toxicity in the Forensic Autopsy

Mary H. Dudley, MD, ¹; Marius Tanau, MD, ¹; Henry J. Carson, MD, ¹; Tom Hensley, F-ABMDI ¹;
Uttam Garg, Ph.D., DABCC, DABFT, FACB ³; C. Clinton Frazee, III, NRCC-TC ³;
Jackson County Medical Examiner’s Office, Kansas City, Missouri; ³ Mercy Hospital Pathology, Iowa City, Iowa;
³Children’s Mercy Hospitals and Clinics, Kansas City, Missouri

ABSTRACT:
We present two cases of acetaminophen overdose to show the range of liver damage that can occur. The first subject was a 49-year-old white male who attempted suicide with acetaminophen but vomited and recovered. A week later, he committed suicide by gunshot. The liver demonstrated centrilobular necrosis, leaving the periportal zone intact. Postmortem toxicological studies were negative. The second subject was a 28-year-old white woman who ingested an overdose of acetaminophen. She died in the hospital 3 days later. The centrilobular and periportal hepatocytes were necrotic. Toxicological studies were positive for acetaminophen in antemortem blood, 45.5 µg/mL.

DISCUSSION:
Acetaminophen may cause liver injury either by a single large overdose or by the cumulative effect of multiple smaller doses that exceed the recommended limit for this drug. The incidence of injury due to a single large overdose is significantly higher, in large part because the high incidence of a single large overdose in suicide attempts.

INTRODUCTION:
Acetaminophen is the antipyretic-analgesic drug most frequently encountered by the toxicology laboratory in the United States. We present two cases of acetaminophen overdose to show the range of liver damage that can occur.

CASE 1:
History:
- 49 year old white male with recent attempted suicide by consuming fifty 325mg acetaminophen pills
- Vomited the pills, shortly after ingestion
- One week later found with self inflicted gunshot wound to left temple

Autopsy Findings:
- Penetrating gunshot wound to left temple
- Grossly unremarkable internal organs
- Microscopy showed liver changes with geographic necrosis (centrilobular), piecemeal necrosis with acute inflammation, intact periportal hepatocytes (Figures 1 & 2)

Toxicology Results: Cause of Death: Manner of Death:
Toxicology was negative Gunshot wound of head Suicide

CASE 2:
History:
- 28 year old female, ingested fifty to sixty 325mg acetaminophen pills
- Taken to hospital
- Died the third day of stay

Autopsy Findings:
- Grossly, liver was congested with nutmeg appearance
- Microscopic liver showed fulminant centrilobular coagulative necrosis of hepatocytes
- Ballooning degeneration and pyknosis of periportal hepatocytes. (Figures 3 & 4)
- Lungs with early bronchopneumonitis

Toxicology Results: Cause of Death: Manner of Death:
Acetaminophen - 45.5 µg/mL Acetaminophen toxicity Suicide
Cannabinoids with massive liver necrosis

REFERENCES:
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Poster Presentation

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Forensic Epidemiology of Child Homicide Deaths by Their Mother’s Partner: How Soon After "First Contact" Do These Deaths Most Often Occur?

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Forensic Epidemiology of Child Homicide Deaths by Their Mothers Partner: How Soon After "First Contact" Do These Deaths Most Often Occur?

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Introduction: Non-biologically related males are the most likely perpetrators of homicidal violence against small children. The primary aim of this study is to examine the time interval between first extended contact and the death of the child. First extended contact is defined as the first time interval from the perpetrator “baby sat” the child or when the time the perpetrator moved in with the decedent and mother, to the time of homicidal violence. Secondary aims are to correlate other characteristics of the perpetrator, custodial parent and victim in order to develop possible predictive criteria for earlier social worker intervention or enhanced surveillance.

Methods: The coroners office database was examined for records of child homicides from which victim data (age, sex, race and cause of death) was recovered. The associated child protective services (CPS) reports were examined for the following additional characteristics: history of prior CPS contact, whether the biologic parent was charged, age, sex and race of the perpetrator and biological parent, and length of time the perpetrator had known or lived with the child and when the child was killed. A person was deemed a perpetrator if they had been charged or convicted with the child's homicide.

Results: Over a period of 14 years, 79 cases of homicides were recovered in children aged 6 years and younger. Of these, there were 15 cases in which both victim, perpetrator and CPS data was recorded. The victims included 12 males and 3 females with an age range of 2 to 61 months. The median age was 22 months. There were 10 white, 4 black, and 1 Hispanic victim. Blunt force trauma to the head was the cause of death in 13 of 15 deaths. The time interval from first contact to death ranged from 14 to 240 days with a median of 75 days. Approximately 80% of all victims were killed within 90 days. Just over a third (6/15) had prior CPS contact.

All the perpetrators were male who ranged from 18 to 34 years in age with median of 28 years. Out of the fifteen, 10 were white and 4 black, and 1 was Hispanic. All were charged with or convicted of some form of homicide.

In all cases, the female biological parent had custody of the decedent at the time of death and ranged in age from 16 to 30 years in age with a median age of 22.5 years. Out of the fifteen, 11 were white, 2 were black, 1 was biracial, and 1 was Hispanic.

Conclusion: Young children are most likely to be killed within 90 days of first extended contact with non-biologically related male. Most victims were male and blunt force trauma to the head was the leading cause of death.
Unusual Diastatic Separation of the Sagittal Sinus of a Stillbirth: Avoiding Potential Confusion with Inflicted Head Trauma

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Unusual Diastatic Separation of the Saggital Sinus of a Stillbirth: Avoiding Potential Confusion with Inflicted Head Trauma

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INTRODUCTION:

Determining the etiology of a skull fracture is important to exclude inflicted head trauma. In newborns these are often associated with instrument delivery and are typically depressed skull fractures. Diastatic skull fractures occur along suture lines and are almost always seen in infants and children. They occur following impact on a blunt surface, including falls, motor vehicle collisions and inflicted head trauma. The case presented concerns a stillborn with widely diastatic fractures not typically seen in birth trauma. The findings were concerning for inflicted trauma which prompted an additional review of the clinical/social history and physical findings in order to exclude inflicted trauma.

CASE SUMMARY AND DISCUSSION:

The decedent was a macerated still born male delivered after 40 weeks gestation. The mother had complained about not sensing fetal movements for about 24 hours prior to presentation. Her most recent antenatal visit 3 days earlier was unremarkable. The mother is obese (BMI of 40.8). Labour was induced with oxytocin and artificial rupture of membranes after ultrasound confirmation of fetal demise. Delivery was spontaneous and vaginal after labour of approximately 11 hours with vertex presentation. There were no cord anomalies.

A post-mortem examination was conducted approximately 30 hours after delivery. The body was moderately macerated with multiple areas of skin slippage. No gross anomalies were identified. Radiologic examination showed excessive molding of the skull bones. There were no bony anomalies.

On internal examination, the skull bones are widely separated and there were marked galeal and subgaleal hematomas. The brain weighed 366 gm and was remarkable only for meningeal congestion. Cut surfaces were unremarkable. There were no basal skull fractures or any injuries to other parts of the fetus. The placenta weighed < 10th percentile for age and no infection or other anomalies were noted on microscopic examination. Fetal demise is estimated to have occurred within 24 to 48 hours. The mother denied any abdominal trauma (intentional or accidental). Medical record review showed no reports of domestic violence, or involvement with social or police services.

CONCLUSION: Head trauma and skull fractures are common in many newborns and still births even without instrument assistance. When the pattern of fractures is unusual especially in a death that has preceded arrival to hospital, a thorough investigation of the circumstances is required to exclude inflicted trauma to the mother. In this case the absence of a history of or physical evidence of maternal trauma, the fact that the fetus had been alive for up to 2-3 days prior, the lack of any social history of domestic abuse or contact with law enforcement and the presence of moderate fetal maceration and the lack of other fetal injuries are all consistent with birth trauma.