Brief Outline of Partial Selected CEW Research and Information[1,2,3,4]

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[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.

[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).

[3] This document specifically supersedes, nullifies, and obsoletes any prior draft or version of this document.

[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.

TABLES

FIGURES

Selected CEW Misconceptions Papers

1. (12/2014 Jauchem) J. R. Jauchem, "TASER conducted electrical weapons: misconceptions in the scientific/medical and other literature," *Forensic Sci Med Pathol*, Dec 31 2014.

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

    b. "Key points:

        i. The scientific/medical and other literature contains many misconceptions regarding the use of conducted electrical weapons (CEWs) during law-enforcement operations.

        ii. Durations of incapacitating effects and possible associations of CEWs with deaths-in-custody have often been overstated or exaggerated.

        iii. Assumptions that all uses of CEWs constitute excessive force or torture are misleading and unwarranted.

        iv. Clarification of these and other misconceptions may be important during policymaker decisions, practitioner operations, expert witness testimonies, and court proceedings. Scientists, medical professionals, legal advisors, and investigators of police tactics should be aware of these misconceptions."

Selected CEW Treatises, Organization Position and Review Papers

Selected CEW Treatises:

Table 1 Selected CEW Treatises

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

1. (02/2012 Ho) Atlas of Conducted Electrical Weapon Wounds and Forensic Analysis. Edited by Jeffrey D. Ho, Donald M. Dawes, and Mark W. Kroll, Springer Science Business Media. June 2012.

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

3. (04/2008 Williams) TASER ELECTRONIC CONTROL DEVICES AND SUDDEN IN-CUSTODY DEATH: Separating Evidence from Conjecture, By Howard E. Williams. C C Thomas 2008. 226 pp.

Selected Treatise CEW Chapters:

Table 2 Selected Treatise CEW Chapters

No.	Date	Title
1	Sep. 2011	Chapter 8: TASER Conducted Electrical Weapons, Clinical Forensic Medicine: A Physician's Guide. 3rd Edition
2	Apr. 2011	Chapter 10: Electric Stun Devices and Electric Shock, Electric Stun Devices and Electric Shock. In: Electrostimulation: Theory, Applications, and Computational Model
3	Feb. 2009	Chapter 42: TASER Electronic Control Devices, Electrical Injuries: Medical and Bioengineering Aspects, Second Edition

1. (09/2011 Stark/Kroll) Clinical Forensic Medicine: A Physician's Guide. 3rd Edition. Edited by Stark, M. Springer Science+Business Media, LLC. Sept 2011;(8):233–275. Chapter 8: TASER Conducted Electrical Weapons.

2. (04/2011 Reilly) Reilly P, Diamont AM. Electric Stun Devices and Electric Shock. In: Electrostimulation: Theory, Applications, and Computational Model. Artech House. 2011;(10):155–198. [Chapter 10: Electric Stun Devices and Electric Shock, pages 155–198]

3. (02/2009 Fish/Kroll) Electrical Injuries: Medical and Bioengineering Aspects, Second Edition, Edited by Raymond M. Fish and Leslie A. Geddes, Lawyers & Judges Publishing Company, Inc. Chapter 42: TASER Electronic Control

Devices.

Selected CEW Organization White Papers/Statements:

Table 3 Selected CEW Organization White Papers/Statements

No.	Date	Title	
1	Oct. 2013	Canada:	Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.
2	Oct. 2013	Canada:	Hall, C. 2013. RESTRAINT[5]. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.
3	May 2011	AAEM:	Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician
4	May 2011	NIJ:	Study of Deaths Following Electro Muscular Disruption
5	Mar. 2011	PERF/DOJ:	2011 Electronic Control Weapon Guidelines
6	Apr. 2010	IACP:	Electronic Control Weapons, Concepts and Issues Paper
7	Jun. 2009	AMA:	Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D)
8	Jun. 2008	NIJ:	Study of Deaths Following Electro Muscular Disruption: Interim Report

1. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

2. (10/2013 Hall) Hall, C. 2013. RESTRAINT[6]. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

3. (05/2011 AAEM-Vilke) Vilke GM, Bozeman WP, Chan TC. Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. J Emerg Med. May 2011;40(5):598–604.

4. (05/2011 NIJ-Laub) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

5. (03/2011 PERF/DOJ) 2011 Electronic Control Weapon Guidelines, Police Executive Research Forum (PERF) and Community Oriented Policing Services, U.S. Department of Justice (DOJ).

6. (04/2010 IACP) Electronic Control Weapons, Concepts and Issues Paper,

[5] RESTAINT stands for "Risk of dEath in Subjects That Resist: Assessment of Incidence and Nature of fAtal events."

[6] RESTAINT stands for "Risk of dEath in Subjects That Resist: Assessment of Incidence and Nature of fAtal events."

International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, April 2010.

7. (06/2009 AMA-Robinowitz) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

8. (06/2008 Hagy/NIJ) Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. US Dept of Justice. Office of Justice Programs. June 2008.

Selected Primary CEW Review Papers:

Table 4 Selected Primary CEW Review Papers

No.	Date	Title
1	Jan. 2014	Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]
2	Oct. 2013	Hall, C. 2013. RESTRAINT. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.
3	Oct. 2013	Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.
4	Jun. 2013	Levy, K. 2013. Multiple and prolonged Taser deployments. Crime and Misconduct Commission (CMC). Brisbane, Queensland, Australia. June 2013.
5	Dec. 2012	Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.
6	Mar. 2012	Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans- A review of current literature. Forensic Sci Int. 221 (2012) 1–4. [Mar 2012;Epub].
7	Jan. 2012	United Kingdom Defence Scientific Advisory Council. DSAC Sub-Committee on the Medical Implications of Less-lethal Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).
8	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.
9	May 2011	Pasquier, M. Electronic Control Device Exposure - A Review of Morbidity and Mortality. Annals of Emergency Medicine May 2011.
10	May 2011	Vilke GM, Bozeman WP, Chan TC. Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. J Emerg Med. May 2011;40(5):598-604.
11	Oct. 2010	Choudhary, R., Sabri, I. Review Paper: Taser Technology: Medical, Legal, Ethical & Social Implications of Introduction of Taser Gun in India. *J Indian Acad Forensic Med*, 32(4).
12	Aug. 2010	Adler, A., David, D.P., Yasheng, M. 2010. Biomedical research literature with respect to the effects of Conducted Energy Weapons. August 1, 2010.

No.	Date	Title
13	Jan. 2009	Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.
14	Jun. 2008	Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. Office of Justice Programs, National Institute of Justice, United States Department of Justice. June 2008.
15	Nov. 2007	Bovbjerg VE, Kelly JM, Heal CS, Murray WB. Field-based Evaluation of Non-lethal Weapons: Conducted Energy Weapons. NTIC. 2007. See also, Kenny J, Bovbjerg V, Heal C. Los Angeles Sheriff's Department's Use of M26 and X26 TASERs During the 1995–2004 Timeframe (Draft): Penn State Applied Research Laboratory. August 25 2008.
16	2006	Wilkinson D. Supplement to HOSDB Evaluations of Taser Devices. Home Office Scientific and Development Branch (HOSDB), United Kingdom.
17	Mar. 2005	Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.
18	Mar. 2005	Wilkinson, D.I. 2005. PSDB Further Evaluation of Taser Devices, Publication No. 19/05. Home Office, Police Scientific Development Branch, United Kingdom.
19	Jun. 2004	Maier A, Nance P, Price P, Sherry C, Reilly J. Human Effects Center of Excellence Human Effects and Risk Characterization of the Electromuscular Disruption Device – TASER Part 1 Technical Report. HECOE. Jun 2004.
20	Mar. 2004	Bleetman A, Steyn R, Lee C. Introduction of the Taser into British policing. Implications for UK emergency departments: an overview of electronic weaponry. Emerg Med J. Mar 2004;21(2):136–140.

1. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? *Circulation*. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

2. (10/2013 Hall) Hall, C. 2013. RESTRAINT. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

3. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

4. (06/2013 Levy) Levy, K. 2013. Multiple and prolonged Taser deployments. Crime and Misconduct Commission (CMC). Brisbane, Queensland, Australia. June 2013.

5. (12/2012 Adedipe) Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.

6. (03/2012 Kunz) Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans- A review of current literature. Forensic Sci Int. 221 (2012) 1–4. [Mar 2012;Epub].

7. (01/2012 UK DSAC DOMILL) 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 Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).

8. (05/2011 NIJ-Laub) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

9. (05/2011 Pasquier) Pasquier, M. Electronic Control Device Exposure – A Review of Morbidity and Mortality. Annals of Emergency Medicine May 2011.

10. (05/2011 AAEM-Vilke) Vilke GM, Bozeman WP, Chan TC. Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. J Emerg Med. May 2011;40(5):598-604.

11. (10/2010 Choudhary) Choudhary, R., Sabri, I. Review Paper: Taser Technology: Medical, Legal, Ethical & Social Implications of Introduction of Taser Gun in India. *J Indian Acad Forensic Med*, 32(4).

    a. "**Conclusion:** Thus we can say that introduction of Taser gun has got minimum medical dangers, least legal problems, ethically acceptable and socially sound. By using a Taser a dangerous assailant or violent mob could be controlled, thus preventing any injury or harm to law enforcement officers, innocent citizens, or themselves. This reinforces the value of Taser as a useful tool to make the public and officers safer and to resolve potentially violent situations effectively and rapidly. To conclude we‟ll say Taser is a proportionate, low risk means of resolving incidents where the public or officers face severe violence or the threat of such violence which cannot safely be dealt with by other means."

12. (08/2010 Adler) Adler, A., David, D.P., Yasheng, M. 2010. Biomedical research literature with respect to the effects of Conducted Energy Weapons. August 1, 2010.

13. (01/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

14. (06/2008 NIJ-Hagy) Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. Office of Justice Programs, National Institute of Justice, United States Department of Justice. June 2008.

15. (11/2007 Bovjerg) Bovbjerg VE, Kelly JM, Heal CS, Murray WB. Field-based Evaluation of Non-lethal Weapons: Conducted Energy Weapons. NTIC. 2007. See also, Kenny J, Bovbjerg V, Heal C. Los Angeles Sheriff's Department's Use of M26 and X26 TASERs During the 1995–2004 Timeframe (Draft): Penn State Applied Research Laboratory. August 25 2008.

16. (2006 UK/HOSDB-Wilkinson) Wilkinson D. Supplement to HOSDB Evaluations of Taser Devices. Home Office Scientific and Development Branch (HOSDB), United Kingdom.

17. (03/2005 HECOE-Maier) Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.

    a. (03/2005 HECOE/Maier) Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part 2 – APPENDICES: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1 2005.

18. (03/2005 UK/PSDB-Wilkinson) Wilkinson, D.I. 2005. PSDB Further Evaluation of Taser Devices, Publication No. 19/05. Home Office, Police Scientific Development Branch, United Kingdom.

19. (06/2004 HECOE-Maier) Maier A, Nance P, Price P, Sherry C, Reilly J. Human Effects Center of Excellence Human Effects and Risk Characterization of the Electromuscular Disruption Device – TASER Part 1 Technical Report. HECOE. Jun 2004.

    a. (06/2004 HECOE-Maier) HECOE/Maier) Maier A Nance P, Price P, Sherry C, Reilly J. Human Effects Center of Excellence Human Effects and Risk Characterization of the Electromuscular Disruption Device – TASER Part 2 Appendices. HECOE. Jun 2004.

20. (03/2004 UK-Bleetman) Bleetman A, Steyn R, Lee C. Introduction of the Taser into British policing. Implications for UK emergency departments: an overview of electronic weaponry. *Emerg Med J.* Mar 2004;21(2):136–140.

Selected CEW Survey Papers:

1. (12/2014 Jauchem) J. R. Jauchem, "Exposures to Conducted Electrical Weapons (Including TASER Devices): How Many and for How Long are Acceptable?," *J Forensic Sci*, Nov 28 2014.

Selected Autopsy/Forensic Pathology CEW-Related Papers:

1. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "**ABSTRACT:** The investigation of a death that occurs in custody requires a careful and methodical approach since concerns of police or institutional misconduct may be raised. The medicolegal official charged with the investigation and ultimate certification of death bears heavy responsibility to the decedent's family, the public, law enforcement and other institutions. A wide variety of causes of death and manners of death are seen in these deaths. This paper reviews causes, mechanisms, manners, findings, and evaluation of persons who have died in temporal relation to legal apprehension."

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

Table 5 Selected CEW-Temporal Arrest-Related Death (ARD) Review Papers

No.	Date	Title
1	Jan. 2015	Hall C, Votova K, Heyd C, Walker M, MacDonald S, Eramian D, Vilke GM, Restraint in police use of force events: Examining sudden in custody death for prone and not-prone positions, *Journal of Forensic and Legal Medicine* (2015), doi: 10.1016/j.jflm.2014.12.007.
2	Jan. 2014	Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? *Circulation*. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]
3	Oct. 2013	Hall, C. 2013. RESTRAINT. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.
4	Dec. 2012	Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.
5	Aug. 2012	White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85–112.
6	Jan. 2012	Hall C, McHale A, Kader A, Stewart L, MacCarthy C, Fick G. Incidence and outcome of prone positioning following police use of force in a prospective, consecutive cohort of subjects. Journal of Forensic and Legal Medicine. Jan 2012:1-7.
7	Sep. 2009	Mash D, Duque L, Pablo J, et al. Brain biomarkers for identifying excited delirium as a cause of sudden death. Foren Sci Intl. 2009.
8	May 2009	Swerdlow, C, Fishbein, M, Chaman, L, Lakkireddy, DR, Tchou, P. Presenting Rhythm in Sudden Deaths Temporally Proximate to Discharge of TASER Conducted Electrical Weapons. Acad Emerg Med. Aug 2009;16(8):726–39.
9	May 2009	Ho J, Heegaard W, Dawes D, et al. Unexpected Arrest Related Deaths in America: 12 Months of Open Source Surveillance. West J Emerg Med. May 2009;10(2):68–73.
10	May 2001	Stratton S, Rogers C, Brickett K, Gruzinski G. Factors Associated With Sudden Death of Individuals Requiring Restraint for Excited Delirium. AJEM. 2001;19(3):(187–191).

1. (01/2015 Hall) Hall C, Votova K, Heyd C, Walker M, MacDonald S, Eramian D, Vilke GM, Restraint in police use of force events: Examining sudden in custody death for prone and not-prone positions, *Journal of Forensic and Legal Medicine* (2015), doi: 10.1016/j.jflm.2014.12.007.

    a. "Conducted Energy Weapon Use As part of the standard use of force reports, officers were required to document every use of a conducted energy weapon (CEW). The CEW used by all participating agencies was the Taser©. Data collected involving a CEW included whether the laser sight was displayed, the number of deployments, the mode of weapon (drive/contact/push stun, probe or a combination) and the number of trigger pulls."

2. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal?

Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

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.

3. (10/2013 Hall) Hall, C. 2013. RESTRAINT. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

4. (12/2012 Adedipe) Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.

5. (08/2012 White) White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85–112.

   a. Dawes, D.M., How, J.D., White, M. 2013. An incident-level profile of TASER device deployments in Arrest-Related Deaths (ARDs). (2013), Australasian College for Emergency Medicine 29th Annual Scientific Meeting, 19–22 November 2012, Hobart, Australia. Emergency Medicine Australasia, 25: 15–17. doi: 10.1111/1742-6723.12071.

6. (01/2012 Hall) Hall C, McHale A, Kader A, Stewart L, MacCarthy C, Fick G. Incidence and outcome of prone positioning following police use of force in a prospective, consecutive cohort of subjects. Journal of Forensic and Legal Medicine. Jan 2012:1-7.

7. (09/2009 Mash) Mash D, Duque L, Pablo J, et al. Brain biomarkers for identifying excited delirium as a cause of sudden death. Foren Sci Intl. 2009.

   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).”

8. (05/2009 Swerdlow) Swerdlow, C, Fishbein, M, Chaman, L, Lakkireddy, DR, Tchou, P. Presenting Rhythm in Sudden Deaths Temporally Proximate to Discharge of TASER Conducted Electrical Weapons. Acad Emerg Med. Aug 2009;16(8):726–39.

   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.”

      (1) (GA) Gresmond Gray Autopsy Report (CASE: 2004·1028709):

         (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. …”

9. (05/2009 Ho) Ho J, Heegaard W, Dawes D, et al. 2009. Unexpected Arrest Related Deaths in America: 12 Months of Open Source Surveillance. West J Emerg Med. May 2009;10(2):68–73.

    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."

10. (05/2001 Stratton) Stratton S, Rogers C, Brickett K, Gruzinski G. 2001. Factors Associated With Sudden Death of Individuals Requiring Restraint for Excited Delirium. AJEM. 2001;19(3):(187–191).

    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

No.	Date	Title
1	Jan. 2015	Hall C, Votova K, Heyd C, Walker M, MacDonald S, Eramian D, Vilke GM, Restraint in police use of force events: Examining sudden in custody death for prone and not-prone positions, *Journal of Forensic and Legal Medicine* (2015), doi: 10.1016/j.jflm.2014.12.007.
2	Oct. 2013	Hall, C. 2013, RESTRAINT. 2013. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.
3	Aug. 2012	White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. 2012. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85-112.
4	May 2012	Bozeman W, Teacher E, Winslow J. 2012. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j.jemermed.2012.03.022.
5	May 2009	Swerdlow, C, Fishbein, M, Chaman, L, Lakkireddy, DR, Tchou, P. 2009. Presenting Rhythm in Sudden Deaths Temporally Proximate to Discharge of TASER Conducted Electrical Weapons. Acad Emerg Med. Aug 2009;16(8):726–39.

1. (01/2015 Hall) Hall C, Votova K, Heyd C, Walker M, MacDonald S, Eramian D, Vilke GM, Restraint in police use of force events: Examining sudden in custody death for prone and not-prone positions, *Journal of Forensic and Legal Medicine* (2015), doi: 10.1016/j.jflm.2014.12.007.

    a. "Conducted Energy Weapon Use As part of the standard use of force reports, officers were required to document every use of a conducted energy weapon (CEW). The CEW used by all participating agencies was the Taser©. Data collected involving a CEW included whether the laser sight was displayed, the number of deployments, the mode of weapon (drive/contact/push stun, probe or a combination) and the number of trigger pulls."

2. (10/2013 Hall) Hall, C. 2013. RESTRAINT. 2013. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

    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.

3. (08/2012 White) White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. 2012. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85-112.

   a. White found that only 36% (57/158) of ECD-involved arrest-related deaths had a chest probe (p = 0.004 by chi-square).

4. (05/2012 Bozeman) Bozeman W, Teacher E, Winslow J. 2012. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j.jemermed.2012.03.022.

   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."

5. (05/2009 Swerdlow) Swerdlow, C, Fishbein, M, Chaman, L, Lakkireddy, DR, Tchou, P. 2009. Presenting Rhythm in Sudden Deaths Temporally Proximate to Discharge of TASER Conducted Electrical Weapons. Acad Emerg Med. Aug 2009;16(8):726–39.

Cardiac – Selected CEW Medical/Scientific Literature

CEW Adverse Cardiac Events Inconclusive or Controversial

No.	Date	Lead Author	CEW VF Risk
1	Feb. 2015	Havranek	"Existing data concerning adverse cardiac events of EMD including incidental deaths are still inconclusive. …"
2	Nov. 2014	Graham	"Whether or not an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial" "If an ECD can induce VF in a human adult, it must be a very rare event. Although the issue as to whether an ECD under normal use conditions has caused the death of a human has not been definitively settled, there does seem to be general agreement that such an event, if it happens, is rare."
	Jun. 2014	Dawes	In this swine study setting, the probability of VF is no more than 0.69 % (95 % CI 0.018–3.8 %). Among exposures with capture, the probability of VF in this study setting is no more than 1.6 % (95 % CI 0.040–8.5 %).
3	Jan. 2014	Kroll	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.
4	Oct. 2013	Canada	no "confirmation or exclusion of a clear causal link"
5	Mar. 2013	Dawes	no more than 0.59% (even with cardiac capture)
6	Aug. 2012	White	disproving the hypothesis that a CEW application anywhere on the chest presents a risk of VF
7	May 2012	Bozeman	0.0–0.6
8	Nov. 2011	Kroll	1:2,500,000 (theoretical VF risk estimate)
9	May 2010	Michaud	"When put together, the results of those studies suggest that TASER-induced VF is possible, but it is a rare phenomenon that is probably not electrically induced."

1. (02/2015 Havranek) Havranek, S., P. Neuzil, and A. Linhart, Electromuscular Incapacitating Devices Discharge and Risk of Severe Bradycardia. *Am J Forensic Med Pathol*, 2015.

    a. "Existing data concerning adverse cardiac events of EMD including incidental deaths are still inconclusive. …"

2. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "Whether or not an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial" (page 381).

    b. "If an ECD can induce VF in a human adult, it must be a very rare event. Although the issue as to whether an ECD under normal use conditions has caused the death of a human has not been definitively settled, there does seem to be general agreement that such an event, if it happens, is rare." (page 382).

3. (06/2014 Dawes) Dawes, D., Ho, J., Moore, J., Laudenbach, A., Reardon, R., Miner, J. An evaluation of two conducted electrical weapons using a swine comparative cardiac safety model. *Forensic Sci Med Pathol*. June 2014.

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

    b. Among exposures with capture, the probability of VF in this study setting is no more than 1.6 % (95 % CI 0.040–8.5 %).

4. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

    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.

5. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

    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).

6. (05/2010 Michaud) A. Michaud and J. Y. Dupuis, "Echocardiographic evaluation of TASER X26 in healthy volunteers," *Am J Emerg Med*, vol. 28, pp. 521-3, May 2010.

a. "When put together, the results of those studies suggest that TASER-induced VF is possible, but it is a rare phenomenon that is probably not electrically induced." Page 521.

Ability to Cause Cardiac is not Equivalent to Ability to Induce VF

1. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "The ability to cause cardiac capture is not equivalent to the ability to induce VF. The threshold for cardiac capture associated with five second ECD discharge cycle exceeds the VF threshold by a factor of three to four. Thus, the risk of VF is substantially lower than the risk of cardiac capture."

Table 5: Mechanisms of Electrically-Induced Ventricular Fibrillation (107)

Mechanism	Duration	Requisite Current
Shock on T	1-10 msec	Very strong
Direct induction	1-5 sec	Strong
High rate capture-induced ischemia	90-300 sec	Weak

CEW Does not Electrically Induce PEA or Asystole

1. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "A variety of studies, including some involving testing of implanted defibrillators (ICD), indicate that VF occurs within one to five seconds of discharge, pulseless electrical activity (PEA) or asystole is not induced, pulse is lost within seconds, consciousness is lost within 5-15 seconds, and agonal breathing begins soon thereafter (107, 114) (Table 6)."

Table 6: Features of Direct Induction of Ventricular Fibrillation (VF) by Electricity (114)	
1.	VF induced within 1-5 seconds or induction does not occur
2.	Pulseless electrical activity (PEA) or asystole is not induced
3.	Loss of pulse within seconds
4.	Loss of consciousness within 5-15 seconds
5.	High probability of successful defibrillation

Probability of CEW Induced Ventricular Fibrillation:

Table 7 Probability of CEW Induced Ventricular Fibrillation

No.	Date	Lead Author	CEW VF Risk
1	Aug. 2015	Panescu	“The overall theoretical VF risk [for 9 mm darts] was estimated not to exceed 1 in 2,873,147, consistent with epidemiological CEW statics. Given their reduced output delivered charge levels, newer CEW models, such as TASER X26P and X2 CEWs, are expected to pose even lower cardiac risk.”
1	Nov. 2014	Graham	“Whether or not an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial”
2	Jan. 2014	Kroll	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.
3	Oct. 2013	Canada	no “confirmation or exclusion of a clear causal link”
4	Mar. 2013	Dawes	no more than 0.59% (even with cardiac capture)
5	Aug. 2012	White	disproving the hypothesis that a CEW application anywhere on the chest presents a risk of VF
6	May 2012	Bozeman	0.0–0.6
7	Nov. 2011	Kroll	1:2,500,000 (theoretical VF risk estimate)

1. (08/2015 Panescu) Panescu, D., Kroll, M., and Brave, M. Cardiac Fibrillation Risks with TASER Conducted Electrical Weapons, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 323-329.

    a. Panescu, D., Kroll, M., and Brave, M. Cardiac Fibrillation Risks with TASER Conducted Electrical Weapons, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 323-329, PowerPoint, August 26, 2015.

    b. “Conclusions—While not risk-free, the use of TASER X26 CEWs implies an extremely low cardiac risk profile.”

    c. “CONCLUSIONS: To-date, there has been no undisputed medical evidence linking causation of VF to use of TASER X26 CEWs. In general, CEWs should not be considered risk-free force options. However, the use of TASER X26 CEWs implies an extremely low cardiac risk profile. The overall theoretical VF risk was estimated not to exceed 1 in 2,873,147, consistent with epidemiological CEW statics. Given their reduced output delivered charge levels, newer CEW models, such as TASER X26P and X2 CEWs, are expected to pose even lower cardiac risk.”

2. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. “Whether or not an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial” (page 381).

b. “If an ECD can induce VF in a human adult, it must be a very rare event. Although the issue as to whether an ECD under normal use conditions has caused the death of a human has not been definitively settled, there does seem to be general agreement that such an event, if it happens, is rare.” (page 382).

3. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

   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.

4. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

   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).

5. (03/2013 Dawes) Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.[7]

[7] [Also see: Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013; and, Dawes, D.M. 2013. Lightening Oral Presentation #547. An Evaluation of Two Electronic Control Devices Using a Swine Comparative Cardiac Safety Model. Society for Academic Emergency Medicine (SAEM), Atlanta, GA. May 17, 2013.]

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 %.”[8]

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 %).”

6. (08/2012 White) White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. 2012. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85-112.

    a. White found that only 36% (57/158) of ECD-involved arrest-related deaths had a chest probe (p = 0.004 by chi-square).

7. (05/2012 Bozeman) Bozeman W, Teacher E, Winslow J. 2012. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. J Emerg Med. 2012;43:970–975.

    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.”

8. (09/2011 Kroll) Kroll M, Lakkireddy D, Rahko P, Panescu D. 2011. Ventricular Fibrillation Risk Estimation for Conducted Electrical Weapons: Critical Convolutions. EMBS. IEEE International Conference; Sept 2011:271–277.

[8] Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013.

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.”

Prospective CEW Human Cardiac Studies:

Table 8 Prospective CEW Human Cardiac Studies

No.	Date	Document
1	Feb. 2015	Havranek, S., P. Neuzil, and A. Linhart, Electromuscular Incapacitating Devices Discharge and Risk of Severe Bradycardia. Am J Forensic Med Pathol, 2015.
2	Dec. 2011	VanMeenen K, Lavietes M, Cherniack N. Respiratory and Cardiovascular Response During Electronic Control Device (ECD) Exposure in Law Enforcement Trainees. National Criminal Justice Reference Service.
3	Jun. 2010	Moscati R, Ho JD, Dawes DM, Miner JR. Physiologic effects of prolonged conducted electrical weapon discharge in ethanol-intoxicated adults. Am J Emerg Med. Jun 2010;28(5):582–587.
4	May 2010	Ho JD, Dawes DM, Reardon RF, et al. Human cardiovascular effects of a new generation conducted electrical weapon. Forensic Sci Int. May 26 2010.
5	Mar. 2010	Dawes DM, Ho JD, Kroll MW, Miner JR. Electrical characteristics of an electronic control device under a physiologic load: a brief report. Pacing Clin Electrophysiol. Mar 2010;33(3):330–336.
6	Jan. 2010	Dawes DM, Ho JD, Reardon RF, Miner JR. Echocardiographic evaluation of TASER X26 probe deployment into the chests of human volunteers. Am J Emerg Med. Jan 2010;28(1):49–55.
7	Jul. 2009	Bozeman W, Barnes D, Winslow J, et al. Immediate cardiovascular effects of the Taser X26 conducted electrical Weapon. Emerg Med J. 2009;26(8):567–570.
8	May 2009	Ho JD, Dawes DM, Heegaard WG, Calkins HG, Moscati RM, Miner JR. Absence of electrocardiographic change after prolonged application of a conducted electrical weapon in physically exhausted adults. J Emerg Med. May 12 2009.
9	Sep. 2008	Ho JD, Dawes DM, Reardon RF, et al. Echocardiographic evaluation of a TASER-X26 application in the ideal human cardiac axis. Acad Emerg Med. Sep 2008;15(9):838–844.
10	Jan. 2008	Vilke G, Sloane C, Levine S, Neuman T, Castillo E, Chan TC. Twelve-lead electrocardiogram monitoring of subjects before and after voluntary exposure to the Taser X26. Am J Emerg Med. Jan 2008;26(1):1–4.
11	Dec. 2007	Vilke G, Sloane C, Levine S, et al. Does the Taser Cause Electrical Changes in Twelve Lead ECG Monitoring of Human Subjects. Acad Emerg Med 2007;14(5):104.
12	Sep. 2007	Ho J, Reardon RF, Dawes DM, Johnson MA, Miner JR. Ultrasound Measurement of Cardiac Activity During Conducted Electrical Weapon Application in Exercising Adults. Ann Emerg Med. Sep 2007;50(3)s108.
13	Dec. 2007	Ho J, Reardon R, Dawes DM, Johnson M, Miner J. Ultrasound Measurement Of Cardiac Activity During Conducted Electrical Weapon Application In Exercising Adults: Fourth Mediterranean Emergency Medicine Congress (MEMC IV); 2007.
14	Dec. 2007	Ho J, Dawes D, Calkins H, Johnson M. Absence of Electrocardiographic Change Following Prolonged Application of a Conducted Electrical Weapon in Physically Exhausted Adults. Acad Emerg Med 2007;14(5):128–129.
15	Dec. 2007	Ho J, Dawes D, Bultman L, et al. Respiratory Effect of Prolonged Electrical Weapon Application on Human Volunteers. Acad Emerg Med. Mar 2007;14(3):197-201.
16	Jun. 2007	Levine SD, Sloane CM, Chan TC, Dunford JV, Vilke GM. Cardiac monitoring of human subjects exposed to the Taser. J Emerg Med. 2007 Aug;33(2):113-7. Epub 2007 Jun 13.
17	Jun. 2006	Ho J, Miner J, Lakkireddy D, Bultman L, Heegaard W. Cardiovascular and physiologic effects of conducted electrical weapon discharge in resting adults. Acad Emerg Med. Jun 2006;13(6):589–595.

1. (02/2015 Havranek) Havranek, S., P. Neuzil, and A. Linhart, Electromuscular Incapacitating Devices Discharge and Risk of Severe Bradycardia. Am J Forensic Med Pathol, 2015.

   a. “Existing data concerning adverse cardiac events of EMD including incidental deaths are still inconclusive. …”

   b. “CONCLUSIONS: Standard [electromuscular incapacitating devices (“EMD”)] exposure was not associated with any clinically relevant ECG changes except the significant sinus tachycardia in the majority of subjects and the new onset of frequent [supraventricular premature beats (“SPB”)] in 1 case, which was possibly induced by stress reaction due to stun gun shock. The observation of the 2 extraordinary cases in which the EMD discharge induced a brief but profound bradycardia possibly related to vagal stimulation by holding breath and muscular contraction is of particular importance. The new [microvolt T-wave alternans (“MTWA”)] positivity detected in 2 of the 21 subjects after the EMD exposure may be caused by its direct effect on the myocardium or by sympathetic activation induced by stress, pain, and anger related to the procedure but may be also caused by a potential false positivity of MTWA assessment.”

2. (12/2011 VanMeenen) VanMeenen K, Lavietes M, Cherniack N, Bergen M, Teichman R, Servatius R. 2011. Respiratory and Cardiovascular Response During Electronic Control Device (ECD) Exposure in Law Enforcement Trainees. National Criminal Justice Reference Service. Dec 2011: 1–33.

   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.”

3. (06/2010 Moscati) Moscati R, Ho JD, Dawes DM, Miner JR. 2010. Physiologic effects of prolonged conducted electrical weapon discharge in ethanol-intoxicated adults. Am J Emerg Med. Jun 2010;28(5):582–587.

   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.”

4. (05/2010 Ho) Ho JD, Dawes DM, Reardon RF, et al. 2010. Human cardiovascular effects of a new generation conducted electrical weapon. Forensic Sci Int. May 26 2010. (Shot with ECD deployed probes.)

    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."

5. (03/2010 Dawes) Dawes DM, Ho JD, Kroll MW, Miner JR. 2010. Electrical characteristics of an electronic control device under a physiologic load: a brief report. Pacing Clin Electrophysiol. Mar 2010;33(3):330–336.

    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."

6. (01/2010 Dawes) Dawes DM, Ho JD, Reardon RF, Miner JR. 2010. Echocardiographic evaluation of TASER X26 probe deployment into the chests of human volunteers. Am J Emerg Med. Jan 2010;28(1):49–55. (Shot with ECD deployed probes.)

    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."

7. (07/2009 Bozeman) Bozeman W, Barnes D, Winslow J, et al. 2009. Immediate cardiovascular effects of the Taser X26 conducted electrical Weapon. Emerg Med J. 2009;26(8):567–570.

    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."

8. (05/2009 Ho) Ho JD, Dawes DM, Heegaard WG, Calkins HG, Moscati RM, Miner JR. 2009. Absence of electrocardiographic change after prolonged application of

a conducted electrical weapon in physically exhausted adults. J Emerg Med. May 12 2009.

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."

9. (09/2008 Ho) Ho JD, Dawes DM, Reardon RF, et al. 2008. Echocardiographic evaluation of a TASER-X26 application in the ideal human cardiac axis. Acad Emerg Med. Sep 2008;15(9):838–844.

    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."

10. (01/2008 Vilke) Vilke G, Sloane C, Levine S, Neuman T, Castillo E, Chan TC. 2008. Twelve-lead electrocardiogram monitoring of subjects before and after voluntary exposure to the Taser X26. Am J Emerg Med. Jan 2008;26(1):1–4.

    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."

11. (12/2007 Vilke) Vilke G, Sloane C, Levine S, et al. 2007. Does the Taser Cause Electrical Changes in Twelve Lead ECG Monitoring of Human Subjects. Acad Emerg Med 2007;14(5):104.

12. (12/2007 Ho) Ho J, Reardon R, Dawes DM, Johnson M, Miner J. 2007. Ultrasound Measurement Of Cardiac Activity During Conducted Electrical Weapon Application In Exercising Adults: Fourth Mediterranean Emergency Medicine Congress (MEMC IV); 2007.

13. (12/2007 Ho) Ho J, Dawes D, Calkins H, Johnson M. 2007. Absence of Electrocardiographic Change Following Prolonged Application of a Conducted Electrical Weapon in Physically Exhausted Adults. Acad Emerg Med 2007;14(5):128–129.

    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."

14. (12/2007 Ho) Ho J, Dawes D, Bultman L, et al. 2007. Respiratory Effect of Prolonged Electrical Weapon Application on Human Volunteers. Acad Emerg Med. Mar 2007;14(3):197–201.

15. (09/2007) Ho J, Reardon RF, Dawes DM, Johnson MA, Miner JR. 2007. Ultrasound Measurement of Cardiac Activity During Conducted Electrical Weapon Application in Exercising Adults. Ann Emerg Med. Sep 2007;50(3)s108.

    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."

16. (06/2007 Levine) Levine SD, Sloane CM, Chan TC, Dunford JV, Vilke GM. 2007. Cardiac monitoring of human subjects exposed to the Taser. J Emerg Med. 2007 Aug;33(2):113–7. Epub 2007 Jun 13.

    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."

17. (06/2006 Ho) Ho J, Miner J, Lakkireddy D, Bultman L, Heegaard W. 2006. Cardiovascular and physiologic effects of conducted electrical weapon discharge in resting adults. Acad Emerg Med. Jun 2006;13(6):589–595.

    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

No.	Date	Document
1	Apr. 2013	Becour, B. 2013. Conducted Electrical Weapons or Stun Guns A Review of 46 Cases Examined in Casualty. Am J Forensic Med Pathol & Volume 00, Number 00, Month 2013.
2	Dec. 2012	Gardner, A.R., Hauda, W.E. 2nd, Bozeman, W.P. 2012. Conducted Electrical Weapon (TASER) Use Against Minors: A Shocking Analysis. Pediatr Emerg Care. 2012 Aug 27.
3	May 2012	Bozeman W, Teacher E, Winslow J. 2012. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j. jemermed.2012.03.022.
4	Mar. 2012	Becour B. Les armes a impulsion electrique: a propos de 42 cas examines aux Urgences. 2012. Medleg. Mar 2012
5	Dec. 2009	Strote J, Walsh M, Angelidis M, Basta A, Hutson HR. 2009. Conducted electrical weapon use by law enforcement: an evaluation of safety and injury, J Trauma. May 2010; 68(5):1239–1246.
6	Nov. 2009	Bozeman, W P., Additional Information on TASER [ECD] safety. 2009. Annals of Emergency Medicine, November 2009, Vol. 54, No. 5.
7	Apr. 2009	Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480-489, April 2009.
8	Jun. 2008	Eastman, A.L., et al. 2008. Conductive electrical devices: a prospective, population-based study of the medical safety of law enforcement use, J Trauma, 2008, 64(6): p. 1567–72.
9	Dec. 2006	Strote J, Hutson R. Taser Use in Restraint Related Deaths. 2006. Prehosp Emerg Care. Oct 2006;10(4):447–450.
10	May 2004	McManus, J.G., Forsyth, R.W., Hawks, R.W. 2004. A Retrospective Case Series Describing the Injury Pattern of the Advanced M26 TASER in Multnomah County, OR. ACAD EMERG MED, May 2004, Vol. 11, No. 5, pg. 587.

1. (04/2013 Becour) Becour, B. 2013. Conducted Electrical Weapons or Stun Guns A Review of 46 Cases Examined in Casualty. Am J Forensic Med Pathol & Volume 00, Number 00, Month 2013.

2. (08/2012 Gardner) Gardner AR, Hauda WE 2nd, Bozeman WP. Conducted Electrical Weapon (TASER) Use Against Minors: A Shocking Analysis. Pediatr Emerg Care. 2012 Aug 27. [Epub ahead of print].

   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.

3. (05/2012 Bozeman) Bozeman W, Teacher E, Winslow J. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j.jemermed.2012.03.022.

    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."

2. (03/2012 Becour) Becour B. Les armes a impulsion electrique: a propos de 42 cas examines aux Urgences. 2012. Medleg. Mar 2012

3. (12/2009 Strote) Strote J, Walsh M, Angelidis M, Basta A, Hutson HR., Conducted electrical weapon use by law enforcement: an evaluation of safety and injury, J Trauma. May 2010; 68(5):1239–1246.

    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 cardiomyopathy[41] have led some experts to suggest that no conclusive results can be drawn as yet.[4]" Pg. 1245.

4. (11/2009 Bozeman, Correspondence) Bozeman, W P., Additional Information on TASER [ECD] safety, Annals of Emergency Medicine, November 2009, Vol. 54, No. 5.

    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]."

5. (04/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480-489, April 2009.

    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."

6. (06/2008 Eastman) Eastman, A.L., et al., Conductive electrical devices: a prospective, population-based study of the medical safety of law enforcement use, J Trauma, 2008, 64(6): p. 1567–72.
    a. No cardiac arrests caused by CEDs among 426 consecutive CED activations (November 1, 2004 through January 31, 2006).
7. (12/2006 Strote) Strote J, Hutson R. Taser Use in Restraint Related Deaths. Prehosp Emerg Care. Oct 2006;10(4):447–450.
    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."
8. (05/2004 McManus) McManus, J.G., Forsyth, R.W., Hawks, R.W. 2004. A Retrospective Case Series Describing the Injury Pattern of the Advanced M26 TASER in Multnomah County, OR. ACAD EMERG MED, May 2004, Vol. 11, No. 5, pg. 587.
    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

No.	Date	Title
1	2013	Venara, A., et al., Tomodensitometric survey of the distance between thoracic and abdominal vital organs and the wall according to BMI, abdominal diameter and gender: Proposition of an indicative chart for the forensic activities. Forensic science international, 2013. 229(1): p. 167. e1-167. e6.
2	Sep. 2011	Kroll M, Lakkireddy D, Rahko P, Panescu D. 2011. Ventricular Fibrillation Risk Estimation for Conducted Electrical Weapons Critical Convolutions. EMBS. IEEE International Conference; Sept 2011:271–277.
3	Apr. 2011	Sun H, Haemmerich D, Rahko PS, Webster JG. 2010. Estimating the probability that the Taser directly causes human ventricular fibrillation. J Med Eng Technol. Apr 2010;34(3):178–191.
4	Jun. 2008	Rahko, P.S. 2008. Evaluation of the Skin-To-Heart Distance in the Standing Adult by Two-Dimensional Echocardiography. Journal of the American Society of Echocardiography June 2008. Pgs. 761–764.
5	May 2007	Bashian, G.G., Wagner, G.A., Wallick, D.W., Tchou. P.J. 2007. Abstract 115: Relationship of Body Mass Index (BMI) to Minimum Distance from Skin Surface to

		Myocardium: Implications for Neuromuscular Incapacitating Devices (NMID). Circulation. 2007;116:II_947.

1. Venara, A., et al., *Tomodensitometric survey of the distance between thoracic and abdominal vital organs and the wall according to BMI, abdominal diameter and gender: Proposition of an indicative chart for the forensic activities.* Forensic Science International, 2013. **229**(1): p. 167. e1-167. e6.

2. (09/2011 Kroll) Kroll M, Lakkireddy D, Rahko P, Panescu D. 2011. Ventricular Fibrillation Risk Estimation for Conducted Electrical Weapons Critical Convolutions. EMBS. IEEE International Conference; Sept 2011:271–277.

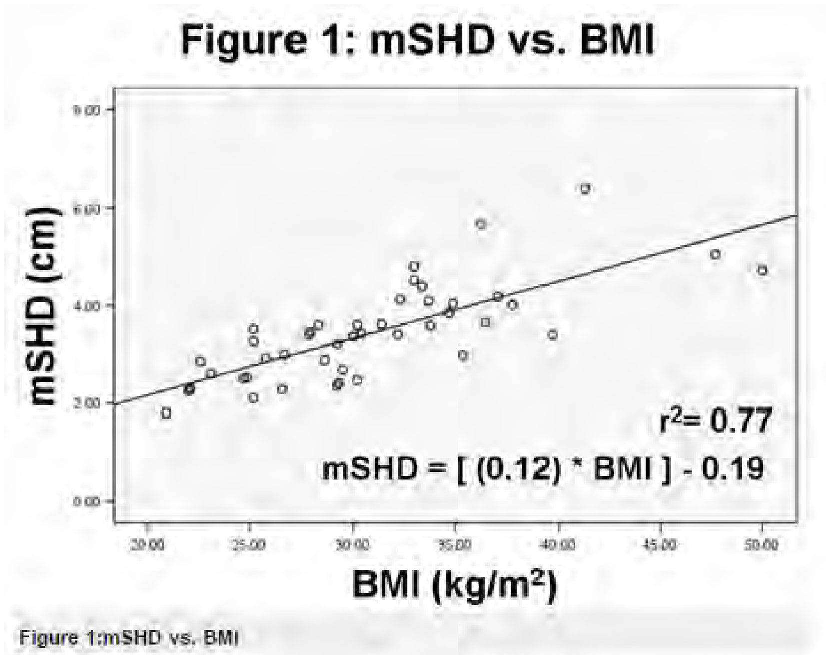
3. (04/2011 Sun) Sun H, Haemmerich D, Rahko PS, Webster JG. 2010. Estimating the probability that the Taser directly causes human ventricular fibrillation. J Med Eng Technol. Apr 2010;34(3):178–191.

4. (06/2008 Rahko) Rahko, P.S. 2008. Evaluation of the Skin-To-Heart Distance in the Standing Adult by Two-Dimensional Echocardiography. Journal of the American Society of Echocardiography June 2008. Pgs. 761–764.

5. (05/2007 Bashian) Bashian, G.G., Wagner, G.A., Wallick, D.W., Tchou. P.J. 2007. Abstract 115: Relationship of Body Mass Index (BMI) to Minimum Distance from Skin Surface to Myocardium: Implications for Neuromuscular Incapacitating Devices (NMID). Circulation. 2007;116:II_947.

    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."

Figure 1 Bashian: mSHD vs. BMI.



CEW VF Safety Margin – Partial Publications List:

Table 11 CEW VF Safety Margin – Partial Publications List

No.	Date	VF Cardiac Safety Factor	Document
1	Jan. 2013	X26 in “no VF” safety of IEC 60479 Part 2	Adler[9], Modern Instrumentation
2	Mar. 2012	0.0–0.6[%] sudden death probability with transcardiac CEW discharge	Bozeman[10], Journal of Emergency Medicine
3	Nov. 2009	“very large” safety margin	Jauchem[11], Forensic Science Medical Pathol.
4	Sep. 2009	“low likelihood;” 50% probability of X26-like pulses ranged from 4 to 5 times higher	Beason[12], Journal of Forensic Science
5	Sep. 2007	“large safety factors”	Ideker[13], Am J Forensic Med Pathol
6	Sep. 2007	30X	Panescu[14], EMB Mag. IEEE
7	Feb. 2007	M26 > 70X; X26 > 240X	Holden[15], Physics in Medicine & Biology
8	Sep. 2006	No VF	Stratbucker[16], EMBS, IEEE
9	Aug. 2006	No VF (normal X26)	Nanthakumar[17], J Am Coll Cardiol.
10	Aug. 2006	Significant safety margin	Lakkireddy (cocaine)[18], J Am Coll Cardiol.
11	Mar. 2005	240:1	U.K., Police Scientific Development Branch[19]
12	Mar. 2005	16:1 (160 lbs)	U.S. Government, HECOE[20], AFRL
13	Jan. 2005	Significant safety margin	McDaniel[21], PACE

[9] Adler, A., Dawson, D., Evans, R., Garland, L., Miller, M., Sinclair, I., Youmaran, R. Toward a Test Protocol for Conducted Energy Weapons. Modern Instrumentation, 2013, 2, 7-15.

[10] Bozeman W, Teacher E, Winslow J. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. *JEM*. March 2012.

[11] Jauchem JR. Repeated or long-duration TASER electronic control device exposures: acidemia and lack of respiration. *Forensic Sci Med Pathol.* Mar 2010;6(1):46–53.

[12] Beason C, Jauchem J, Clark C, Parker JE, Fines DA. Pulse Variations of a Conducted Energy Weapon (Similar to the TASER X26 Device): Effects on Muscle Contraction and Threshold for Ventricular Fibrillation*. *J Forensic Sci*. Sep 2009;54(5):1113–1118.

[13] 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.

[14] Panescu, D. Emerging Technologies design and medical safety of neuromuscular incapacitation devices. Engineering in Medicine and Biology Magazine. IEEE. October 2007;57-67.

[15] Holden SJ, Sheridan RD, Coffey TJ, Scaramuzza RA, Diamantopoulos P. Electromagnetic modeling of current flow in the heart from TASER devices and the risk of cardiac dysrhythmias. Phys Med Biol. Feb 2007;52(54):7193–7209.

[16] Stratbucker, R.A., Kroll, M.W., McDaniel, W., and Panescu, D. 2006. Cardiac Current Density Distribution by Electrical Pulses from TASER devices, EMBS, IEEE:6305–6307.

[17] Nanthakumar K, Billingsley I, Masse S, et al. Cardiac electrophysiological consequences of neuromuscular incapacitating device discharges. J Am Coll Cardiol. Aug 15 2006;48(4):798–804.

[18] Lakkireddy D, Wallick D, Ryschon K, et al. Effects of cocaine intoxication on the threshold for stun gun induction of ventricular fibrillation. J Am Coll Cardiol. Aug 15 2006;48(4):805–811.

[19] Wilkinson, D.I. 2005. “The X26 Taser – a review of the experimental and operational data related to an assessment of the medical implications of use.”, DSTL/PUB20752, 20 January 2005. Home Office, Police Scientific Development Branch, United Kingdom.

[20] Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1 2005. Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part 2 –APPENDICES: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1 2005.

[21] McDaniel W, Stratbucker R, Nerheim M, Brewer JE. Cardiac safety of neuromuscular incapacitating defensive devices. Pacing Clin Electrophysiol. 2005 Jan;28 Suppl 1:S284-7.

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No.	Date	VF Cardiac Safety Factor	Document
14	Oct. 2004	No reported VF in field or training; VF not expected in healthy adult populations	U.S. Government, HECOE[22], HERC Abstract
15	Jun. 2004	X26 No VF	Southwell[23], Australia, Alpert Hospital
16	Jun. 2004	M26/MES VF "extremely unlikely"	Sherry[24], HECOE, AFRL
17	Sep. 2003	M26 No VF	Southwell[25], Australia, Alpert Hospital
18	Sep. 2003	>20X	Stratbucker[26], EMBS, IEEE
19	Mar. 2003	TASER Area Denial – power far below that necessary to cause VF	Gonzalez[27], HECOE, AFRL

Risk of Cardiac Arrhythmia from CEW:

Table 12 Risk of Cardiac Arrhythmia from CEW

No.	Date	Title
1	Nov. 2014	Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.
2	Apr. 2014	Kunz, S.N., Aronshtam, J., Tränkler, H-R, Kraus, S., Graw, M., Peschel, O. Cardiac Changes Due to Electronic Control Devices? A Computer-Based Analysis of Electrical Effects at the Human Heart Caused by an ECD Pulse Applied to the Body's Exterior. *J Forensic Sci*, 2014. doi: 10.1111/1556-4029.12383.
3	Jan. 2014	Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? *Circulation*. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]
4	Dec. 2012	Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.
5	May 2012	Bozeman W, Teacher E, Winslow J. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j.jemermed.2012.03.022.
6	Mar. 2012	Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans – A review of current literature. Forensic Sci Int. 221 (2012) 1–4. [Mar 2012;Epub].
7	Jan. 2012	United Kingdom Defence Scientific Advisory Council. DSAC Sub-Committee on the Medical Implications of Less-lethal Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).
8	Sep. 2011	Kroll M, Lakkireddy D, Rahko P, Panescu D. Ventricular Fibrillation Risk Estimation for Conducted Electrical Weapons: Critical Convolutions. EMBS. IEEE International Conference; Sept 2011:271–277.
9	Sep. 2011	Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.
10	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

[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.

[23] Southwell, J. (2004) Taser X-26 Safety Analysis, Biomedical Engineering, The Alfred, Victoria, Australia.

[24] Sherry C, Beason C, Brown GC et al. Variable Taser Parameters: Effectiveness (Muscle Contraction) and Cardiac Safety (Ventricular Fibrillation). United States Air Force Research Laboratory. July 2004.

[25] Southwell J. (2004) Advanced TASER M-26 Safety Analysis. The Alfred Hospital. Sept 22 2003.

[26] Stratbucker, R., Roeder, R. Nerheim, M. 2003. Cardiac Safety of High Voltage TASER X26 Waveform. IEEE EMBS. Pgs 3261–3262 Vol.4 . September 2003.

[27] Gonzalez, D.L., Constable, R., Sherry, C.J., Dayton, T. TASER Area Denial Device: A Human Effects Review. United States Air Force Research Laboratory. AFRL-HE-BR-TR-2003-0026. March 2003.

No.	Date	Title
11	May 2011	Pasquier, M. Electronic Control Device Exposure – A Review of Morbidity and Mortality. Annals of Emergency Medicine May 2011.
12	Jan. 2011	Vilke, G.M., Bozeman, W.P., Chan, T.C., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. The Journal of Emergency Medicine. JEM, Vol. 40, No. 5, pp. 598–604, 2011.
13	Sep. 2010	Biria M, Bommana S, Kroll M, Lakkireddy D., Multi-System Interactions of Conducted Electrical Weapons (CEW) – A Review, Engineering in Medicine and Biology Society Proceedings, Sept 2010:1266–1270.
14	Apr. 2010	Electronic Control Weapons, Concepts and Issues Paper, International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, April 2010.
15	Set. 2009	Beason C, Jauchem J, Clark C, Parker JE, Fines DA. Pulse Variations of a Conducted Energy Weapon (Similar to the TASER X26 Device): Effects on Muscle Contraction and Threshold for Ventricular Fibrillation*. J Forensic Sci. Sep 2009;54(5):1113–1118.
16	Jun. 2009	Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.
17	Apr. 2009	Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.
18	Jun. 2008	Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. Office of Justice Programs, National Institute of Justice, United States Department of Justice. June 2008.
19	Sep. 2007	Panescu, D. Emerging Technologies design and medical safety of neuromuscular incapacitation devices. Engineering in Medicine and Biology. IEEE. October 2007;57–67.
20	Feb. 2007	Holden SJ, Sheridan RD, Coffey TJ, Scaramuzza RA, Diamantopoulos P. Electromagnetic modeling of current flow in the heart from TASER devices and the risk of cardiac dysrhythmias. Phys Med Biol. Feb 2007;52(54):7193–7209.
21	Nov. 2006	Wilkinson, D.I. 2006. Supplement to HOSDB Evaluations of Taser Devices, A collection of medical evidence and other source material. Pub. No. 64/06. Home Office, Police Scientific Development Branch, United Kingdom.
22	Sep. 2006	Stratbucker, R.A., Kroll, M.W., McDaniel, W., and Panescu, D. 2006. Cardiac Current Density Distribution by Electrical Pulses from TASER devices, EMBS, IEEE:6305–6307.
23	2006	Wilkinson D. Supplement to HOSDB Evaluations of Taser Devices. Home Office Scientific and Development Branch (HOSDB), United Kingdom.
24	Mar. 2005	Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.
25	Mar. 2005	Wilkinson, D.I. 2005. PSDB Further Evaluation of Taser Devices, Publication No. 19/05. Home Office, Police Scientific Development Branch, United Kingdom.
26	Jan. 2005	McDaniel W, Stratbucker R, Nerheim M, Brewer JE. Cardiac Safety of Neuromuscular Incapacitating Defensive Devices. Pacing Clin Electrophysiol. 2005 Jan;28 Suppl 1:S284-7.
27	Jan. 2005	Wilkinson, D.I. 2005. "The X26 Taser – a review of the experimental and operational data related to an assessment of the medical implications of use.", DSTL/PUB20752, 20 January 2005. Home Office, Police Scientific Development Branch, United Kingdom.
28	Jun. 2004	Southwell, J. (2004) Taser X-26 Safety Analysis, Biomedical Engineering, The Alfred, Victoria, Australia.

No.	Date	Title
29	Jun. 2004	Sherry C, Beason C, Brown GC et al. Variable Taser Parameters: Effectiveness (Muscle Contraction) and Cardiac Safety (Ventricular Fibrillation). United States Air Force Research Laboratory. July 2004.
30	Sep. 2003	Stratbucker) Stratbucker, R., Roeder, R. Nerheim, M. 2003. Cardiac Safety of High Voltage TASER X26 Waveform. IEEE EMBS. Pgs 3261–3262 Vol.4. September 2003.
31	Mar. 2003	Gonzalez, D.L., Constable, R., Sherry, C.J., Dayton, T. TASER Area Denial Device: A Human Effects Review. United States Air Force Research Laboratory. AFRL-HE-BR-TR-2003-0026. March 2003.

1. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "Whether or not an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial" (page 381).

    b. "If an ECD can induce VF in a human adult, it must be a very rare event. Although the issue as to whether an ECD under normal use conditions has caused the death of a human has not been definitively settled, there does seem to be general agreement that such an event, if it happens, is rare." (page 382).

2. (04/2014 Kunz) Kunz, S.N., Aronshtam, J., Tränkler, H-R, Kraus, S., Graw, M., Peschel, O. Cardiac Changes Due to Electronic Control Devices? A Computer-Based Analysis of Electrical Effects at the Human Heart Caused by an ECD Pulse Applied to the Body's Exterior. *J Forensic Sci, 2014.* doi: 10.1111/1556-4029.12383.

    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."

3. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? *Circulation*. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

    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.

4. (12/2012 Adedipe) Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.

   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.

5. (05/2012 Bozeman) Bozeman W, Teacher E, Winslow J. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j.jemermed.2012.03.022.

   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[%]."

6. (03/2012 Kunz) Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans- A review of current literature. Forensic Sci Int. 221 (2012) 1–4. [Mar 2012;Epub].

   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."

7. (01/2012 UK DSAC DOMILL) United Kingdom Defence Scientific Advisory Council. DSAC Sub-Committee on the Medical Implications of Less-lethal

Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).

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.

8. (09/2011 Kroll) Kroll M, Lakkireddy D, Rahko P, Panescu D. Ventricular Fibrillation Risk Estimation for Conducted Electrical Weapons: Critical Convolutions. EMBS. IEEE International Conference; Sept 2011:271–277.

   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."

9. (09/2011 Walcott) Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.

    "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."

10. (05/2011 NIJ-Laub) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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 dysrhythmias[9,10] ...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.

11. (05/2011 Pasquier) Pasquier, M. Electronic Control Device Exposure - A Review of Morbidity and Mortality. Annals of Emergency Medicine May 2011.

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

12. (01/2011 AAEM/JEM-Vilke) Vilke GM, Bozeman WP, Chan TC., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. The Journal of Emergency Medicine, In Press, Corrected Proof, Position Paper Approved by the American Academy of

Emergency Medicine Clinical Guidelines Committee. [Vilke, G.M., Bozeman, W.P., Chan, T.C., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. The Journal of Emergency Medicine. JEM, Vol. 40, No. 5, pp. 598–604, 2011.]

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]."

13. (09/2010 Biria) Biria M, Bommana S, Kroll M, Lakkireddy D., Multi-System Interactions of Conducted Electrical Weapons (CEW) – A Review, Engineering in Medicine and Biology Society Proceedings, Sept 2010:1266–1270.

    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."

14. (04/2010 IACP) Electronic Control Weapons, Concepts and Issues Paper, International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, April 2010.

    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."

15. (09/2009 Beason) Beason C, Jauchem J, Clark C, Parker JE, Fines DA. Pulse Variations of a Conducted Energy Weapon (Similar to the TASER X26 Device): Effects on Muscle Contraction and Threshold for Ventricular Fibrillation*. J Forensic Sci. Sep 2009;54(5):1113–1118.

    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."

16. (06/2009 AMA-Robinowitz) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

    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.

17. (04/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

    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."

18. (06/2008 NIJ-Hagy) Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. Office of Justice Programs, National Institute of Justice, United States Department of Justice. June 2008.

19. (09/2007 Panescu) Panescu, D. Emerging Technologies design and medical safety of neuromuscular incapacitation devices. Engineering in Medicine and Biology. IEEE. October 2007;57–67.

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

20. (02/2007 Holden) Holden SJ, Sheridan RD, Coffey TJ, Scaramuzza RA, Diamantopoulos P. Electromagnetic modeling of current flow in the heart from TASER devices and the risk of cardiac dysrhythmias. Phys Med Biol. Feb 2007;52(54):7193–7209.

    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."

21. (11/2006 Wilkinson) Wilkinson, D.I. 2006. Supplement to HOSDB Evaluations of Taser Devices, A collection of medical evidence and other source material. Pub. No. 64/06. Home Office, Police Scientific Development Branch, United Kingdom. See specifically:

    a. Appendix F – "Effects of simulated M26 and X26 Taser waveforms on the guinea-pig isolated heart.", DSTL/PUB20754, 15 March 2005. Pg. 241–266.

    b. Appendix G – "The X26 Taser – a review of the experimental and operational data related to an assessment of the medical implications of use.", DSTL/PUB20752, 20 January 2005. Pgs. 267–291.

22. (09/2006 Stratbucker) Stratbucker, R.A., Kroll, M.W., McDaniel, W., and Panescu, D. 2006. Cardiac Current Density Distribution by Electrical Pulses from TASER devices, EMBS, IEEE:6305–6307.

    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."

23. (2006 UK/HOSDB-Wilkinson) Wilkinson D. Supplement to HOSDB Evaluations of Taser Devices. Home Office Scientific and Development Branch (HOSDB), United Kingdom.

24. (03/2005 HECOE-Maier) Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.

    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

Body Weight (pounds)	Predicted Threshold for Ventricular Fibrillation[a]	
	Typical human	Sensitive human
10	2.4	1.5
20	3.6	2.1
40	5.8	3.5
60	8.1	4.8
80	10	6.1
120	13	8.1
160	16	10
200	19	11
240	22	13
280	24	15

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.

25. (03/2005 UK/PSDB-Wilkinson) Wilkinson, D.I. 2005. PSDB Further Evaluation of Taser Devices, Publication No. 19/05. Home Office, Police Scientific Development Branch, United Kingdom.

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.

26. (01/2005 McDaniel) McDaniel W, Stratbucker R, Nerheim M, Brewer JE. Cardiac Safety of Neuromuscular Incapacitating Defensive Devices. Pacing Clin Electrophysiol. 2005 Jan;28 Suppl 1:S284-7.

    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."

27. (01/2005 Wilkinson) Wilkinson, D.I. 2005. "The X26 Taser – a review of the experimental and operational data related to an assessment of the medical implications of use." DSTL/PUB20752, 20 January 2005. Home Office, Police Scientific Development Branch, United Kingdom.

28. (06/29/2004 Southwell) Southwell, J. (2004) Taser X-26 Safety Analysis, Biomedical Engineering, The Alfred, Victoria, Australia.

    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.

29. (06/2004 Sherry) Sherry C, Beason C, Brown GC et al. Variable Taser Parameters: Effectiveness (Muscle Contraction) and Cardiac Safety (Ventricular Fibrillation). United States Air Force Research Laboratory. July 2004.

    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."

30. (09/2003 Stratbucker) Stratbucker, R., Roeder, R. Nerheim, M. 2003. Cardiac Safety of High Voltage TASER X26 Waveform. IEEE EMBS. Pgs 3261–3262 Vol.4. September 2003.

    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."

31. (03/2003 Gonzalez) Gonzalez, D.L., Constable, R., Sherry, C.J., Dayton, T. TASER Area Denial Device: A Human Effects Review. United States Air Force Research Laboratory. AFRL-HE-BR-TR-2003-0026. March 2003.

    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. Modem 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

No.	Date	Document
1	Jan. 2014	White, M.D., Ready, J.T., Kane, R.J., Dario, L.M. 2014. Examining the effects of the TASER on cognitive functioning: findings from a pilot study with police recruits. J Exp Criminol DOI 10.1007/s11292-013-9197-9.
2	Jan. 2014	Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]
3	Oct. 2013	Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.
4	Mar. 2013	Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013. [Also see: Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013.][28]
5	Aug. 2012	Gardner AR, Hauda WE 2nd, Bozeman WP. Conducted Electrical Weapon (TASER) Use Against Minors: A Shocking Analysis. Pediatr Emerg Care. 2012 Aug 27.
6	Aug. 2012	White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. 2012. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85-112.
7	Jul. 2012	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.

[28] See also, Dawes, D.M. 2013. Lightening Oral Presentation #547. An Evaluation of Two Electronic Control Devices Using a Swine Comparative Cardiac Safety Model. Society for Academic Emergency Medicine (SAEM), Atlanta, GA. May 17, 2013.

No.	Date	Document
8	May 2012	Bozeman W, Teacher E, Winslow J. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j. jemermed.2012.03.022.
9	Mar. 2012	Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans- A review of current literature. Forensic Sci Int. 221 (2012) 1–4. [Mar 2012;Epub]
10	Jan. 2012	United Kingdom Defence Scientific Advisory Council. DSAC Sub-Committee on the Medical Implications of Less-lethal Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).
11	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.
12	May 2011	Pasquier, M., Electronic Control Device Exposure - A Review of Morbidity and Mortality, Annals of Emergency Medicine, Volume 58, No. 2: August 2011, pgs 178–188 [E-published May 2011].
13	Mar. 2011	2011 Electronic Control Weapon Guidelines, Police Executive Research Forum (PERF) and Community Oriented Policing Services, U.S. Department of Justice (DOJ).
14	Jan. 2011	Vilke, G.M., Bozeman, W.P., Chan, T.C., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. The Journal of Emergency Medicine. JEM, Vol. 40, No. 5, pp. 598–604, 2011.
15	Jun. 2010	John C. Hunsaker III, Associate Chief Medical Examiner, Kentucky Justice and Public Safety Cabinet, Frankfort; Transcript: Are Conducted Energy Devices Safe and Effective?, 2010 NIJ Conference | National Institute of Justice.
16	Apr. 2010	Electronic Control Weapons, Concepts and Issues Paper, International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, April 2010. And, IACP Model Policy.
17	Jun. 2009	Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.
18	Jan. 2009	Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.
19	Jun. 2008	Letter from the National Association of Medical Examiners (NAME) President, Jeffrey Jentzen, M.D.
20	Jun. 2008	Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. US Dept of Justice. Office of Justice Programs. June 2008.
21	Nov. 2006	Cronin, J.M., Ederheimer, J.A. 2006. Conducted Energy Devices: Development of Standards for Consistency and Guidance The Creation of National CED Policy and Training Guidelines. Office of Community Oriented Policing Services. U.S. Department of Justice; Bureau of Justice Assistance, Police Executive Research Forum.
22	Oct. 2005	PERF Conducted Energy Device Policy and Training Guidelines for Consideration and Conducted Energy Device (CED) Glossary of Terms. PERF Center on Force & Accountability.
23	Aug. 2005	Electronic Control Weapons, Concepts and Issues Paper, International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, April 2010. And, IACP Model Policy.

1. (01/2014 White) White, M.D., Ready, J.T., Kane, R.J., Dario, L.M. 2014. Examining the effects of the TASER on cognitive functioning: findings from a pilot study with police recruits. J Exp Criminol DOI 10.1007/s11292-013-9197-9.

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.)

2. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

    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.

3. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

    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).

4. (03/2013 Dawes) Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.

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.”

5. (08/2012 Gardner) Gardner AR, Hauda WE 2nd, Bozeman WP. Conducted Electrical Weapon (TASER) Use Against Minors: A Shocking Analysis. Pediatr Emerg Care. 2012 Aug 27. [Epub ahead of print].

6. (08/2012 White) White, MD, Ready, J, Riggs, C, Dawes, DM, Hinz, A, Ho, JD. 2012. An Incident-Level Profile of TASER Deployments in Arrest-Related Deaths. Police Quarterly. 2013;16(1):85-112.

   a. White found that only 36% (57/158) of ECD-involved arrest-related deaths had a chest probe ($p = 0.004$ by chi-square).

7. (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.

   a. 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.

8. (05/2012 Bozeman) Bozeman W, Teacher E, Winslow J. Transcardiac Conducted Electrical Weapon (TASER) Probe Deployments: Incidence and Outcomes. JEM. doi:10.1016/j.jemermed.2012.03.022.

   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.”

9. (03/2012 Kunz) Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans – A review of current literature. Forensic Sci Int. 221 (2012) 1–4. [Mar 2012;Epub].

    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."

10. (01/2012 UK DSAC DOMILL) United Kingdom Defence Scientific Advisory Council. DSAC Sub-Committee on the Medical Implications of Less-lethal Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).

    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.

11. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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."[39] 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.

12. (05/2011 Pasquier) Pasquier, M., Electronic Control Device Exposure - A Review of Morbidity and Mortality, Annals of Emergency Medicine, Volume 58, No. 2: August 2011, pgs 178–188 [E-published May 2011].

    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.[66,67] Nevertheless, a theoretical risk does exist and increases with low body weight,[68] as well as with short dart-to-heart distances.[69,70]" 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.

13. (03/2011 PERF/DOJ) 2011 Electronic Control Weapon Guidelines, Police Executive Research Forum (PERF) and Community Oriented Policing Services, U.S. Department of Justice (DOJ).

    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.

14. (01/2011 AAEM/JEM-Vilke) Vilke GM, Bozeman WP, Chan TC., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. The Journal of Emergency Medicine, In Press, Corrected Proof, Position Paper Approved by the American Academy of Emergency Medicine Clinical Guidelines Committee. [Vilke, G.M., Bozeman, W.P., Chan, T.C., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. The Journal of Emergency Medicine. JEM, Vol. 40, No. 5, pp. 598–604, 2011.]

    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]."

15. (06/2010 NIJ/Hunsaker) John C. Hunsaker III, Associate Chief Medical Examiner, Kentucky Justice and Public Safety Cabinet, Frankfort; Transcript: Are Conducted Energy Devices Safe and Effective?, 2010 NIJ Conference | National Institute of Justice.

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.)

16. (04/2010 IACP) Electronic Control Weapons, Concepts and Issues Paper, International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, April 2010. And, IACP Model Policy.

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.

17. (06/2009 AMA-Robinowitz) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

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

18. (01/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

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

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."

20. (06/2008 Hagy/NIJ) Hagy D. Study of Deaths Following Electro Muscular Disruption: Interim Report. US Dept of Justice. Office of Justice Programs. June 2008.

    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.

21. (11/2006 Cronin) Cronin, J.M., Ederheimer, J.A. 2006. Conducted Energy Devices: Development of Standards for Consistency and Guidance The Creation of National CED Policy and Training Guidelines. Office of Community Oriented Policing Services. U.S. Department of Justice; Bureau of Justice Assistance, Police Executive Research Forum.

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

22. (10/2005) PERF Conducted Energy Device Policy and Training Guidelines for Consideration and Conducted Energy Device (CED) Glossary of Terms. PERF Center on Force & Accountability.

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

23. (08/2005 IACP) Electronic Control Weapons, Concepts and Issues Paper, International Association of Chiefs of Police (IACP) National Law Enforcement Policy Center, August 2005. And, IACP Model Policy.

    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"

1. (09/2007 Ideker) 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.

   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)

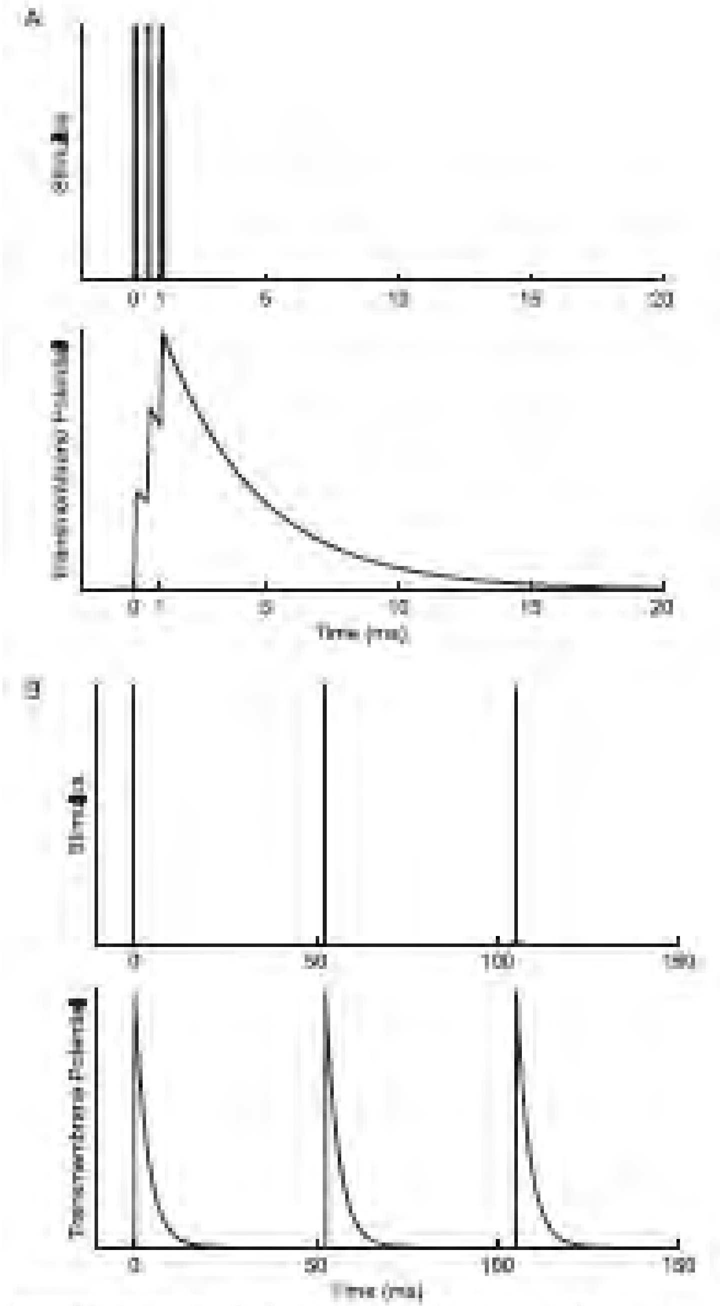


FIGURE 6. Effects of multiple electrical stimuli on the transmembrane potential according to Blair's[13] model. The time constant is 3.6 ms and the stimuli are 0.1 ms in duration. When the pulses are 0.5 ms apart (A), the membrane has not fully recovered when the next pulse occurs, so that the transmembrane potential increases with each pulse. However, when the pulses are 53 ms apart (B), as in the TASER X26, the transmembrane potential has returned almost to its initial value before the next pulse is given, so that summation does not occur.

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

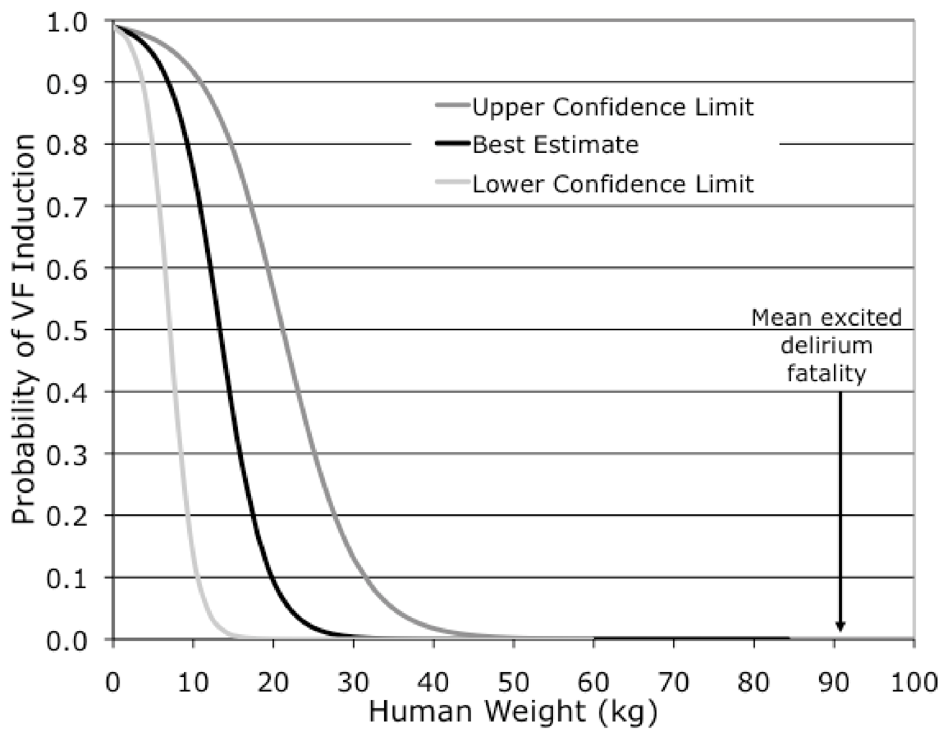
No.	Date	Document
1	Nov. 2012	Flaker, G.C., Koerber, S.M., Ardhanari, S.,Chockalingam, A., Zymek, P., McDaniel. W. Abstract 18722: Cardiac Stimulation Occurs with Electronic Control Devices and is Dependent Upon Subject Size, Dart Location, and Device Characteristics. Circulation. 2012; 126: A18722.
2	Sep. 2011	Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.
3	May. 2009	Kroll M, Panescu D, Brewer J, Lakkireddy D, Graham M. Weight Adjusted Meta-Analysis of Fibrillation Risk From TASER Conducted Electrical Weapons. Proceedings of the American Academy of Forensic Science. Feb 2009:177–177. Kroll M, Panescu D, Brewer J, Lakkireddy D, Graham M. Meta-Analysis Of Fibrillation Risk From TASER Conducted Electrical Weapons as a Function of Body Mass. Heart Rhythm. 2009;6:AB20-21.
4	Aug. 2006	Lakkireddy D, Wallick D, Ryschon K, et al. Effects of cocaine intoxication on the threshold for stun gun induction of ventricular fibrillation. J Am Coll Cardiol. Aug 15 2006;48(4):805–811.
5	Mar. 2005	Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.
6	Jan. 2005	McDaniel W, Stratbucker R, Nerheim M, Brewer JE. Cardiac Safety of Neuromuscular Incapacitating Defensive Devices. Pacing Clin Electrophysiol. 2005 Jan;28 Suppl 1:S284-7.
7	1973	Geddes LA, Cabler P, Moore AG, Rosborough J, Tacker WA. Threshold 60-Hz current required for ventricular fibrillation in subjects of various body weights. IEEE Trans Biomed Eng 1973;20(6):465–8.
8	1968	Dalziel, C. F. and W. R. Lee (1968). "Reevaluation of lethal electric currents." IEEE Transactions on Industry and General Applications IGA-4(5): 467–476.
9	1936	Ferris, L. P., B. G. King, et al. (1936). "Effect of electric shock on the heart." Electrical Engineering 55: 498–515.

1. (11/2012 (Abstract) Flaker) Flaker, G.C., Koerber, S.M., Ardhanari, S.,Chockalingam, A., Zymek, P., McDaniel. W. Abstract 18722: Cardiac Stimulation Occurs with Electronic Control Devices and is Dependent Upon Subject Size, Dart Location, and Device Characteristics. Circulation. 2012; 126: A18722.

    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.”

2. (05/14/2009 Kroll) Kroll M, Panescu D, Brewer J, Lakkireddy D, Graham M. Meta-Analysis Of Fibrillation Risk From TASER Conducted Electrical Weapons as a Function of Body Mass. Heart Rhythm. 2009;6:AB20-21.
    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."
3. (02/2009 Kroll) Kroll M, Panescu D, Brewer J, Lakkireddy D, Graham M. Weight Adjusted Meta-Analysis of Fibrillation Risk From TASER Conducted Electrical Weapons. Proceedings of the American Academy of Forensic Science. Feb 2009:177.[29]

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



4. (08/2006 Lakkireddy) Lakkireddy D, Wallick D, Ryschon K, et al. Effects of cocaine intoxication on the threshold for stun gun induction of ventricular fibrillation. J Am Coll Cardiol. Aug 15 2006;48(4):805-811.
    a. Pig weights: 34 ± 8.7 kg (75 ± 19 lbs) [56–94 lbs]

[29] Kroll M, Panescu D, Brewer J, Lakkireddy D, Graham M. Meta-Analysis Of Fibrillation Risk From TASER Conducted Electrical Weapons as a Function of Body Mass. Heart Rhythm. 2009;6:AB20-21.

b. Significant X26 CEW discharge safety factor

5. (03/2005 HECOE-Maier) Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.

   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

Body Weight (pounds)	Predicted Threshold for Ventricular Fibrillation[a]	
	Typical human	Sensitive human
10	2.4	1.5
20	3.6	2.1
40	5.8	3.5
60	8.1	4.8
80	10	6.1
120	13	8.1
160	16	10
200	19	11
240	22	13
280	24	15

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.

6. (01/2005 McDaniel) McDaniel W, Stratbucker R, Nerheim M, Brewer JE. Cardiac Safety of Neuromuscular Incapacitating Defensive Devices. Pacing Clin Electrophysiol. 2005 Jan;28 Suppl 1:S284-7.

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.”

7. (1973 Geddes) Geddes LA, Cabler P, Moore AG, Rosborough J, Tacker WA. Threshold 60-Hz current required for ventricular fibrillation in subjects of various body weights. IEEE Trans Biomed Eng 1973;20(6):465–8.

Cardiac Safety Dependent Upon Dart Orientation and Pig Size:

1. (11/2012 (Abstract) Flaker) Flaker, G.C., Koerber, S.M., Ardhanari, S.,Chockalingam, A., Zymek, P., McDaniel. W. Abstract 18722: Cardiac Stimulation Occurs with Electronic Control Devices and is Dependent Upon Subject Size, Dart Location, and Device Characteristics. Circulation. 2012; 126: A18722.

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 1: Heart Rate Response During ECD Stimulation

	Device	X26		S200 AT		M26		X3		C2	
	Location	Mean HR	S.D	Mean HR	S.D	Mean HR	S.D	Mean HR	S.D.	Mean HR	S.D.
Group 1 (25 kg)	Cardiac	225*	17.2	214*	62.6	132*	41.7	100	13.0	253*	11.8
	Abdominal	96	2.5	94	1.6	91	6.8	92	4.4	91	1.5
Group 2 (67 kg)	Cardiac	99	21.5	207	25.3	88	8.0	90	11.0	92	8.9
	Abdominal	87	7.0	91	4.9	89	8.7	88	8.7	99	15.3

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

2. (09/2011 Walcott) Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.

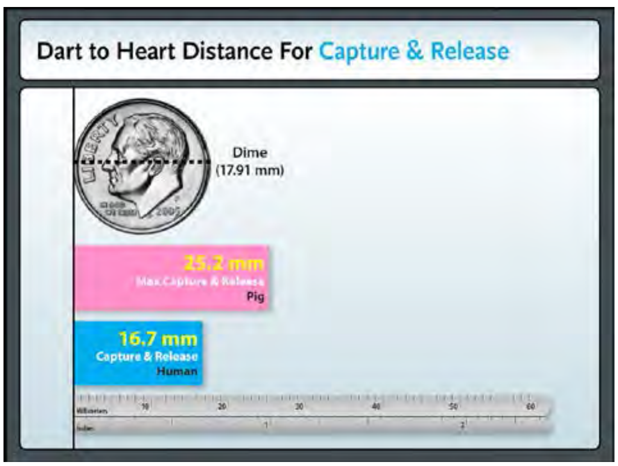
    a. No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance

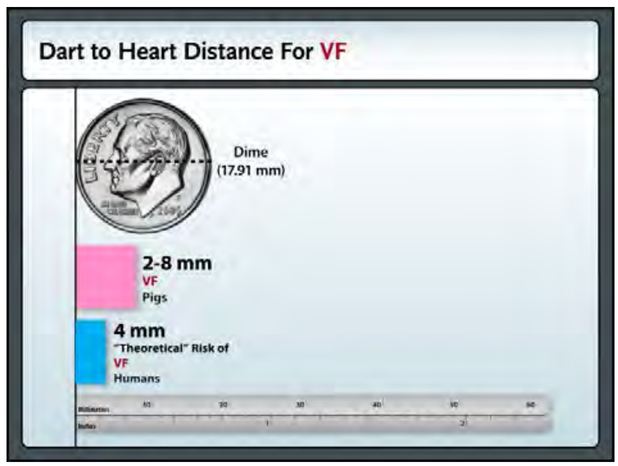
    b. “This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”

3. (03/2005 HECOE-Maier) Maier A, Nance P, Price P, et al. Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report: The Joint Non-Lethal Weapons Human Effects Center of Excellence; March 1, 2005.

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

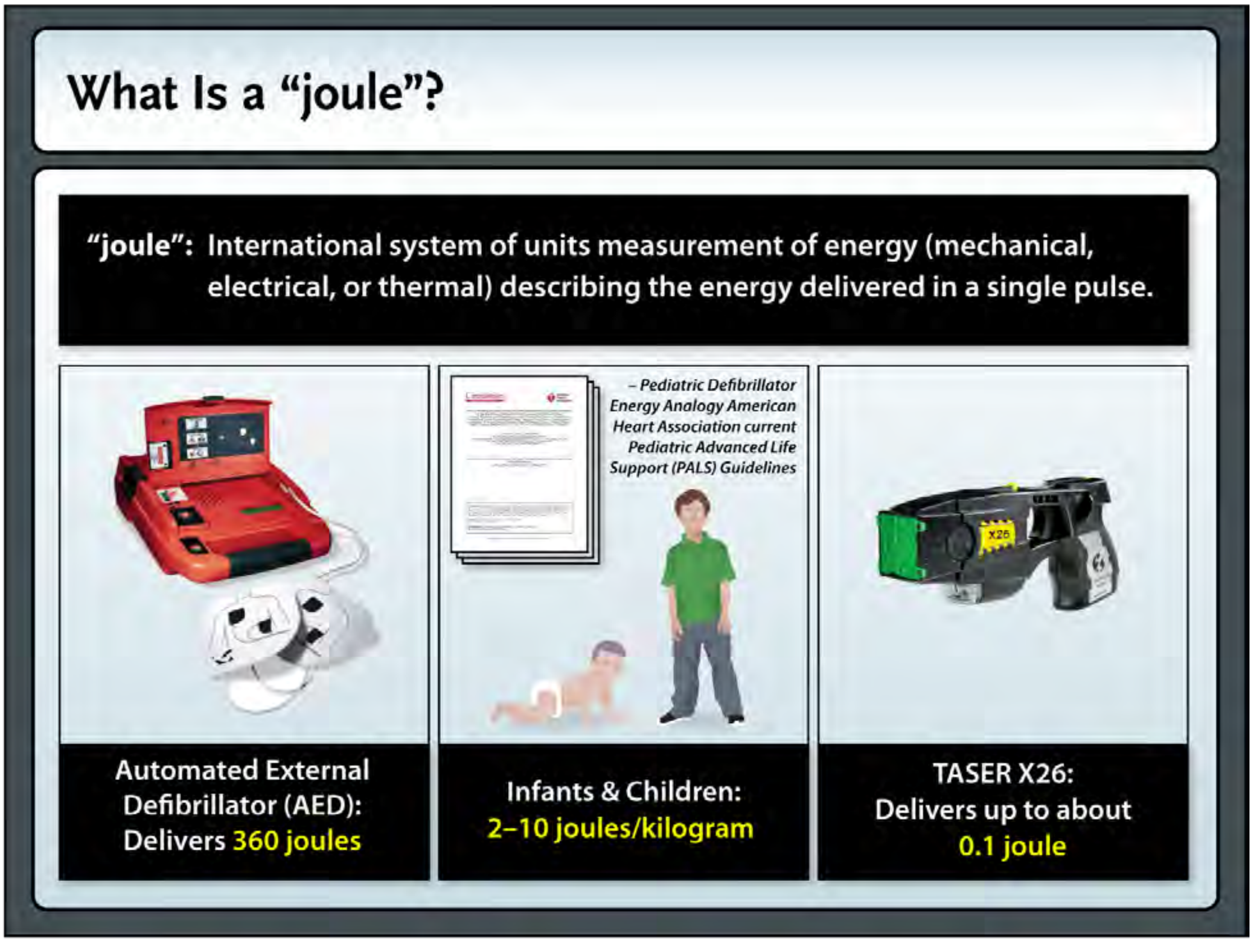
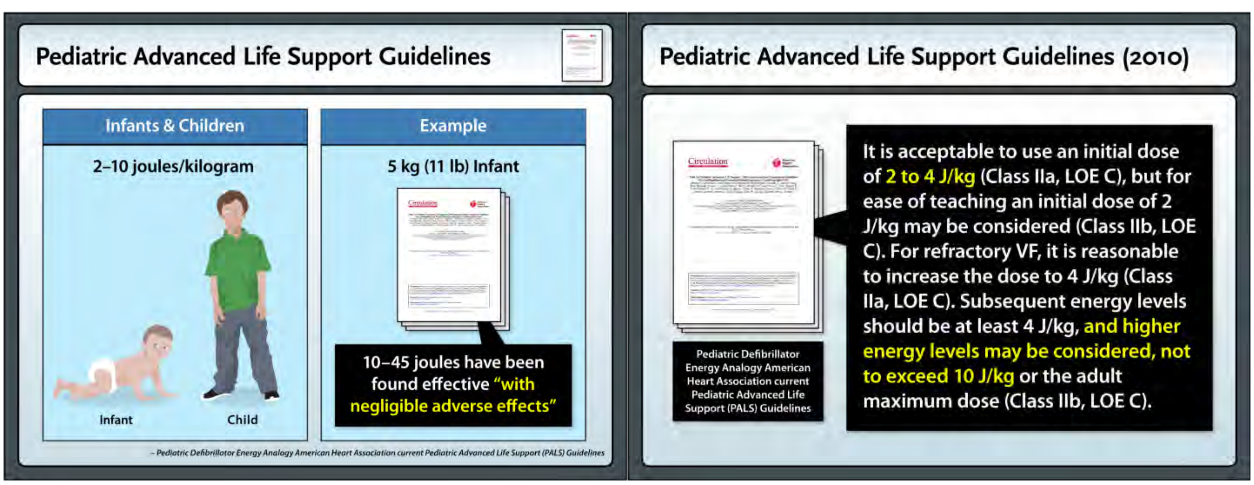


Figure 6 Joule Comparisons 2



Swine CEW Cardiac Research

Animal Model Differences (including Swine):

1. (09/2014 Lelovas) Lelovas, P.P., N.G. Kostomitsopoulos, and T.T. Xanthos, A Comparative Anatomic and Physiologic Overview of the Porcine Heart. Journal of the American Association for Laboratory Animal Science, 2014. 53(5): p. 432-438.

    a. "... the use of swine is associated with several limitations, including anatomic variation in the thoracic cavity, a trait that is common to most mammals used in biomedical research, and substantial differences between the conduction systems of swine compared with humans. However, the conduction systems of other commonly used animal species also differ significantly anatomically and physiologically from that of humans ..."

2. (2010 Štengl) Štengl, M., Experimental models of spontaneous ventricular arrhythmias and of sudden cardiac death. Physiol. Res, 2010. 59(1): p. S25-S31.

    a. "... Interpretation of various sudden death mechanisms occurring in the [animal] models will be always complicated by species differences. In this respect the comparative (patho)physiology must be taken into account and complement the translational efforts."

3. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

    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.[20]" Pg. 4.

4. (2007 Hamlin) Hamlin, R.L. (2007) Animal models of ventricular arrhythmias. Pharmacology & Therapeutics, 113 (2007) 276–295.

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

5. (1983 Verdouw) Verdouw, P.D., Wolfenbuttel, B.H.R., Van Der Giessen, W.J. 1983. Domestic pigs in the study of myocardial ischemia. European Heart Journal (1983) 4 (Supplement C), 61–67.

    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[26l."

        (1) "[26] Hamlin RL, Burton RR, Leverett SO, Burns JW. Ventricular activation process in minipigs. J Electrocardiol. 1975; 8: 113–6."

6. (1975 Hamlin) Hamlin RL, Burton RR, Leverett SO, Burns JW. 1975. Ventricular activation process in minipigs. J Electrocardiol. 1975; 8: 113–6.

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

1. (01/2015 Walcott) Walcott, G. P., M. W. Kroll, and R. E. Ideker, 2015, Ventricular fibrillation: are swine a sensitive species?: *J Interv Card Electrophysiol*.

    a. "*Conclusions* Swine are about three times as sensitive to the electrical induction of VF as are humans."

    b. "7. **Conclusions** Swine are about three times as sensitive to the electrical induction of VF by a series of 24 rapid pulses during the vulnerable period as are humans."

2. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

    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)

3. (09/10/2010 Biria) Biria M, Bommana S, Kroll M, Lakkireddy D. Multi-Organ Effects of Conducted Electrical Weapons (CEW) – A Review. Conf Proc IEEE Eng Med Biol Soc. September 2010:1266–70.

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

4. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

   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.[20]" Pg. 4.

5. (2007 Pippin) Pippin JJ. Taser research in pigs not helpful. J Am Coll Cardiol. 2007;49:731–732.

6. (1968 Dalziel) Dalziel CF, Lee WR. Reevaluation of lethal electric currents. IEEE Transactions on Industry and General Applications 1968;IGA-4:467–476.

7. (1935 Ferris) Ferris LP, King BG, Spence PW, Williams HB. Effect of electric shock on the heart. Electrical Engineering 1936;55:498–515.

Epinephrine Increases VFT:

1. (1975 Zipes) Zipes, D.P. 1975. Electrophysiological Mechanisms Involved in Ventricular Fibrillation. Supplement III to Circulation, Vols. 51 and 52, December, 1975, pages III-120 - III-130.

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

Table 1

Some Factors that Alter Refractory Period Dispersion or Ventricular Fibrillation Threshold

Increased RPD or decreased VFT	Decreased RPD or increased VFT
Myocardial ischemia[34–36]	Epinephrine (initial ↓ VFT)[39, 45]
Slower heart rates without ischemia[37]	Slower heart rates with ischemia[38]
Faster heart rates with ischemia[38]	Faster heart rates without ischemia[37]
Sympathetic nerve stimulation[39]	Vagal stimulation[46, 47]
Ventricular premature systoles[40]	Drugs: lidocaine,[48] bretylium,[49] procainamide,[50] diphenylhydantoin,[51] propranolol,[42] quinidine,[45] nitroglycerin,[52] edrophonium[47]
Acidosis[41, 42]	
Ouabain toxicity[43]	
Aminophylline[42] (for first 30 min after i.v. administration)	Aminophylline[42] (after first 30 min following i.v. administration)
Digitalis with autonomic denervation or propranolol[44]	Digitalis in intact dog or after stellate stimulation[42, 44]
Hypothermia[43]	Respiratory acidosis with hypoxia[53]
Quinidine (high doses)[43]	
Chloroform[43]	

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

Epinephrine Infusion Alone Causes Ventricular Tachycardia:

1. (04/1988 Inoue) Inoue, H., Zipes, D.P. 1988. Cocaine-Induced Supersensitivity and Arrhythmogenesis. JACC Vol 11. No. 4. April 1988:867–74.
    a. "In the remaining dog, spontaneous ventricular tachycardia appeared during norepinephrine infusion after cocaine injection." pg 871.
2. (1968 Gy) Gy, J., Szekeres, L., 1968. Analysis of the Mechanism of Adrenergic Actions on Ventricular Vulnerability. *European Journal of Pharmacology* 3 (1968) 15-26. See Table 4, page 23:
    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:

1. (08/2009 Calzia) Calzia, E., Georgieff, M., Huber-Lang, M., Radermacher, P. Commentary: Epinephrine kinetics in septic shock – a means to understand variable catecholamine efficiency? *Critical Care 2009*, 13:177 (doi:10.1186/cc7987).
    a. "… in the present study (115 to 140 L/h, corresponding to a half-life of 3.5 minutes) …"

2. (07/1980 Clutter) Clutter, W.E., Bier, D.M., Shah, S.D., Cryer, P.E. Epinephrine Plasma Metabolic Clearance Rates and Physiologic Thresholds for Metabolic and Hemodynamic Actions in Man. *J. Clin. Invest.* Volume 66 July 1980 94-101.

   a. Figure 1.

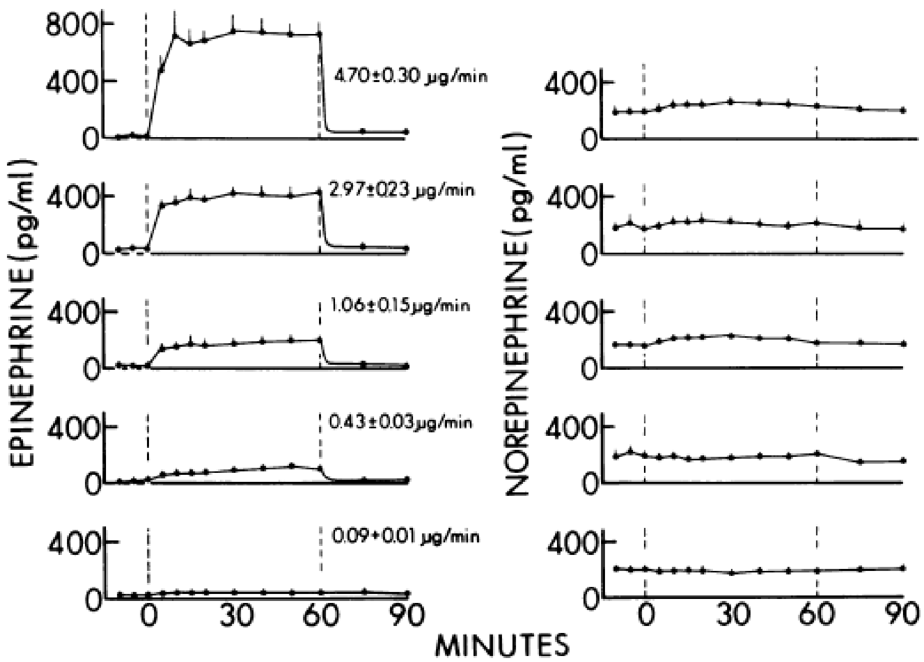


FIGURE 1 Mean (±SE) plasma epinephrine and norepinephrine concentrations before, during, and after 60-min epinephrine infusions at the five nominal infusion rates. The mean (±SE) measured infusion rates are listed at the right of the epinephrine plots.

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

Pub. Date	Lead Author	Animal Age	Animal Weight with VF	CEW Exposure Duration	Notes
Aug. 2006	Nanthakumar[33]		No VF in any instance that did not have simultaneous epinephrine infusion 50 kg (110 lb) [All animals weighed: - 45–55 kg or - 99–121 lb	5, 15 s 15 s	6 pigs, 150 CEW discharges, 16 with simultaneous infused epinephrine (See Zipes, 1975, after initial decrease epinephrine increased VFT)[34] only one instance had VF in 16 attempts after significant infused epinephrine with undisclosed time interval.
Sep. 2007	Dennis[35]	3–6 mo	29 kg (64 lb) 31 kg (68 lb)	80 s total 2 x 40 s	Ventilator off during exposures. 31 kg pig had a thoracotomy
Jan. 2008	Walter[36]	3–6 mo	28 kg (62 lb)	80 s total 2 x 40 s	VF after first 40 s; ventilator off during exposures.
Dec. 2008	Valentino[37]	3–4 mo	25 kg (55 lb) 36 kg (79 lb)	10 s	XP probes fully embedded

[30] Does not include studies using special long rod-electrodes which were intentionally plunged deep enough though previously bored holes to the heart. See, Wu JY, Sun H, O'Rourke AP, et al. Taser blunt probe dart-to-heart distance causing ventricular fibrillation in pigs. IEEE Trans Biomed Eng. Dec 2008;55(12):2768-2771; and Kroll MW, Panescu D, Hinz AF, Lakkireddy D. A novel mechanism for electrical currents inducing ventricular fibrillation: The three-fold way to fibrillation. Conf Proc IEEE Eng Med Biol Soc. 2010;1:1990-1996.

[31] Kroll MW, Calkins H, Luceri RM, Graham MA, Heegaard WG. Sensitive swine and TASER electronic control devices. Acad Emerg Med 2008;15:695–6; author reply 696–8.

[32] In this table "CEW" refers to a TASER X26 CEW at standard discharge levels.

[33] Nanthakumar K, Billingsley I, Masse S, et al. Cardiac electrophysiological consequences of neuromuscular incapacitating device discharges. J Am Coll Cardiol. Aug 15 2006;48(4):798–804. See also, Nanthakumar K, Masse S, Umapathy K, Dorian P, Sevaptsidis E, Waxman M. Cardiac stimulation with high voltage discharge from stun guns. CMAJ 2008;178:1451–7. See also, Kroll MW, Calkins H, Luceri RM, Graham MA, Heegaard WG. TASER safety (Review of a review). CMAJ 2008;179:677–8.

[34] Zipes, D.P. 1975. Electrophysiological Mechanisms Involved in Ventricular Fibrillation. Supplement III to Circulation, Vols. 51 and 52, December, 1975, pages III-120 - III-300. (after initial decrease, epinephrine increased VFT)

[35] Dennis AJ, Valentino DJ, Walter RJ, et al. Acute effects of Taser X26: discharges in a swine model. J Trauma. Sep 2007;63(3):581–90.

[36] Walter RJ, Dennis AJ, Valentino DJ, et al. TASER X26 discharges in swine produce potentially fatal ventricular arrhythmias. Acad Emerg Med. Jan 2008;15(1):66–73.

[37] Valentino D, Walter R, Dennis A, et al. Taser X26 Discharges in Swine: Ventricular Rhythm Capture is Dependent on Discharge Vector. J Trauma. Dec 2008;65(6):1478–1485; discussion 1485–1477.

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

Pub. Date	Lead Author	Animal Age	Animal Weight with VF	CEW Exposure Duration	Notes
Sep. 2003	Stratbucker[38]		92–158 lbs	5 s	"... 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."
Jan. 2005	McDaniel[39]		No VF Weight: 60 ± 28 kg		Significant safety factor
Aug. 2006	Jauchem[40]		No VF Weight: 49.5–58 kg (109–128 lbs)		
Aug. 2006	Lakkireddy[41]		No VF Weight: 34 ± 8.7 kg (75 ± 19 lbs) (56–94 lbs)	5, 15 s	Cocaine VF threshold study Significant X26 CEW discharge safety factor
Aug. 2006	Nanthakumar[42]		No VF in any instance that did not have simultaneous epinephrine infusion 50 kg (110 lb) [All animals weighed: - 45–55 kg or - 99–121 lb	5, 15 s 15 s	6 pigs, 150 CEW discharges, 16 with simultaneous infused epinephrine only one instance had VF in 16 attempts with infused epinephrine

[38] Stratbucker, R., Roeder, R., Nerheim, M. 2003. Cardiac Safety of High Voltage TASER X26 Waveform. IEEE EMBS, Engineering in Medicine and Biology Society, Proceedings of the 25th Annual International Conference of the IEEE. Sep 2003;4:3261–3262.

[39] McDaniel W, Stratbucker R, Nerheim M, Brewer JE. Cardiac safety of neuromuscular incapacitating defensive devices. Pacing Clin Electrophysiol. 2005 Jan;28 Suppl 1:S284-7.

[40] Jauchem JR, Sherry CJ, Fines DA, Cook MC. Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of Sus scrofa following repeated TASER exposures. Forensic Sci Int 2006;161:20–30.

[41] Lakkireddy D, Wallick D, Ryschon K, et al. Effects of cocaine intoxication on the threshold for stun gun induction of ventricular fibrillation. J Am Coll Cardiol. Aug 15 2006;48(4):805–811.

[42] Nanthakumar K, Billingsley I, Masse S, et al. Cardiac electrophysiological consequences of neuromuscular incapacitating device discharges. J Am Coll Cardiol. Aug 15 2006;48(4):798–804. See also, Nanthakumar K, Masse S, Umapathy K, Dorian P, Sevaptsidis E, Waxman M. Cardiac stimulation with high voltage discharge from stun guns. CMAJ 2008;178:1451–7. See also, Kroll MW, Calkins H, Luceri RM, Graham MA, Heegaard WG. TASER safety (Review of a review). CMAJ 2008;179:677–8.

Pub. Date	Lead Author	Animal Age	Animal Weight with VF	CEW Exposure Duration	Notes
Mar. 2007	Jauchem[43]		No VF Weight: 50.8 ± 1.6 kg 46–61 kg (101–134 lbs)	15 s	
May 2007	Valentino[44]		No VF (MK63)	2 x 40 s	10 Yucatan minipigs Lengthy EMI exposures did not cause extreme acidosis or cardiac arrhythmias
Sep. 2007	Dennis[45]	3–6 mo	29 kg (64 lb) 31 kg (68 lb)	2 x 40 s	 31 kg pig had a thoracotomy
Jan. 2008	Walter[46]	3–6 mo	28 kg (62 lb)	2 x 40 s	
Feb. 2008	Valentino[47]	3–4 mo	No VF Weight: 15–33 kg (33–73 lbs)		MK63 Stun Device Yucatan mini pigs
Apr. 2008	Lakkireddy[48]		No VF Weight: 34.4 ± 6.95 kg (76 ± 15 lbs) 61–91 lbs	5–15 s	Barb placement study
Dec. 2008	Valentino[49]	3–4 mo	25 kg (55 lb) 36 kg (79 lb)	10 s	XP probes
Jun. 2009	Kroll[50]		19.5 & 20 kg 43 & 44 lbs	5 s	3.4 mm and 7.9 mm DTH no induction of VF at pulse charges up to 300 μC
Apr. 2010	Dawes[51]		No VF Weight: 26–78 kg (57–172 lbs)	5, 15, 30, and 40 seconds	16 Dorset Sheep with methamphetamine NO VF with X26 CEW

[43] Jauchem J, Cook M, Beason C. Blood factors of Sus scrofa following a series of three TASER electronic control device exposures. Forensic Sci Int. Mar 5 2007;175(2-3):166–170.

[44] Valentino DJ, Walter RJ, Nagy K, Dennis AJ, Winners J, Bokhari F, Wiley D, Joseph KT, Roberts R. 2007. Repeated thoracic discharges from a stun device. J Trauma. 2007 May;62(5):1134–42.

[45] Dennis AJ, Valentino DJ, Walter RJ, et al. Acute effects of Taser X26: discharges in a swine model. J Trauma. Sep 2007;63(3):581–90.

[46] Walter RJ, Dennis AJ, Valentino DJ, et al. TASER X26 discharges in swine produce potentially fatal ventricular arrhythmias. Acad Emerg Med. Jan 2008;15(1):66–73.

[47] Valentino, D.J., Walter, R.J., Dennis, A.J., Nagy, K., Loor, M.M., Winners, J., Bokhari, F., Wiley, D., Merchant, A., Joseph, K., Roberts, R. 2008. Acute Effects of MK63 Stun Device Discharges in Miniature Swine. Military Medicine, Volume 173, 2:167–173, February 2008.

[48] Lakkireddy D, Wallick D, Verma A, et al. Cardiac Effects of Electrical Stun Guns: Does Position of Barbs Contact Make a Difference? Pacing Clin Electrophysiol. Apr 2008;31(4):398–408.

[49] Valentino D, Walter R, Dennis A, et al. Taser X26 Discharges in Swine: Ventricular Rhythm Capture is Dependent on Discharge Vector. J Trauma. Dec 2008;65(6):1478–1485; discussion 1485–1477.

[50] Kroll M, Panescu D, Carver M, et al. Cardiac Effects of Varying Pulse Charge and Polarity of TASER Conducted Electrical Weapons. Conf Proc IEEE Eng Med Biol Soc. 2009;1:3195–3198.

[51] Dawes D, Ho J, Cole J, et al. Effect of an electronic control device exposure on a Methamphetamine-intoxicated Animal Model. Acad Emerg Med. 2010;17:436–43.

Pub. Date	Lead Author	Animal Age	Animal Weight with VF	CEW Exposure Duration	Notes
Sep. 2011	Walcott[52]		No VF Weight: 20–25 kg (44–55 lbs)		No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance "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."
Dec. 2012	Flaker[53]		No VF		No cardiac stimulation with TASER X3 CEW
Mar. 2013	Jenkins[54]	3–5 mo	No VF Death (No death in first 3 minutes) Weight: 30 – 40 kg (66–88 lbs)	10, 15, 20, 25, and 30 minutes	Paper first appeared dated November 30, 2007
Mar. 2013	Dawes (SAEM poster presentation)[55]		No VF or other dysrhythmias after any CEW exposure	5 & 10 seconds	X26 and X2 CEW swine cardiac capture study model X2 CEW had a smaller "window" of capture
Mar. 2013	Dawes[56]		No VF 84–85 lbs	5 & 10 seconds	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

[52] Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255-258.

[53] Flaker, G.C., Koerber, S.M., Ardhanari, S.,Chockalingam, A., Zymek, P., McDaniel. W. Abstract 18722: Cardiac Stimulation Occurs with Electronic Control Devices and is Dependent Upon Subject Size, Dart Location, and Device Characteristics. Circulation. 2012; 126: A18722.

[54] Jenkins, M.D., Murray, W.B., Kennet, M.J. 2013. The Effects of Continuous Application of the TASER X26 [CEW] Waveform on Sus scrofa. J Forensic Sci, 2013.

[55] (SAEM Presentation) Dawes, D. 2013. An Evaluation of two Electronic Control Devices Using a Swine Comparative Cardiac Safety Model, Track 6: Cardiology/International, Society for Academic Emergency Medicine (SAEM) Western Regional Meeting. March 23, 2013.

[56] Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013. [Also see: Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013; and, Dawes, D.M. 2013. Lightening Oral Presentation #547. An Evaluation of Two Electronic Control Devices Using a Swine Comparative Cardiac Safety Model. Society for Academic Emergency Medicine (SAEM), Atlanta, GA. May 17, 2013.]

Pub. Date	Lead Author	Animal Age	Animal Weight with VF	CEW Exposure Duration	Notes
May 2013	Masse[57]	unk	No VF Unk weight	5 & 15 seconds	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
May 2013	Hado[58]	unk	No VF Unk weight		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. “**Conclusion:** 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.
Jun. 2014	Dawes[59]	unk	No VF 81–85 pounds	5 seconds	144 CEW exposures 63 exposures with cardiac capture no cases of VF.
Aug. 2014	Koerber[60]	unk	No VF 25, 25, 68, & 71 kg		160 CEW exposures 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.]

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.

58 (2013; 10:S404) Hado, H.S., Masse, S.M., Das, M., Gizurarson, S., Khan, F., Roshn, J., Waxman, M., Nanthakumar, K. 2013. Poster Session PO05-110 - The Effect Of Stun Gun Discharges On The Atrium. HRS. May 10, 2013. Also, it is suspected that this POSTER is simply a rehash of the 2006 Nanthakumar swine study and not new or original research.

59 Dawes, D., Ho, J., Moore, J., Laudenbach, A., Reardon, R., Miner, J. An evaluation of two conducted electrical weapons using a swine comparative cardiac safety model. Forensic Sci Med Pathol. June 2014.

60 Koerber, S.M., Ardhanari, S., McDaniel, W.C., Chockalingam, A., Zymek, P., and Flaker, G.: ‘Cardiac Stimulation with Electronic Control Device Application’, The Journal of Emergency Medicine, 2014.

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X26/X2 CEWs Comparative Cardiac Capture Safety Study:

1. (08/2014 Koerber) Koerber, S.M., Ardhanari, S., McDaniel, W.C., Chockalingam, A., Zymek, P., and Flaker, G.: 'Cardiac Stimulation with Electronic Control Device Application', *The Journal of Emergency Medicine*, 2014.

   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.]

2. (06/2014 Dawes) Dawes, D., Ho, J., Moore, J., Laudenbach, A., Reardon, R., Miner, J. An evaluation of two conducted electrical weapons using a swine comparative cardiac safety model. *Forensic Sci Med Pathol*. June 2014.

   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."

3. (03/2013 Dawes) Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.[61]

   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 %."[62]

   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

[61] [Also see: Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013; and, Dawes, D.M. 2013. Lightening Oral Presentation #547. An Evaluation of Two Electronic Control Devices Using a Swine Comparative Cardiac Safety Model. Society for Academic Emergency Medicine (SAEM), Atlanta, GA. May 17, 2013.]

[62] Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013.

model. (John Webster, Ph.D. has had similar experiences with the swine model.[63])

[63] 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.

DTH Distances in Swine:

Table 18 DTH distances in swine cardiac effects.

Pub. Date	Lead Author	Animal Weight	DTH Distances	Notes
Jun. 2014	Dawes[64]	81–85 lbs	-3.4–18.0 mm	No VF. No capture > 257 bmp.
Mar. 2013	Dawes[65]	84–85 lbs	2.7–25.2 mm	No VF. No capture >313 bpm.
Sep. 2011	Walcott[66]	44–45 lbs	10 mm	No VF
Jun. 2009	Kroll[67]	43–44 lbs	3.4 & 7.9 mm	No VF at pulse charges up to 300 µC
Dec. 2008	Wu[68]	121–149 lbs	2–8 mm	VF through pre-bored hole to heart
Apr. 2008	Lakkireddy[69]	61–91 lbs	12–23 mm[70]	No VF. Significant VF safety margin.
Jul. 2006	Lakkireddy[71]	59.1–81.6 lbs	12.3–16.5 mm[72]	No VF. Significant VF safety margin.
Jun. 2003	Stratbucker[73]	92–158 lbs		No VF. Probes on sensitive areas of thorax. >20X VF safety factor.

1. (06/2014 Dawes) Dawes, D., Ho, J., Moore, J., Laudenbach, A., Reardon, R., Miner, J. An evaluation of two conducted electrical weapons using a swine comparative cardiac safety model. *Forensic Sci Med Pathol*. June 2014.

    a. Animal weights 81–85 pounds [37–39 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.

    (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:

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[64] Dawes, D., Ho, J., Moore, J., Laudenbach, A., Reardon, R., Miner, J. An evaluation of two conducted electrical weapons using a swine comparative cardiac safety model. Forensic Sci Med Pathol. June 2014.

[65] Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.

[66] Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.

[67] Kroll M, Panescu D, Carver M, et al. Cardiac Effects of Varying Pulse Charge and Polarity of TASER Conducted Electrical Weapons. Conf Proc IEEE Eng Med Biol Soc. 2009;1:3195–3198.

[68] Wu J, Sun H, O'Rourke A, et al. Taser blunt probe dart-to-heart distance causing ventricular fibrillation in pigs. IEEE Trans Biomed Eng. Dec 2008;55(12):2768–2771.

[69] Lakkireddy D, Wallick D, Verma A, et al. Cardiac Effects of Electrical Stun Guns: Does Position of Barbs Contact Make a Difference? Pacing Clin Electrophysiol. Apr 2008;31(4):398–408.

[70] Personal communication. Review of Lakkireddy's study's raw data.

[71] Lakkireddy D, Wallick D, Ryschon K, et al. Effects of Cocaine Intoxication on the Threshold for Stun Gun Induction of Ventricular Fibrillation. J Am Coll Cardiol. Aug 15 2006;48(4):805–811.

[72] Personal communication. Review of Lakkireddy's study's raw data.

[73] Stratbucker, R., Roeder, R., Nerheim, M. 2003. Cardiac Safety of High Voltage TASER X26 Waveform. IEEE EMBS, Engineering in Medicine and Biology Society, Proceedings of the 25th Annual International Conference of the IEEE. Sep 2003;4:3261–3262.

(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

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 19 Dawes 2014 Swine X2/KA MPID Swine Study DTH (-3.4–18.0 mm), Fig. 1 (a–c).

Subject 1 (a)				Subject 2 (b)				Subject 3 (c)			
PL	STH (cm)	DTH (mm)	No Capture	PL	STH (cm)	DTH (mm)	No Capture	PL	STH (cm)	DTH (mm)	No Capture
-1	nv	nv		-1	nv	nv		-1	nv	nv	
-2	2.38	10.8		-2	nv	nv		-2	nv	nv	
1	nv	nv		1	2.79	14.9		1	3.10	18.0	
2	nv	nv		2	0.96	-3.4		2	2.48	11.8	
3	nv	nv		3	nv	nv		3	4.59	N/A	NC
4	2.48	11.8		4	2.37	10.7		4	2.63	13.3	
5	1.91	6.1		5	1.85	5.5		5	1.99	6.9	
6	1.95	6.5		6	2.22	9.8		6	2.23	9.7	
7	1.63	3.5		7	1.51	3.1		7	1.74	4.4	
8	1.62	3.2		8	1.73	4.3		8	1.42	1.2	
10	nv	nv		10	2.20	9.0		10	2.58	12.8	
11	2.05	7.5		11	2.20	9.0		11	1.90	7.0	
12	2.13	8.3		12	2.09	7.9		12	2.25	9.5	
13	2.79	14.9		13	2.66	13.6		13	3.00	17.0	
17	2.47	11.7		17	2.17	8.7		17	2.58	12.8	
18	3.05	17.5		18	2.98	16.8		18	1.97	6.7	
23	5.93	N/A	NC	23	3.33	N/A	NC	23	nv		

2. (03/2013 Dawes) Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.[74]

   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).

[74] [Also see: Dawes, D.M., Ho, J.D., Moore, J.C., Minor, J.R. 2013. Erratum to: An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9451-5. Published online May 1, 2013; and, Dawes, D.M. 2013. Lightening Oral Presentation #547. An Evaluation of Two Electronic Control Devices Using a Swine Comparative Cardiac Safety Model. Society for Academic Emergency Medicine (SAEM), Atlanta, GA. May 17, 2013.]

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

d. Cardiac capture ratio:

(1) Mean 232 BPM X26 CEW and 222 BPM X2 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.

Subject 1 (a)			Subject 2 (b)			Subject 3 (c)			Subject 4 (d)		
PL	STH (cm)	DTH (mm)	PL	STH (cm)	DTH (mm)	PL	STH (cm)	DTH (mm)	PL	STH (cm)	DTH (mm)
1	2.80	15.0	-2	1.99	6.9	-1	2.43	11.3	-1	2.58	12.8
2	2.00	7.0	1	2.12	8.2	-2	2.09	7.9	-2	2.54	12.4
4	2.80	11.0	2	1.97	6.7	1	2.10	8.0	5	2.01	7.1
5	2.20	9.0	5	1.71	4.1	2	1.87	5.7			
6	2.40	11.0	6	2.17	8.7	5	1.81	5.1			
7	2.80	15.0	7	2.35	10.5	6	2.03	7.3			
11	2.20	9.0	8	1.57	2.7	7	2.40	11.0			
12	2.60	13.0	12	2.27	9.7						

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

Subject 5 (a)			Subject 6 (b)			Subject 7 (c)		
PL	STH (cm)	DTH (mm)	PL	STH (cm)	DTH (mm)	PL	STH (cm)	DTH (mm)
6	2.32	10.2	2	3.03	17.3	2	3.63	23.3
11	2.55	12.5	5	3.10	18.0	6	2.63	13.3
12	2.69	13.9	6	2.58	12.8	11	2.67	13.7
13	3.01	17.1	11	2.72	14.2	12	2.09	7.9
17	2.39	10.9	12	2.59	12.9	13	2.36	10.6
18	2.74	14.4	13	2.62	13.2	14	2.90	16.0
			17	3.82	25.2	17	1.82	5.2
			18	2.71	14.1	18	2.19	8.9
			19	3.32	20.2	19	3.35	20.5
						23	2.36	10.6
						24	2.29	9.9

3. (09/2011 Walcott) Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.

a. Swine weight: 20–25 kg (44–55 lbs).

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.

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.”

4. (06/2009 Kroll) Kroll M, Panescu D, Carver M, et al. Cardiac Effects of Varying Pulse Charge and Polarity of TASER Conducted Electrical Weapons. Conf Proc IEEE Eng Med Biol Soc. 2009;1:3195–3198.

   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.

5. (12/2008 Wu) Wu J, Sun H, O'Rourke A, et al. Taser blunt probe dart-to-heart distance causing ventricular fibrillation in pigs. IEEE Trans Biomed Eng. Dec 2008;55(12):2768–2771.

   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.

Figure 8 Wu: 100 mm STH Distance Measurement and 50 mm Stimulation Electrodes.

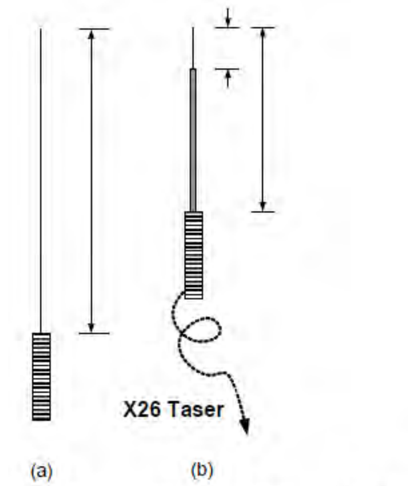

Fig. 1. (a) The distance testing probe measured the skin-to-heart distance. (b) The blunt-probe delivered the stimulation current from the exposed 9 mm long wire.

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. ..."

Figure 9 Wu: graphic showing depth of probe penetration to induce VF in swine.

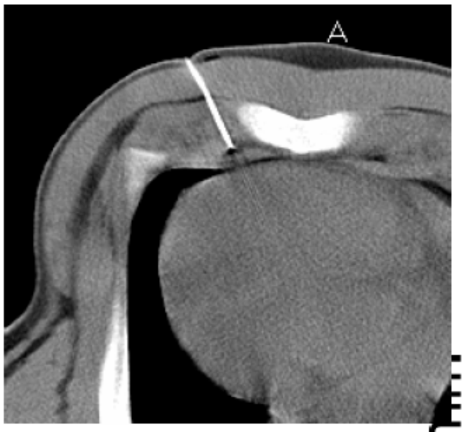

Table 22 Wu: Experimental parameters and results of five animal tests.

Table 1. Experimental parameters and results of five animal tests.

Pig	Mass (kg)	Site 1		Site 2	
		Skin-heart distance (mm)	VF distance (mm)	Skin-heart distance (mm)	VF distance (mm)
1	58	51	5	57	7
2	68.8	49	6	45	4
3	53	45	8	47	8
4	65.6	42	4	45	2
5	60.4	44	8	45	6
Ave	61.16	46.2	6.2	47.8	5.4
SD	6.23	3.7	1.79	5.2	2.41

d. The dart-to-heart distance where the T[ASER 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).

6. (04/2008 Lakkireddy) Lakkireddy D, Wallick D, Verma A, et al. Cardiac Effects of Electrical Stun Guns: Does Position of Barbs Contact Make a Difference? Pacing Clin Electrophysiol. Apr 2008;31(4):398-408.

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).

Table 23 DTH distances for Lakkireddy studies from raw data.

Pig ID	DTH (mm)	Pig ID	DTH (mm)	Pig ID	DTH (mm)
05-P-46	14.1	05-P-34	13.8	05-P-17	14.0
05-P-45	12.3	05-P-33	19.0	05-P-70	15.1
05-P-44	14.7	05-P-23	14.7	05-P-71	16.5
05-P-42	14.7	05-P-19	18.6		
05-P-35	11.6	05-P-18	22.9		

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. ..."

7. (07/2006 Lakkireddy) Lakkireddy D, Wallick D, Ryschon K, et al. Effects of Cocaine Intoxication on the Threshold for Stun Gun Induction of Ventricular Fibrillation. J Am Coll Cardiol. Aug 15 2006;48(4):805–811.

   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).

Table 24 DTH distances for Lakkireddy studies from raw data.

Pig ID	DTH (mm)	Pig ID	DTH (mm)	Pig ID	DTH (mm)
05-P-46	14.1	05-P-34	13.8	05-P-17	14.0
05-P-45	12.3	05-P-33	19.0	05-P-70	15.1
05-P-44	14.7	05-P-23	14.7	05-P-71	16.5
05-P-42	14.7	05-P-19	18.6		
05-P-35	11.6	05-P-18	22.9		

   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."

8. (06/2003 Stratbucker) Stratbucker, R., Roeder, R., Nerheim, M. 2003. Cardiac Safety of High Voltage TASER X26 Waveform. IEEE EMBS, Engineering in Medicine and Biology Society, Proceedings of the 25th Annual International Conference of the IEEE. Sep 2003;4:3261–3262.

   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

No.	Date	Citation
1	Dec. 2008	Valentino D, Walter R, Dennis A, et al. 2008. Taser X26 Discharges in Swine: Ventricular Rhythm Capture is Dependent on Discharge Vector. J Trauma. Dec 2008;65(6):1478–1485; discussion 1485–1477.
2	Apr. 2008	Lakkireddy D, Wallick D, Verma A, et al. 2008. Cardiac Effects of Electrical Stun Guns: Does Position of Barbs Contact Make a Difference? Pacing Clin Electrophysiol. Apr 2008;31(4):398-408.
3	May 2007	Lakkireddy, D.R., Vacek, J., Wallick, D., Kowalewski, W., Martin, D.O., Butany, J., Natale, A., Tchou, P. 2007. Abstract: Effect of Varying Dart Separation Along the Cardiac Axis on Ventricular Arrhythmia Induction During TASER Application. Heart Rhythm, Vol. 4, No. 5, May Supplement 2007, P01-87, Page S140.

1. (12/2008 Valentino) Valentino D, Walter R, Dennis A, et al. 2008. Taser X26 Discharges in Swine: Ventricular Rhythm Capture is Dependent on Discharge Vector. J Trauma. Dec 2008;65(6):1478–1485; discussion 1485–1477.

    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 dysrhythmia was observed with this vector but capture with a rapid rhythm consistent with VT/ventricular flutter was not seen. With nonpenetrating, taped darts in this arrangement, capture was seen only when the emitting dart was on the chest (vector 10 right chest).” Pages 1481–1482.

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.

2. (04/2008 Lakkireddy) Lakkireddy D, Wallick D, Verma A, et al. 2008. Cardiac Effects of Electrical Stun Guns: Does Position of Barbs Contact Make a Difference? Pacing Clin Electrophysiol. Apr 2008;31(4):398–408.

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.

3. (05/2007 Lakkireddy) Lakkireddy, D.R., Vacek, J., Wallick, D., Kowalewski, W., Martin, D.O., Butany, J., Natale, A., Tchou, P. 2007. Abstract: Effect of Varying Dart Separation Along the Cardiac Axis on Ventricular Arrhythmia Induction During TASER Application. Heart Rhythm, Vol. 4, No. 5, May Supplement 2007, P01-87, Page S140.

    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:

1. (12/2008 Valentino) Valentino D, Walter R, Dennis A, et al. 2008. Taser X26 Discharges in Swine: Ventricular Rhythm Capture is Dependent on Discharge Vector. J Trauma. Dec 2008;65(6):1478–1485; discussion 1485–1477.

    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."

Swine: Changes in Plasma Proteins:

1. (10/2014 Jauchem) Jauchem JR, Cerna CY, Lim TY, Seaman RL. Exposures of Sus scrofa to a TASER® conducted electrical weapon: no effects on 2-

dimensional gel electrophoresis patterns of plasma proteins. Forensic Sci Med Pathol. 2014 Oct 16. [Epub ahead of print].

a. " … There were no statistically significant changes in plasma proteins following the conducted-electrical-weapon exposures. Overall gel patterns of fibrinogen were similar to results of other studies of both pigs and humans (in control settings, not exposed to conducted electrical weapons). The lack of significant changes in plasma proteins may be added to the body of evidence regarding relative safety of TASER C2 device [30 second] exposures."

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]

2. (03/2013 Dawes) Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.

    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[77]

Basics of electrical charge diversion, shunting, and depth of penetration of the body:[78]

- Skeletal muscle anisotropy and high-resistivity fat divert 88% of electrical current away from deeper tissue layers by longitudinal muscle electrical conduction (anisotropy)[79].
- Deale and Lerman studied the ratio of transcardiac to transthoracic threshold electrical currents in dogs:[80]
    - o the thoracic cage shunted 82% of the input current, and
    - o the lungs shunted 14%.
    - o Only the remaining 4% of the input electrical current passed through the heart.
    - o 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

No.	Graphic Illustration	Illustration Description
1		**External Anatomy** External View of Torso

[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 physiolgic 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.).

Graphic illustrations from Visible Body, http://www.visiblebody.com/index.html.

[78] See: D. Panescu, J. G. Webster, W. J. Tompkins and R. A. Stratbucker, "Optimization of transcutaneous cardiac pacing by three-dimensional finite element modeling of the human thorax," Med. Biol. Eng. Comput., vol. 33(6), pp. 769–775, 1995: D. Panescu, J. G. Whayne, S. D. Fleischman, M. S. Mirotznik, D. K. Swanson and J. G. Webster, "Three-dimensional finite element analysis of current density and of thermal profiles during radiofrequency ablation," IEEE Trans. Biomed. Eng., vol. 42, no. 9, pp. 879–890, 1995: D. Panescu, J. G. Webster, W. J. Tompkins and R. A. Stratbucker, "Optimization of cardiac defibrillation by three-dimensional finite element modeling of the human thorax," IEEE Trans. Biomed. Eng., vol. 42, no. 2, pp. 185–192, 1995; D. Panescu, J. G. Webster and R. A. Stratbucker, "A nonlinear finite element model of the electrode-electrolyte-skin system," IEEE Trans. Biomed. Eng., vol. 41, no. 7, pp. 681–687, 1994; D. Panescu, J. G. Webster and R. A. Stratbucker, "A nonlinear electrical-thermal model of the skin," IEEE Trans. Biomed. Eng., vol. 41, no. 7, pp. 672–680, 1994; D. Panescu, J. G. Webster and R. A. Stratbucker, "Modeling current density distribution during transcutaneous cardiac pacing," IEEE Trans. Biomed. Eng., vol. 41, no. 6, pp. 549–555, 1994; D. Panescu, J. G. Webster and R. A. Stratbucker, "Measurement of ventricular volume from blood conductance using two-dimensional finite element analysis," Physiol. Meas., vol. 15(1), pp. 49–56, 1994; and D. Panescu, K. P. Cohen, J. G. Webster and R. A. Stratbucker, "The mosaic electrical characteristics of the skin," IEEE Trans. Biomed. Eng., vol. 40, no. 5, pp. 434–439, 1993.

[79] Panescu, D., Stratbucker, R.A. 2009. Chapter 6: Current Flow in the Human Body. Kroll M, Ho J, eds. TASER® Conducted Electrical Weapons: Physiology, Pathology, and Law. Springer, 2009. Pgs 70–71.

[80] Deale OC and Lerman BB. Intrathoracic current flow during transthoracic defibrillation in dogs. Circ Res 1990; 67(6); 1405–1419.

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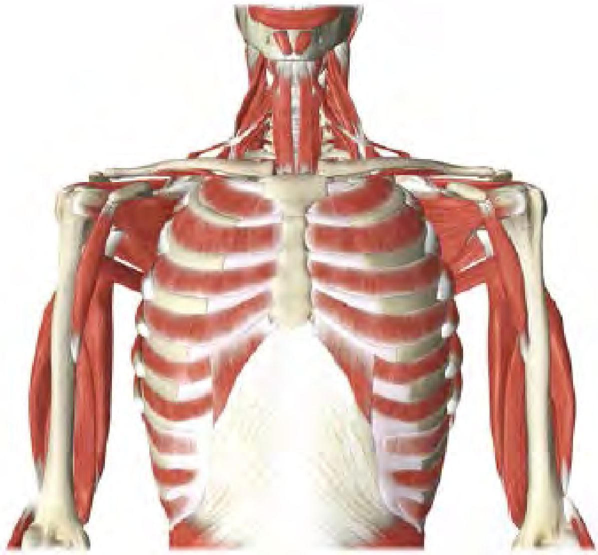
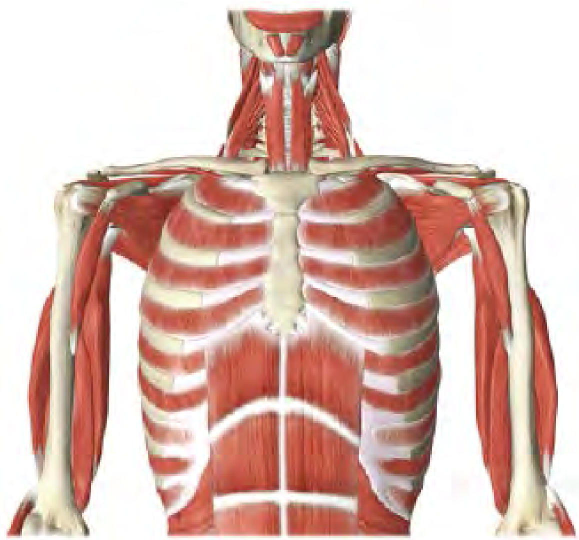
No.	Graphic Illustration	Illustration Description
2		**Subcutaneous Fat Layer** Subcutaneous fat layer showing after removal of epidermis and dermis Note: Fat is highly resistive to the flow of electrical current.
3		**Upper Muscles Layer** Muscles visible after removal of skin and subcutaneous fat layer. Note: Anisotropy (horizontal grain) of the muscles. Note: Multiple muscle layers in next illustrations.
4		**Muscle Group 1 Removed** Platysma-–neck Pectoralis major–chest Deltoids–shoulders Trapezius–shoulders

NO.	**GRAPHIC ILLUSTRATION**	**ILLUSTRATION DESCRIPTION**
5		**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** Internal Oblique–upper abdomen Omohyoid–neck region Teres major–shoulder region Serratus Anterior–along ribs
7		**Muscle Group 4 Removed** Intercostal Externus–along ribs Coracobrachialis–upper arm Scalenes–along neck Rectus Abdominis–middle abdomen

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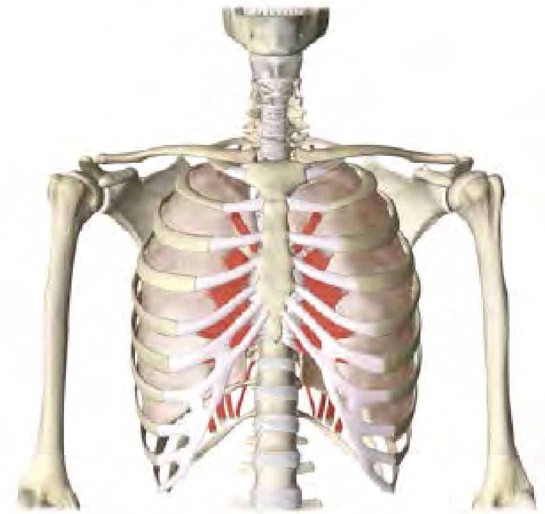
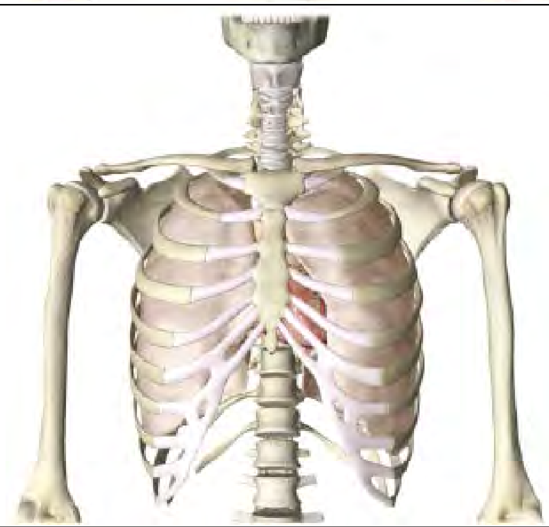
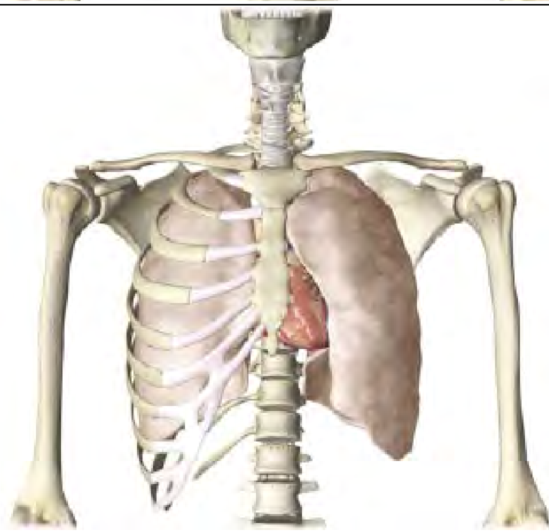
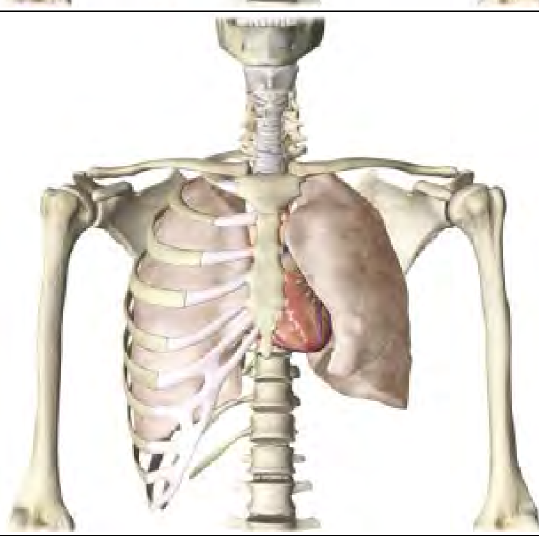
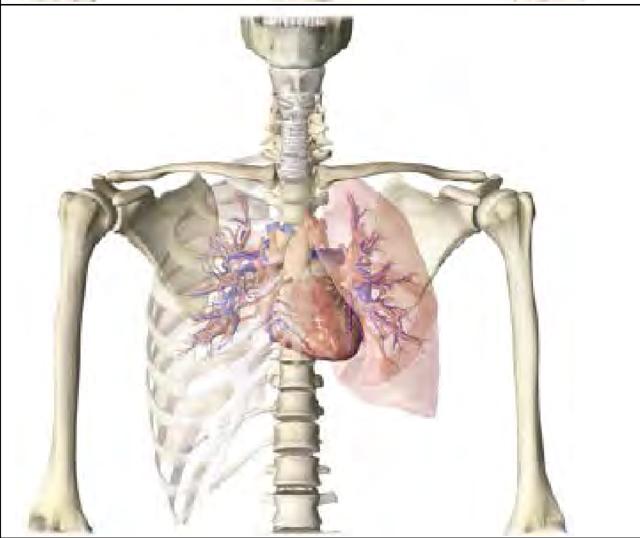
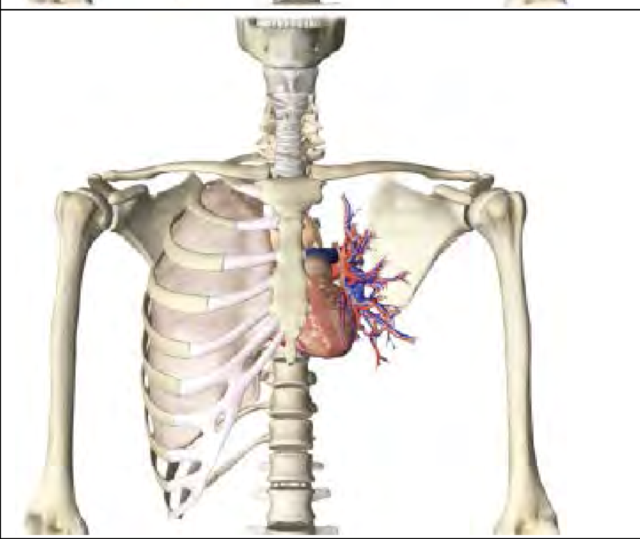
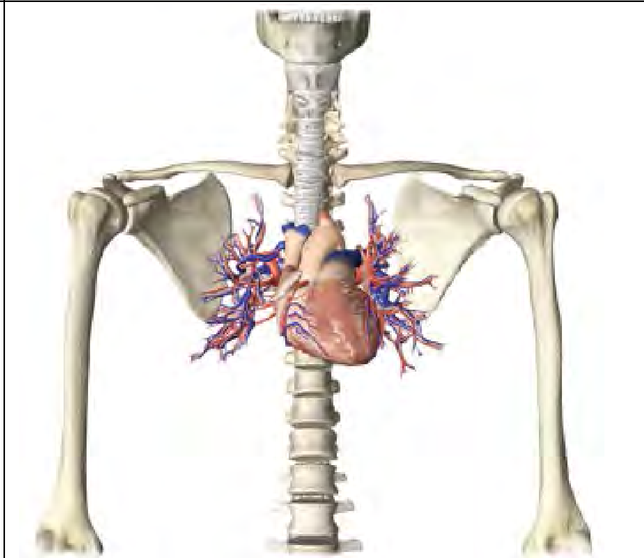
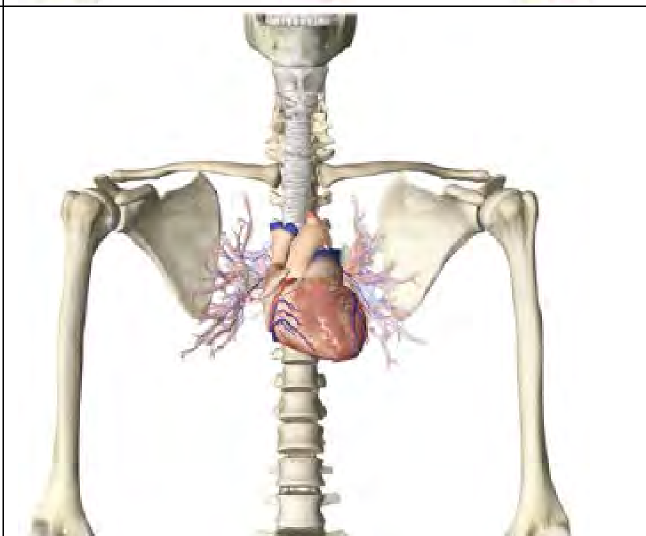
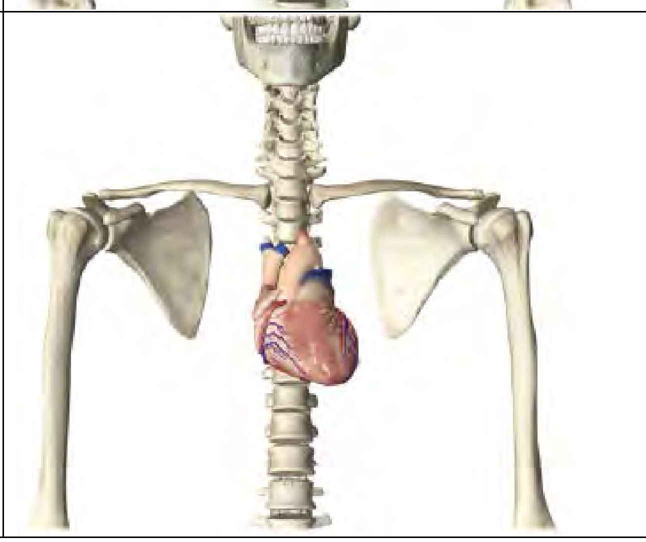
No.	Graphic Illustration	Illustration Description
8		**Muscle Group 5 Removed** Transversus Abdominis–middle abdomen Inferior Pharyngeal Constrictor–neck Longissimus Cervicis–neck Subscapularis–shoulder area Supraspinatus–shoulder area Sternothyroid–neck Subclavius–collar bone area Triceps/all–upper arm
9		**Muscle Group 6 Removed** Intercostal Innermost-ribs 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.
10		**Muscle Group 5 Removed** Transversus Thoracis–sternum area Subcostalis–ribs area Visible ribs, lung outer pleura, heart behind sternum

No.	Graphic Illustration	Illustration Description
11		**Ribs 1-10 Removed from Left Side**
12		**Ribs 11-12 Removed from Left Side**
13		**Removal of the Parietal Pleura Surrounding the Left Lung**

NO.	GRAPHIC ILLUSTRATION	ILLUSTRATION DESCRIPTION
14		**Removal of the Visceral Pleura Surrounding the Left Lung**
15		**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.
16		**Removal of Transparent Lung Revealing Pulmonary Vessels**

No.	**Graphic Illustration**	**Illustration Description**
17		**Removal of Remaining Ribs, Sternum, and Lung Exposing Heart and Pulmonary Vessels**
18		**Fading of Pulmonary Vessels to Show Heart**
19		**Removal of Pulmonary Vessels to Completely Show Heart**

X2 CEW Human Studies

X2 CEW Prospective Human Studies:

1. (11/2013 Ho) Ho, J.D., Dawes, D.M., Chang, R.J., Nelson, R.S., Miner, J.R. 2013. Physiologic Effects of a New-Generation Conducted Electrical Weapon on Human Volunteers. Original Research Article. The Journal of Emergency Medicine, Available online 12 November 2013.
    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

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

1. (06/2009 Sweeney) Sweeney J. Theoretical Comparisons of Nerve and Muscle Activation by Neuromuscular Incapacitation Devices. Conf Proc IEEE Eng Med Biol Soc. 2009;1:3188–3190.

    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."

2. (02/2009 Sweeney) Sweeney, J.D. Chapter 5, Transcutaneous Muscle Stimulation. Page 60. Kroll M, Ho J, eds. TASER® Conducted Electrical Weapons: Physiology, Pathology, and Law. Springer, 2009.

    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."

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No Clinically Significant Biochemical/Physiologic Changes:

1. (11/2014) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "Deaths temporally related to ECD discharges have raised the issue of death being directly caused by electrocution or some other effect of ECD discharge such as respiratory paralysis, metabolic perturbation or catecholamine toxicity; however, human studies have failed to detect any significant ECD-induced alterations in cardiovascular, respiratory and/or metabolic parameters following single or prolonged discharges (31, 89-95). Animal (swine) studies have also not demonstrated excess mortality attributable to prolonged continuous ECD discharges (96, 97)." (page 381). [highlighting emphasis added].]

2. (05/2011 Pasquier) Pasquier, M., Electronic Control Device Exposure: A Review of Morbidity and Mortality, Annals of Emergency Medicine, May 2011.

    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."

3. (01/2011 AAEM/JEM-Vilke) Vilke GM, Bozeman WP, Chan TC., Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician, The Journal of Emergency Medicine, In Press, Corrected Proof. Position Paper Approved by the American Academy of Emergency Medicine Clinical Guidelines Committee.

    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."

4. (04/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

    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."

(CK/Rhabdomyolysis) No Clinically Significant CK Increase from CEW:

1. (03/2012 Kunz) S.N. Kunz, et al., Acute pathophysiological influences of conducted electrical weapons in humans: A review of current literature, Forensic Sci. Int. 221 (2012) 1–4. [Mar 2012;Epub].

   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."

2. (03/2011 Dawes) Dawes DM, Ho JD, Sweeney JD, et al. The effect of an electronic control device on muscle injury as determined by creatine kinase enzyme. Forensic Sci Med Pathol. Mar 2011;7(1):3–8.

   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."

(Lactate) No Clinically Relevant Lactate from Short-Duration (≤ 45 s) CEW Discharge:

1. (04/2013 Jauchem) Jauchem, J.R. 2013. Blood lactate concentration after exposure to conducted energy weapons (including TASER® devices): is it clinically relevant? Forensic Science, Medicine, and Pathology. April 2013.

   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 [up to 45 seconds] CEW applications, due to the short time course of any increase."

b. "Investigators have presented strong evidence of no serious detrimental effects of relatively short-duration (up to 15 s) TASER" CEW exposures to healthy human volunteers [11, 59–64]. Exposures of 30 s [65] and 45 s [66] also resulted in no serious detrimental effects."

c. "Key points

(1) Significant increases in blood lactate concentration (BLac) due to conducted energy weapon (CEW) applications have been consistent with previous reports in the literature dealing with studies of muscle stimulation or exercise. Some have suggested that the increased BLac would have detrimental consequences.

(2) 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.

(3) Even though increases in BLac were often statistically significant after CEW exposures, such changes would not be expected to be clinically significant due to the short time course. BLac, separate from acidemia, would not be expected to be clinically relevant immediately after short-duration CEW applications."

Breathing – Evidence Suggests CEW Increases Respiratory Parameters:

1. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

   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 dysfunction[11] following exposures less than 45 seconds." Page 27.

2. (01/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical

Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

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."

3. (11/2007 Ho) Ho JD, Dawes DM, Bultman LL, et al. Respiratory effect of prolonged electrical weapon application on human volunteers. Acad Emerg Med. 2007;14:197-201.

a. "**Conclusions:** Prolonged [15 second] CEW application did not impair respiratory parameters in this population of volunteers. Further study is recommended to validate these findings in other populations."

(Blood Pressure) 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

Author	N	SBP1	SBP2	Delta	DBP1	DBP2	Delta
Dawes[81]	11	141.3	142.9	1.6	81.8	76	-5.8
Ho[82]	45	149	147	-2	86	83	-3
Ho[83]	12	139	141	2	88	84	-4
Bozeman[84]	28	138.6	145.8	7.2	82.8	85.6	2.8
Vilke[85]	25	139	128	-11	86	78	-8
Vilke[86]	32	139	128	-11	84	83	-1
Totals	153			-3.1			-2.6

[81] Dawes DM, Ho JD, Reardon RF, Miner JR. The cardiovascular, respiratory, and metabolic effects of a long duration electronic control device exposure in human volunteers. Forensic Sci Med Pathol. Dec 2010;6(4):268–274.

[82] Ho JD, Dawes DM, Reardon RF, et al. Human cardiovascular effects of a new generation conducted electrical weapon. Forensic Sci Int. May 26 2010.

[83] Ho JD, Dawes DM, Nelson RS, et al. Acidosis and catecholamine evaluation following simulated law enforcement "use of force" encounters. Acad Emerg Med. Jul 2010;17(7):e60–68.

[84] Bozeman WP, Barnes DG, Jr., Winslow JE, 3rd, Johnson JC, 3rd, Phillips CH, Alson R. Immediate cardiovascular effects of the Taser X26 conducted electrical weapon. Emerg Med J. Aug 2009;26(8):567–570.

[85] Vilke GM, Sloane CM, Suffecool A, et al. Physiologic effects of the TASER after exercise. Acad Emerg Med. Aug 2009;16(8):704–710.

[86] Vilke GM, Sloane CM, Bouton KD, et al. Physiological effects of a conducted electrical weapon on human subjects. Ann Emerg Med. Nov 2007;50(5):569–575.

Number of CEW Discharges: Multiple and Prolonged CEW Discharges:

1. (12//2014 Jauchem Survey Paper) J. R. Jauchem, "Exposures to Conducted Electrical Weapons (Including TASER Devices): How Many and for How Long are Acceptable?," *J Forensic Sci*, Nov 28 2014.

   "**ABSTRACT:**

   TASER® conducted electrical weapons (CEWs) are an important law-enforcement tool. The purposes of this study are a) to review recent literature regarding potential pathophysiological responses to applications of CEWs, and other related issues and b) to evaluate whether enough data exist to determine the acceptability of longer-duration (or repeated) exposures. This is a narrative review, using a multidisciplinary approach of analyzing reports from physiological, legal-medical, and police-strategy literature sources. In general, short-duration exposures to CEWs result in limited effects. Longer-duration or repeated exposures may be utilized with caution, although there are currently not enough data to determine the acceptability of all types of exposures. Data examined in the literature have inherent limitations. Appropriateness of specific types of CEW usage may be determined by individual police agencies, applying risk/benefit analyses unique to each organization. While more research is recommended, initial concepts of potential future long-duration or repeated CEW applications are presented."

   "**Conclusions**

   The benefits of CEWs, as designed for common short-duration law-enforcement usage, outweigh the risks. CEWs may be, in general, more effective and less dangerous than other use-of-force options in certain circumstances. As Synyshyn (243) succinctly stated, "controversy surrounding their use in law enforcement will undoubtedly continue." It is unknown, at this time, exactly for how long and how many CEW exposures to a subject are acceptable. Not enough data exist to determine the acceptability of long-duration (or repeated) exposures.

   Predictions of physiological results of different on/off cycles of CEWs can only be very speculative. A working hypothesis, however, may be proposed that, in some situations, different times of CEW exposure (interspersed with different "rest" intervals) may be useful for future weapon development. Relatively continuous exposure for durations of several min, though, may create unacceptable target safety risks." (highlighted emphasis)

2. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

a. “Deaths temporally related to ECD discharges have raised the issue of death being directly caused by electrocution or some other effect of ECD discharge such as respiratory paralysis, metabolic perturbation or catecholamine toxicity; however, human studies have failed to detect any significant ECD-induced alterations in cardiovascular, respiratory and/or metabolic parameters following single or prolonged discharges (31, 89-95). Animal (swine) studies have also not demonstrated excess mortality attributable to prolonged continuous ECD discharges (96, 97).” (page 381). (highlighting emphasis added).

3. (06/2013) Levy, K. 2013. Multiple and prolonged Taser deployments. Crime and Misconduct Commission (CMC). Brisbane, Queensland, Australia. June 2013.

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:

1. (05/2011 Laub/NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

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[9,10] or respiratory dysfunction[11] 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,

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from continuous activations of greater than 15 seconds, as few studies have reported on longer time frames." Page viii.

2. (2011 Dawes) Dawes, D.M., Ho, J.D., Sweeney, J.D., Lundin, E.J., Kunz, S.N., and Miner, J.R.: 'The effect of an electronic control device on muscle injury as determined by creatine kinase enzyme', Forensic Sci Med Pathol, 2011, 7, (1), pp. 3-8.

   a. **Key points:**

      1. Electronic devices can cause modest increases in CK.

      2. The number of simultaneous exposures may increase this risk.

      3. There is a correlation between probe spread and elevation in CK.

      4. The duration did not seem to increase the risk up to 30 s.

      5. The large elevations in CK seen in arrest related cases are likely related to other causes such as severe exertion, drugs, and hyperthermia, rather than ECD exposure.

3. (2010 Dawes) Dawes, D.M., Ho, J.D., Reardon, R.F., and Miner, J.R.: The cardiovascular, respiratory, and metabolic effects of a long duration electronic control device exposure in human volunteers, Forensic Sci Med Pathol, 2010, 6, (4), pp. 268-274.

   a. C2 CEW, 30 second exposure on the anterior thorax.

   b. "This study is the first to look at the cardiovascular, respiratory, and metabolic effects of this device on human subjects. This was a prospective, observational study of human subjects involved in a training course. Subjects were exposed for 30 s on the anterior thorax. Vital signs, ECG, troponin I, pH, lactate, and creatine kinase (CK) were measured before and immediately after the exposure. Troponin I, pH, lactate, and CK were measured again 24 h after the exposure. Continuous spirometry was used to evaluate the respiratory effects. Echocardiography was also performed before, during, and immediately after the exposure to determine heart rate and rhythm."

   c. "**Conclusions**. In our study, the civilian device caused a mild lactic acidosis. No other important physiologic effects were found."

4. (12/2009 Jauchem) Jauchem JR. Repeated or long-duration TASER electronic control device exposures: acidemia and lack of respiration. Forensic Sci Med Pathol. Mar 2010;6(1):46-53.

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

5. (03/2009 Dawes) Dawes, D.M. Chapter 14, Effects of CEWs on Respiration, TASER® Electronic Control Devices: Physiology, Pathology, and Law, by Mark W. Kroll (Editor), Jeffrey D. Ho (Editor).

   a. “The XREP® device is a nontethered, shotgun fired projectile weapon manufactured by TASER International with a similar waveform to the TASER X26 CEW. In a study of this weapon, subjects had venipuncture prior to the application of the CEW and immediately after the exposure, and venous samples were analyzed to obtain venous pH, pCO_2, HCO_3, lactate, as well as Na and K [18]. Breathing data were collected by a breath-by-breath gas exchange system. All subjects were exposed for a minimum of 15 seconds. Exposure was thoraco abdominal with one lead over the pectoralis major muscle, and the other in the upper abdomen. In 27 subjects, the device was programmed for a 45-second exposure. The subjects could terminate the exposure with a ‘‘tap out’’ button after 15 seconds. In 23 subjects, the exposure was fixed at 20 seconds. In four of these subjects, the device was programmed to deliver two exposures. The first exposure was the standard thoracoabdominal exposure, and the second was between the contralateral abdomen and the thigh.” (highlighting emphasis added) Page 176.

6. (01/2009 Bozeman) Bozeman W, II WH, Heck J, Graham D, Martin B, Winslow J., Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officer Against Criminal Suspects, Annals of Emergency Medicine, January 2009.

   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.”

7. (09/2007 Dawes) Dawes D, Ho J, Johnson M, Lundin, E., Miner, J. Breathing parameters, venous blood gases, and serum chemistries with exposure to a new

wireless projectile conducted electrical weapon in human volunteers. Ann Emerg Med. 2007;50:S133.

a. "**Methods:** Subjects had venipuncture prior to the application of the CEW and immediately after the exposure, and venous samples were analyzed to obtain venous pH, pCO2, HCO3, lactate, as well as Na and K. Breathing data was collected by a breath by breath gas-exchange system. All subjects were exposed for a minimum of 15 seconds. Exposure was thoraco-abdominal with one lead over the pectoralis major muscle, and the other in the upper abdomen. In 27 subjects, the device was programmed for a 45-second exposure. The subjects could terminate the exposure with a "tap out" button after 15 seconds. In 23 subjects, the exposure was fixed at 20 seconds. In 4 of these subjects, the device was programmed to deliver 2 exposures. The first exposure was the standard thoraco-abdominal exposure, and the second was between the contra-lateral abdomen and the thigh."

b. "**Conclusion:** This study demonstrates that the new CEW has no important deleterious effects on respiratory parameters, blood chemistries, or venous blood gases. These results are consistent with previous results for the TASER X26 CEW.

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

1. (03/2013 Jenkins) Jenkins, M.D., Murray, W.B., Kennet, M.J. 2013. The Effects of Continuous Application of the TASER X26 [CEW] Waveform on Sus scrofa. *J Forensic Sci*, 2013

   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."

2. (11/2007 Hughes) Hughes E, Kennett M, Murray W, Werner JR, Jenkins DM. Electro-Muscular Disruption (EMD) Bioeffects: A Study of the Effects of Continuous Application of the TASER X26 Waveform on Swine. Penn State University Institute for Non-Lethal Defense Technologies. Nov 30 2007.

   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:

1. (06/2011 Ho) Ho JD, Dawes DM, Reardon RF, et al. Human cardiovascular effects of a new generation conducted electrical weapon. Forensic Sci Int. Jan 30 2011;204(1-3):50–57.

    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."

2. (04/2011 Dawes) Dawes D, Ho J, Orozco B, et al. The Respiratory, Metabolic and Neuroendocrine Effects of a New Generation Electronic Control Device. Forensic Sci Int. Apr 25 2011;207(1-3):55–60.

    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."

3. (02/2010 Dawes) Dawes D, Ho J, Reardon RF, Sweeney JD, Miner JR. The Physiologic Effects of Multiple Simultaneous Electronic Control Device Discharges. *West J Emerg Med*. Feb 2010;11(1):49–56.

    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:

1. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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:

1. (03/2014 Dawes) Dawes, D., Ho, J., Nystrom, P., Moore, J., Miner, J. Markers of acidosis and stress in a sprint versus a conducted electrical weapon. Australasian College for Emergency Medicine 30th Annual Scientific Meeting. 24–28 November 2013, Adelaide, Australia. *Emergency Medicine Australasia* (2014) 26, ••–••. doi: 10.1111/1742-6723.12244.

2. (09/2013 Ho) Ho, J.D., Dawes, D.M., Nystrom, P.C., Collins, D.P., Nelson, R.S., Moore, J.S. 2013. Markers of acidosis and stress in a sprint versus a conducted electrical weapon. Forensic Science International, Volume 233, Issues 1–3, 10 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.

3. (05/2013) Dawes) Dawes, D., Ho., J., Nystrom, P., Miner, J. 2013. Poster Presentation #675. Markers of Acidosis and Stress in a Sprint Versus a Conducted Electrical Weapon. Society for Academic Emergency Medicine

[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)

(SAEM), Atlanta, GA. May 17, 2013.

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

4. (03/2013 Dawes) (SAEM Presentation) Dawes, D. 2013. Markers of Acidosis and Stress in a Sprint Versus a Conducted Electrical Weapon, Track 4: EMA/Disaster, Society for Academic Emergency Medicine (SAEM) Western Regional Meeting. March 23, 2013.

   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.]

Catecholamines:

1. (2013 Ishikawa) Ishikawa T, Quan L, Michiue T, et al. Postmortem catecholamine levels in pericardial and cerebrospinal fluids with regard to the cause of death in mediolegal autopsy. *Forensic Sci Int*. 2013:52-60.

   a. "These findings suggest that characteristic elevations in Adr, Nad, and DA levels in PCF and CSF are involved in systemic responses to fatal stress and toxic neuronal dysfunction, reflecting the magnitude of such responses in individual cases."

   b. "In conclusion, the present study has demonstrated topographic differences in catecholamines in right heart blood, PCF, and CSF, which depend on the cause of death, and suggest that characteristic elevations in Adr, Nad, and DA levels in PCF and CSF are involved in systemic responses to fatal stress and toxic neuronal dysfunction, reflecting the magnitude of such responses in individual cases; these PCF and CSF markers can be used as indicators of sitespecific stress responses in the heart and brain following traumatic insults, as well as alternatives to serum markers."

2. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of conducted Energy Weapons – Full Report. Council of Canadian Academies and Canadian Academy of Health Services. 2013. Pages 30-31:

   a. "Results indicate that although CEWs can induce the stress response, the increased hormone levels seen as a result of CEW exposure are lower than levels activated by other forms of restraint and stress, and decrease over time. Key studies include the following:

(1) Werner et al. (2012) explored the effects of stress and other physiological processes in swine by exposing pigs to a one-minute CEW discharge, followed by a one-hour rest and a second discharge of three minutes. Overall, catecholamines increased during and immediately after each CEW application, followed by a gradual decline over time.[88]

(2) Dawes et al., (2009), in a study involving law enforcement agents, examined the capacity of different types of restraint mechanisms (and other interventions) to elicit the human stress response, including pepper spray (oleoresin capsicum spray), a five-second CEW exposure, cold water tank immersion, and physical exertion. The authors concluded that although the CEW did elicit an increase in stress hormones, physical exertion and pepper spray activated the stress response more than exposure to a CEW or a cold water tank."

3. (2012 Werner) [Swine] Werner JR, Jenkins DM, Murray WB, Hughes EL, Bienus DA, Kennett MJ. Human Electromuscular Incapacitation Devices Characterization: A Comparative Study on Stress and the Physiological Effects on Swine. *J Strength Cond Res.* Mar 2012;26(3):804-810.

   a. "Each animal was exposed to an initial 60-second application of the EMD device as an initial stressor. The animals were then allowed to rest under anesthesia for 60 minutes followed immediately by a 180-second application of the same device."

   b. "Cortisol tended to decrease after the initial exposure and slightly increased over the rest period. The extreme muscular work caused bj the electrical stimulation resulting in muscle contractions did not result in a strong stress response but did result in an immediate sympathetic response during both applications of the device leading to the conclusion that initial stressor followed bj rest and prolonged EMD device application did not exhaust the sympathetic system. For healthy adult animals, despite the prolonged muscular exertion and physiological stress caused by EMD devices, the body should be able to mount an appropriate sympathetic response and recover normally."

   c. "Furthermore, the animals that died also did not exhibit a higher than average catecholamine response, indicating that death is not associated with excessive catecholamines in our model."

[88] Werner JR, Jenkins DM, Murray WB, Hughes EL, Bienus DA, Kennett MJ. Human Electromuscular Incapacitation Devices Characterization: A Comparative Study on Stress and the Physiological Effects on Swine. J Strength Cond Res. Mar 2012;26(3):804-810.

4. (04/2011 Dawes) Dawes D, Ho J, Orozco B, et al. The Respiratory, Metabolic and Neuroendocrine Effects of a New Generation Electronic Control Device. *Forensic Sci Int*. Apr 25 2011;207(1-3):55-60.

5. (09/2010 Dawes) Dawes D, Ho J, Orozco B, et al. The Respiratory, Metabolic and Neuroendocrine Effects of a New Generation Electronic Control Device [POSTER]. SAEM Scientific Assembly. Sept 28, 2010.

6. (08/2009 Vilke) Vilke G, Sloane C, Suffecool A, et al. Physiologic Effects of the TASER After Exercise. *Acad Emerg Med*. Aug 2009;16(8):704–710.

   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."

7. (02/2009 Dawes) Dawes, D.M., Kroll, M.W. Chapter 15, Neuroendocrine Effects of CEWs, Kroll M, Ho J, eds. TASER® Conducted Electrical Weapons: Physiology, Pathology, and Law. Springer, 2009.

8. (01/2009 Dawes) Dawes D, Ho J, Miner J. The neuroendocrine effects of the TASER X26: a brief report. *Forensic Sci Int*. Jan 10 2009;183(1-3):14-9.

9. (1984 Dimsdale) Dimsdale J, Hartley H, Guiney T, Ruskin J, Greenblatt D. Postexercise Peril. *JAMA*. 1984;251(5):630- 632.

   a. "Postexercise cardiac morbidity is noted both in the exercise testing laboratory and in the field, but the physiology of this phenomenon has been unclear. Plasma catecholamine levels were studied in ten healthy men at each work load during exercise testing and during the recovery period after exercise. Both norepinephrine and epinephrine levels increased in response to exercise, although the response was much more noteworthy for norepinephrine. In the recovery period after exercise, both catecholamine levels continued to increase, with the norepinephrine level increasing tenfold over baseline. Such increases may have profound effects, particularly for subjects with preexisting coronary disease."

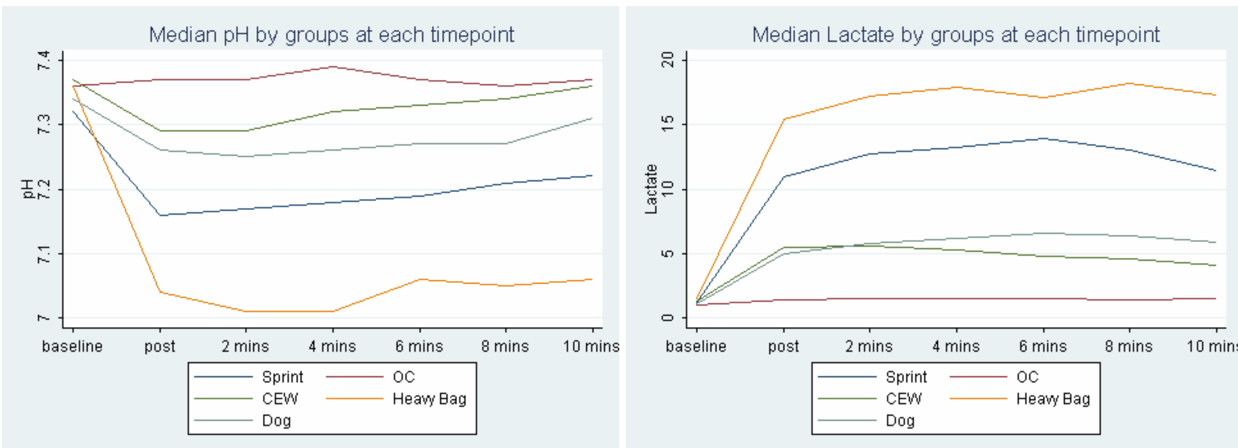
Acidosis/Catecholamine Following Simulated Force Encounters:

1. (07/2010 Ho) Ho, J.D., Dawes, D.M., Nelson, R.S., Lundin, E.J., Ryan, F.J., Overton, K.G., Zeiders, A.J., Miner, J.R. 2010. Acidosis and Catecholamine Evaluation Following Simulated Law Enforcement "Use of Force" Encounters. *Acad Emerg Med*. July 2010;17(7)e60–68.

   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."

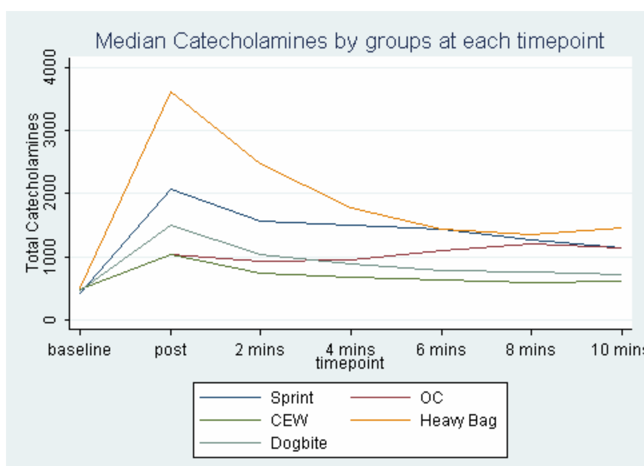
b. **Acidosis:**

Figure 10 Acidosis



c. **Catecholamines:**

Figure 11 Catecholamines



2. (09/2009 Ho) Ho J, Dawes D, Ryan F, et al. Catecholamines and Troponin in Simulated Arrest Scenarios [POSTER]. The Fifth Mediterranean Emergency Medicine Congress (MEMC V). September 14-17 2009.

   a. "**Conclusions.** The comparison of use of force encounters demonstrated that the simulated combat was one of the most activating of catecholamines."

3. (09/2009 Lundin) Lundin, E.J., Dawes, D.M., Ho., J.D., Ryan, F.J., Miner, J.R. 2009. 315: Catecholamines in Simulated Arrest Scenarios. Annals of Emergency Medicine. Volume 54, Issue 3, Supplement, September 2009, Pages S98–S99. ACEP Research Forum 2009 Scientific Assembly.

    a. "**Conclusions.** The comparison of use of force encounters demonstrated that the ECO was one of the least activating of catecholamines while the simulated combat was one of the most activating. The simulated combat also lowered the pH the most out of all the tasks. These results combined suggest that fighting with LEOs may be the most detrimental from a physiologic standpoint. The authors recommend further study in this area to assist LEOs in determining the best tactics and devices to utilize in arrest scenarios that have higher likelihood of being associated with an ARD."

4. (2009 Ho) Ho J, Lundin E, Dawes D, Ryan F, Miner J. Catecholamines in Simulated Arrest Scenarios [POSTER] American College of Emergency Physicians 2009 Scientific Assembly. 2009.

5. (06/2009 Ho) Ho J, Lundin E, Dawes D, Ryan F, Miner J. Catecholamines in Simulated Arrest Scenarios [POSTER] ACEM Winter Symposium. Darwin Northern Territory, Australia. 2009.

6. Ho J, Dawes D, Johnson M, Miner J. The Neuroendocrine Effects Of The TASER X26 Conducted Electrical Weapon As Compared To Oleoresin Capsicum [POSTER]. Fourth Mediterranean Emergency Medicine Congress (MEMC IV), Sorento, Italy.

CEW Physiologic Effects After Exercise/Exhausted:

1. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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.

2. (09/2009 Ho) Ho J, Dawes D, Cole J, et al. Lactate and pH evaluation in exhausted humans with prolonged TASER X26 exposure or continued exertion. Forensic Sci Int. Sep 10 2009;190(1-3):80–86.

    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."

3. (08/2009 Vilke) Vilke G, Sloane C, Suffecool A, et al. Physiologic Effects of the TASER After Exercise. Acad Emerg Med. Aug 2009;16(8):704–710.

   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."

4. (05/2009 Ho) Ho JD, Dawes DM, Buttman LL, et al. Prolonged TASER use on exhausted humans does not worsen markers of acidosis. Amer J Emer Med. 2009;27:413–418.

   a. "**Conclusion:** Prolonged [15 second] CEW application on exhausted humans was not associated with worsening change in pH or troponin. Decreases in pCO_2 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

1. (04/2015 Dawes) Dawes, D., Ho., J. General stress response, not the TASER: reply to "Examining the effects of the TASER on cognitive functioning: findings from a pilot study with police recruits." *Journal of Experimental Criminology*, 2015, 1-3.

2. (04/2015 White) White MD, Ready JT, Kane RJ, Yamashiro CT, Goldsworthy S, Bonds McClain D. Examining Cognitive Functioning Following TASER Exposure: A Randomized Controlled Trial. *Applied Cognitive Psychology*. 2015.

3. (06/2014 Ho) Ho, J., Dawes, D., Nystrom, P., Moore, J., Steinberg, L., Tilton, A., Miner, J. Effect of simulated resistance, fleeing, and use of force on standardized field sobriety testing. *Med Sci Law* 2014 0 (2014), p. 0025802414536152v1.

    a. "**Conclusions:** This is the first human study to examine the effects of physical resistance, flight, and use of force on the SFST result. We did not detect a difference in the performance of subjects taking the SFST before and after exposure to resistance, flight, or a simulated use of force."

4. (03/2014 Dawes) Dawes, D., Ho, J., Vincent, A., Nystrom, P., Moore, J., Brave, Mike. The neurocognitive effects of simulated use-of-force scenarios. Australasian College for Emergency Medicine 30th Annual Scientific Meeting. 24–28 November 2013, Adelaide, Australia. *Emergency Medicine Australasia* (2014) 26, ••–••. doi: 10.1111/1742-6723.12244.

5. (01/2014 White) White, M.D., Ready, J.T., Kane, R.J., Dario, L.M. 2014. Examining the effects of the TASER on cognitive functioning: findings from a pilot study with police recruits. J Exp Criminol. DOI 10.1007/s11292-013-9197-9.

    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.)

6. (11/2013) Dawes, D.M., Ho, J.D., Vincent, A.S., Nystrom, P.C., Moore, J.C., Steinberg, L.W., Tilton, A.M.K., Brave, M.A., Berris, M.S., Miner, J.R. 2013. The neurocognitive effects of simulated use-of-force scenarios. Forensic Science, Medicine, and Pathology, 2013, 1-9. (DOI) 10.1007/s12024-013-9510-y.

    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.

7. (10/2013 Dawes) Dawes, D., Ho, J. 2013. The Neurocognitive Effects of Simulated Use-of-Force Scenarios. Police Physicians Section Track. International Association of Chiefs of Police Annual Conference, Philadelphia, Pennsylvania. October 20, 2013.

8. (10/2013 Dawes) Dawes, D., Ho, J., Vincent, A., Nystrom, P., Moore, J., Brave, M., Miner, J. 2013. Poster: The neurocognitive effects of simulated use-of-force scenarios. American College of Emergency Physicians (ACEP). Scientific Assembly, Seattle (WA). Ann Emerg Med, 2013; 62 (4): S128.

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."

9. (09/2013 Ho) Ho, J.M., Dawes, D.M., Nystrom, P.C., Moore, J.C., Steinberg, L.W., Tilton, A.K., Miner, J.R. 2013. Neurocognitive effect of simulated resistance and use of force encounters on standardized field sobriety testing. European Society for Emergency Medicine (EuSEM), 7th Mediterranean Emergency Medicine Congress, Marseille, France, 8–11 September 2013.

   a. Published at: (01/2014 Ho) Ho, J., Dawes, D., Miner, J., Moore, J., Nystrom, P. 2014. Neurocognitive Effect of Simulated Resistance and Use of Force Encounters on Standardized Field Sobriety Testing. The Journal of Emergency Medicine 01/2014 46(2):283.

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

10. (04/2013 Ho) Ho, J., Dawes, D., Nystrom, P., Moore, J., Steinberg, L., Tilton, A., Miner, J., 2013. Poster Presentation #231. The Neurocognitive Effect of Resistance and Simulated Use of Force Encounters on Standardized Field Sobriety Testing. Society for Academic Emergency Medicine (SAEM), Atlanta, GA. May 15, 2013.

    a. "**Conclusion:** LEO UOF or physical resistance simulations do not appear to impair a person's neurocognitive ability as evaluated by SFSTs."

11. (06/05/2009) John Criscione, Ph.D., M.D., An Independent Assessment of the Physiological and Cognitive Effects from the X-26 TASER® Device in Volunteer Human Subjects, Final Report.

    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

1. (03/2014 Criscione) Criscione, J.C., Kroll, M.W. 2014. Incapacitation recovery times from a conductive electrical weapon exposure. *Forensic Sci Med Pathol*. DOI 10.1007/s12024-014-9551-x. Published online 26 March 2014.

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

No.	Date	Document
1	Nov. 2011	Ready, Justin T., and White, Michael D., Exploring patterns of TASER [ECD] use by the police: an officer-level analysis, Journal of Crime and Justice, Vol. 34, No. 3, November 2011, 190–204.
2	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.
3	Dec. 2010	Maryland Chiefs of Police Association, Maryland Sheriffs' Association, Agency Guidelines, For Use of Electronic Control Devices.
4	2010	Sousa, W., Ready, J., and Ault, M.: 'The impact of TASERs on police use-of-force decisions: Findings from a randomized field-training experiment', J Exp Criminol, 2010, 6, pp. 35-55.
5	Dec. 2009	Report of the Maryland Attorney General's (Douglas F. Gansler's) Task Force on Electronic Weapons
6	Jun. 2009	Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.
7	Mar. 2009	Mesloh, C., Henych, M. Wolf, R. 2009. Chapter 3: Conducted Electrical Weapons and Resolution of Use-of-Force Encounters. TASER® Electronic Control Devices: Physiology, Pathology, and Law, by Mark W. Kroll (Editor), Jeffrey D. Ho (Editor).
8	Nov. 2008	The use of Taser weapons by New South Wales Police Force, A special report to Parliament under section 31 of the Ombudsman Act 1974.
9	Jun. 2008	Eastman, A.L., et al., Conductive electrical devices: a prospective, population-based study of the medical safety of law enforcement use, J Trauma, 2008, 64(6): p. 1567–72.
10	Jun. 2008	Breitkreuz, M.P., G. Chair. Study of the Conductive Energy Weapon–TASER®. Report of the Standing Committee on Public Safety and National Security. House of Commons, Canada, 39th Parliament, 2nd Session,
11	Jul. 2005	Sergeant Brian A. Bruce, Six Month T[ASER ECD] Study July 5, 2005, City of Columbus, Ohio Division of Police.
12	Jan. 2005	Lieutenant Victor Wahl, TASER [ECD] Report, Madison (WI) Police Department ("MPD").
13	2003	Hopkins P, Beary K. TASER use and officer/suspect injuries. Orlando, Fl: Orange County Sheriff's Office. 2003.

1. (11/2011 Ready) Ready, Justin T., and White, Michael D., Exploring patterns of TASER [ECD] use by the police: an officer-level analysis, Journal of Crime and Justice, Vol. 34, No. 3, November 2011, 190–204.

    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).

2. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

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.

3. (12/2010 MCPA) Maryland Chiefs of Police Association, Maryland Sheriffs' Association, Agency Guidelines, For Use of Electronic Control Devices.

   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.

4. (2010 Sousa) Sousa, W., Ready, J., and Ault, M.: 'The impact of TASERs on police use-of-force decisions: Findings from a randomized field-training experiment', J Exp Criminol, 2010, 6, pp. 35-55.

   a. " … The findings indicate that officers who were armed with the TASER were significantly less likely to deploy pepper spray and the baton in response to aggressive physical resistance. Additionally, the results show that officers equipped with the TASER were less likely to discharge their firearm when confronted with suspect resistance that was potentially lethal. No differences in police behavior occurred in response to passive suspect resistance.

5. (12/2009 MAG) Report of the Maryland Attorney General's (Douglas F. Gansler's) Task Force on Electronic Weapons.

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

6. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

   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."

7. (03/2009 Mesloh) Mesloh, C., Henych, M. Wolf, R. 2009. Chapter 3: Conducted Electrical Weapons and Resolution of Use-of-Force Encounters. TASER® Electronic Control Devices: Physiology, Pathology, and Law, by Mark W. Kroll (Editor), Jeffrey D. Ho (Editor).

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.

8. (11/2008) (Australia) The use of Taser weapons by New South Wales Police Force, A special report to Parliament under section 31 of the Ombudsman Act 1974.

    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.

9. (06/2008 Eastman) Eastman, A.L., et al., Conductive electrical devices: a prospective, population-based study of the medical safety of law enforcement use, J Trauma, 2008, 64(6): p. 1567–72.

    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."

10. (06/2008 Breitkreuz) (Canada) Breitkreuz, M.P., G. Chair. Study of the Conductive Energy Weapon–TASER®. Report of the Standing Committee on Public Safety and National Security. House of Commons, Canada, 39th Parliament, 2nd Session,

    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.

11. (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."

12. (01/2005 Wahl) Lieutenant Victor Wahl, TASER [ECD] Report, Madison (WI) Police Department ("MPD").

    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.

13. (2003 Hopkins) Hopkins P, Beary K. TASER use and officer/suspect injuries. Orlando, Fl: Orange County Sheriff's Office. 2003.

CEWs Reduce Suspect Injuries:

Table 29 CEWs Reduce Suspect Injuries

No.	Date	Document
1	Updated	See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®)
2	Feb. 2014	Covington, Michele W.; Huff-Corzine, Lin; Corzine, Jay. 2014. Battered Police: Risk Factors for Violence Against Law Enforcement Officers. *Violence and Victims*, 2014, vol. 29, no. 1, pp. 34-52(19).
3	Feb. 2014	Robert J. Kaminski, Robin S. Engel, Jeff Rojek, Michael R. Smith & Geoffrey Alpert, Justice Quarterly (2013): A Quantum of Force: The Consequences of Counting Routine Conducted Energy Weapon Punctures as Injuries, *Justice Quarterly*, DOI: 10.1080/07418825.2013.788729.
4	Dec. 2012	Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.
5	Jul. 2010	Smith M, Kaminski R, Alpert G, Fridell L, MacDonald J, Kubu B., A Multi-Method Evaluation of Police Use of Force Outcomes: Final Report to the National Institute of Justice: US Department of Justice, 2010.
6	2010	Lin YS, Jones T. Electronic control devices and use of force outcomes. Policing: An International Journal of Police Strategies and Management. 2010; Vol. 33 No. 1, 2010. pp. 152–178.

No.	Date	Document
7	2010	Taylor, B., & Woods, D. J. (2010). Injuries to officers and suspects in police use-of-force cases: A quasi-experimental evaluation. Police Quarterly, 13, 260-289.
8	Sep. 2009	Woods, Taylor B, D, Kubu B, et al. Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi experimental evaluation. National Institute of Justice. September 2009.
9	Jun. 2009	Robinowitz, Carolyn B., MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.
10	Mar. 2009	Brewer J, Kroll M., Field Statistics Overview. In: Kroll M, Ho J, eds. TASER Conducted Electrical Weapons: Physiology, Pathology, and Law. New York City: Springer-Kluwer, 2009.
11	Dec. 2008	Green, Saul A., Jerome, Richard B., Independent Monitor's Final Report, City of Cincinnati (Ohio).
12	Dec. 2008	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.
13	Nov. 2007	Bovbjerg VE, Kelly JM, Heal CS, Murray WB. Field-based Evaluation of Non-lethal Weapons: Conducted Energy Weapons. NTIC. 2007. See also, Kenny J, Bovbjerg V, Heal C. Los Angeles Sheriff's Department's Use of M26 and X26 TASERs During the 1995-2004 Timeframe (Draft): Penn State Applied Research Laboratory. August 25 2008.
14	Oct. 2007	Michael R. Smith, Robert J. Kaminski, Jeffrey Rojek, Geoffrey P. Alpert and Jason Mathis, The impact of conducted energy devices and other types of force and resistance on officer and suspect injuries, Policing: An International Journal of Police Strategies & Management, Vol. 30 No. 3, 2007, pp. 423–446.
15	Jul. 2006	Jenkinson E, Neeson C, Bleetman A. The relative risk of police use-of-force options: evaluating the potential for deployment of electronic weaponry. J Clin. Forensic Med. Jul 2006;13(5):229–241.

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

2. (02/2014 Covington) Covington, Michele W.; Huff-Corzine, Lin; Corzine, Jay. 2014. Battered Police: Risk Factors for Violence Against Law Enforcement Officers. *Violence and Victims*, 2014, vol. 29, no. 1, pp. 34-52(19).

    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."

3. (02/2014 Kaminsky) Robert J. Kaminski, Robin S. Engel, Jeff Rojek, Michael R. Smith & Geoffrey Alpert, Justice Quarterly (2013): A Quantum of Force: The Consequences of Counting Routine Conducted Energy Weapon Punctures as Injuries, *Justice Quarterly*, DOI: 10.1080/07418825.2013.788729.

    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."

4. (12/2012 Adedipe) Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.

5. (07/2010 Smith) Smith M, Kaminski R, Alpert G, Fridell L, MacDonald J, Kubu B., A Multi-Method Evaluation of Police Use of Force Outcomes: Final Report to the

National Institute of Justice: US Department of Justice, 2010.

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."

6. (2010 Lin) Lin YS, Jones T. Electronic control devices and use of force outcomes. Policing: An International Journal of Police Strategies and Management. 2010; Vol. 33 No. 1, 2010. pp. 152–178.

   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.

7. (2010 Taylor) Taylor, B., & Woods, D. J. (2010). Injuries to officers and suspects in police use-of-force cases: A quasi-experimental evaluation. Police Quarterly, 13, 260-289.

   a. " … Compared with non-CED sites, CED sites had lower rates of officer injuries, suspect severe injuries, and officers and suspects receiving injuries requiring medical attention. Our results suggest that CEDs can be effective in helping minimize physical struggles and resulting injuries in use-of-force cases.

8. (09/2009 PERF/Woods) Taylor B, Woods D, Kubu B, et al. Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi experimental evaluation. National Institute of Justice. September 2009.

   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.

9. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

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."

10. (03/2009 Brewer) Brewer J, Kroll M., Field Statistics Overview. In: Kroll M, Ho J, eds. *TASER Conducted Electrical Weapons: Physiology, Pathology, and Law*. New York City: Springer-Kluwer, 2009.

    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%."

11. (12/2008 Cincinnati, OH) Green, Saul A., Jerome, Richard B., Independent Monitor's Final Report, City of Cincinnati (Ohio).

    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.

12. (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)."

13. (11/2007 Bovbjerg) Bovbjerg VE, Kelly JM, Heal CS, Murray WB. Field-based Evaluation of Non-lethal Weapons: Conducted Energy Weapons. NTIC. 2007. See also, Kenny J, Bovbjerg V, Heal C. Los Angeles Sheriff's Department's Use of M26 and X26 TASERs During the 1995-2004 Timeframe (Draft): Penn State Applied Research Laboratory. August 25 2008.

14. (10/2007 Smith) Michael R. Smith, Robert J. Kaminski, Jeffrey Rojek, Geoffrey P. Alpert and Jason Mathis, The impact of conducted energy devices and other types of force and resistance on officer and suspect injuries, Policing: An

International Journal of Police Strategies & Management, Vol. 30 No. 3, 2007, pp. 423–446.

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.

15. (07/2006 Jenkinson) Jenkinson E, Neeson C, Bleetman A. <u>The relative risk of police use-of-force options: evaluating the potential for deployment of electronic weaponry.</u> J Clin. Forensic Med. Jul 2006;13(5):229–241.

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:

Table 30 CEWs Reduce Officer Injuries

No.	Date	Document
1	Updated	See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®)

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4	2012	Brandl, S. G., & Stroshine, M. S. (2012). The physical hazards of police work revisited. *Police Quarterly*, 15, 262–282.
5	2010	Lin YS, Jones T. Electronic control devices and use of force outcomes. Policing: An International Journal of Police Strategies and Management. 2010; Vol. 33 No. 1, 2010. pp. 152–178.
6	2010	Taylor, B., & Woods, D. J. (2010). Injuries to officers and suspects in police use-of-force cases: A quasi-experimental evaluation. Police Quarterly, 13, 260-289.
7	Sep. 2009	Woods, Taylor B, D, Kubu B, et al. Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi experimental evaluation. National Institute of Justice. September 2009.
8	Jun. 2009	Robinowitz, Carolyn B., MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.
9	2009	DeLone, Gregory J., and Liddie M. Thompson. "The application and use of TASERs by a Midwestern police agency." *International Journal of Police Science and Management* 11.4 (2009): 414-428
10	Mar. 2009	Brewer J, Kroll M., Field Statistics Overview. In: Kroll M, Ho J, eds. TASER Conducted Electrical Weapons: Physiology, Pathology, and Law. New York City: Springer-Kluwer, 2009.
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    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."

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    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."

4. (2012 Brandl) Brandl, S. G., & Stroshine, M. S. (2012). The physical hazards of police work revisited. *Police Quarterly*, 15, 262–282.

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

5. (2010 Lin) Lin YS, Jones T. Electronic control devices and use of force

outcomes. Policing: An International Journal of Police Strategies and Management. 2010; Vol. 33 No. 1, 2010. pp. 152–178.

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.

6. (2010 Taylor) Taylor, B., & Woods, D. J. (2010). Injuries to officers and suspects in police use-of-force cases: A quasi-experimental evaluation. Police Quarterly, 13, 260-289.

   a. “ … Compared with non-CED sites, CED sites had lower rates of officer injuries, suspect severe injuries, and officers and suspects receiving injuries requiring medical attention. Our results suggest that CEDs can be effective in helping minimize physical struggles and resulting injuries in use-of-force cases.

7. (09/2009 PERF/Woods) Taylor B, Woods D, Kubu B, et al. Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi experimental evaluation. National Institute of Justice. September 2009.

   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.

8. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

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.”

9. (2010 DeLone) DeLone, Gregory J., and Liddie M. Thompson. "The application and use of TASERs by a Midwestern police agency." *International Journal of Police Science and Management* 11.4 (2009): 414-428.

a. “**ABSTRACT** Of the some 18,000 law enforcement agencies in the United States, TASERs have been adopted by approximately 7,000 departments. Following on the call of White and Ready (2007) for more research on TASER use by police, this paper investigates the use of TASERs by a medium sized, Midwestern police agency. All TASER deployments by police officers in this Midwestern city are examined for a three-and-a-half-year time period (January 2004–August 2007). Findings indicate that the TASER was used primarily against physically resistant white male suspects with a history of police contact. The majority of the incidents took place at a private residence or apartment as opposed to a public place of business. The TASER was overwhelmingly effective and, as for officer safety, on the few occasions that an officer was injured, the injury was not related to the TASER."

10. (03/2009 Brewer) Brewer J, Kroll M., Field Statistics Overview. In: Kroll M, Ho J, eds. *TASER Conducted Electrical Weapons: Physiology, Pathology, and Law*. New York City: Springer-Kluwer; 2009.

    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%."

11. (07/2006 Jenkinson) Jenkinson E, Neeson C, Bleetman A. The relative risk of police use-of-force options: evaluating the potential for deployment of electronic weaponry. J Clin. Forensic Med. Jul 2006;13(5):229–241.

    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 31 CEWs Are Associated With Less Injury Than "Physical Force"

No.	Date	Document
1	Dec. 2012	Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.
2	Aug. 2012	*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
3	May 2012	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.
4	May 2012	Pasquier, M., Electronic Control Device Exposure - A Review of Morbidity and Mortality, Annals of Emergency Medicine, May 2011.
5	Jan. 2011	Haileyesus T, Annest JL, Mercy JA, Non-fatal conductive energy device-related injuries treated in US emergency departments, 2005–2008, Injury Prevention (2010). doi:10.1136/ip.2010.028704.
6	Jul. 2010	Smith, M.R., Kaminsky, R.J., Alpert, G.P. 2010. A Multi-Method Evaluation of Police Use of Force Outcomes: Final Report to the National Institute of Justice. NIJ Grant Award 2005-IJ-CX-0056.

No.	Date	Document
7	2010	Taylor, B., & Woods, D. J. (2010). Injuries to officers and suspects in police use-of-force cases: A quasi-experimental evaluation. Police Quarterly, 13, 260-289.
8	Oct. 2009	MacDonald, J.M., Kaminski, R.J., Smith, M.R. The Effect of Less-Lethal Weapons on Injuries in Police Use-of-Force Events, American Journal of Public Health, December 2009, Vol. 99, No. 12, pages 2268–2274.
9	Sep. 2009	Taylor B, Woods D, Kubu B, et al. Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi experimental evaluation. National Institute of Justice. September 2009.
10	2009	DeLone, Gregory J., and Liddie M. Thompson. "The application and use of TASERs by a Midwestern police agency." *International Journal of Police Science and Management* 11.4 (2009): 414-428
11	Jan. 2009	Hall CA., Public risk from tasers: Unacceptably high or low enough to accept?, Canadian Journal Emergency Medicine, Jan 2009; 11(1):84–86.
12	Sep. 2008	Mesloh, C, Henych M, Wolf R. 2009. Less Lethal Weapon Effectiveness, Use of Force, and Suspect & Officer Injuries: A Five-Year Analysis. National Institute of Justice. 2008.

1. (12/2012 Adedipe) Adedipe, A., Maher, P.J., Strote, J. 2012. Injuries associated with law enforcement use of force. Trauma 15(2) 99–106.

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)

3. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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.

4. (05/2011 Pasquier) Pasquier, M., Electronic Control Device Exposure – A Review of Morbidity and Mortality, Annals of Emergency Medicine, May 2011.

   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."

5. (01/2011 CDC/CPSC) Haileyesus T, Annest JL, Mercy JA, Non-fatal conductive energy device-related injuries treated in US emergency departments, 2005–2008, Injury Prevention (2010). doi:10.1136/ip.2010.028704. Study funded by the National Center for Injury Prevention and Control, Centers for Disease Control and Prevention; with the assistance of the Division of Hazard and Injury Data Systems, US Consumer Product Safety Commission.

   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%)."

6. (07/2010 Smith) Smith, M.R., Kaminsky, R.J., Alpert, G.P. 2010. A Multi-Method Evaluation of Police Use of Force Outcomes: Final Report to the National Institute of Justice. NIJ Grant Award 2005-IJ-CX-0056.

   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.

b. "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.

7. (2010 Taylor) Taylor, B., & Woods, D. J. (2010). Injuries to officers and suspects in police use-of-force cases: A quasi-experimental evaluation. Police Quarterly, 13, 260-289.

(1) " … Compared with non-CED sites, CED sites had lower rates of officer injuries, suspect severe injuries, and officers and suspects receiving injuries requiring medical attention. Our results suggest that CEDs can be effective in helping minimize physical struggles and resulting injuries in use-of-force cases.

8. (10/2009 MacDonald) John M. MacDonald, Robert J. Kaminski, and Michael R. Smith, The Effect of Less-Lethal Weapons on Injuries in Police Use-of-Force Events, American Journal of Public Health, December 2009, Vol. 99, No. 12, pages 2268–2274.

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."

9. (09/2009 PERF/Woods) Taylor B, Woods D, Kubu B, et al. Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi experimental evaluation. National Institute of Justice. September 2009.

   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.

c. 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.

10. (2010 DeLone) DeLone, Gregory J., and Liddie M. Thompson. "The application and use of TASERs by a Midwestern police agency." *International Journal of Police Science and Management* 11.4 (2009): 414-428.

a. "**ABSTRACT** Of the some 18,000 law enforcement agencies in the United States, TASERs have been adopted by approximately 7,000 departments. Following on the call of White and Ready (2007) for more research on TASER use by police, this paper investigates the use of TASERs by a medium sized, Midwestern police agency. All TASER deployments by police officers in this Midwestern city are examined for a three-and-a-half-year time period (January 2004–August 2007). Findings indicate that the TASER was used primarily against physically resistant white male suspects with a history of police contact. The majority of the incidents took place at a private residence or apartment as opposed to a public place of business. The TASER was overwhelmingly effective and, as for officer safety, on the few occasions that an officer was injured, the injury was not related to the TASER."

11. (01/2009 Hall Editorial) Hall CA., Public risk from tasers: Unacceptably high or low enough to accept?, Canadian Journal Emergency Medicine, Jan 2009; 11(1):84-86.

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?'"

12. (09/2008 Mesloh/NIJ) Mesloh, C, Henych M, Wolf R. 2009. Less Lethal Weapon Effectiveness, Use of Force, and Suspect & Officer Injuries: A Five-Year Analysis. National Institute of Justice. 2008.

    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:

1. (09/2012 Fox) Fox A, Payne-James J. Conducted energy devices: Pilot analysis of (non-)attributability of death using a modified Naranjo algorithm. Forensic Sci Intl. Sept 2012.

    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:

1. (03/2012 Kunz) Kunz SN, Grove N, Fischer F. Acute pathophysiological influences of conducted electrical weapons in humans - A review of current literature. Forensic Sci Int. 221 (2012), 1–4. [Mar 2012;Epub].

    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."

2. (05/2011 NIJ) Five (5) year NIJ study: Laub, J. Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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.

3. (10/2009 MacDonald) John M. MacDonald, Robert J. Kaminski, and Michael R. Smith, The Effect of Less-Lethal Weapons on Injuries in Police Use-of-Force Events, American Journal of Public Health, December 2009, Vol. 99, No. 12, pages 2268–2274.

    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."

4. (09/2009 PERF) Taylor B, Woods D, Kubu B, et al. Police Executive Research Forum (PERF), Comparing safety outcomes in police use-of-force cases for law enforcement agencies that have deployed Conducted Energy Devices and a matched comparison group that have not: A quasi-experimental evaluation, September 2009.

    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."

5. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

    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."

6. (01/2009 Bozeman) Bozeman W, II WH, Heck J, Graham D, Martin B, Winslow J. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officer Against Criminal Suspects, Annals of Emergency Medicine, January 2009.

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

7. (06/2008 Eastman) Eastman, A.L., et al., Conductive electrical devices: a prospective, population-based study of the medical safety of law enforcement use, J Trauma, 2008. 64(6): p. 1567–72.

    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."

8. (2005) Wilkinson D., PSDB Further Evaluation of TASER Devices Hertfordshire, United Kingdom: United Kingdom Police Scientific Development Branch, 2005, page 108.

    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:

1. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

   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

2. (09/2008 Mesloh) (NIJ funded study) Mesloh, Wolf, Henych & Thompson, Less Lethal Weapons for Law Enforcement: A Performance-Based Analysis, Law Enforcement Executive Forum, 2008.

   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:

1. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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.

2. (05/2011 Pasquier) Pasquier, M., Electronic Control Device Exposure – A Review of Morbidity and Mortality, Annals of Emergency Medicine, May 2011.

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

3. (09/2010 Biria) Biria M, Bommana S, Kroll M, Lakkireddy D., Multi-System Interactions of Conducted Electrical Weapons (CEW) - A Review, Engineering in Medicine and Biology Society Proceedings, Sept 2010:1266–1270.

    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.'"

4. (07/2010 Smith) Smith M, Kaminski R, Alpert G, Fridell L, MacDonald J, Kubu B., A Multi-Method Evaluation of Police Use of Force Outcomes: Final Report to the National Institute of Justice, US Department of Justice, 2010.

    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."

5. (03/2009 Vilke) Gary M. Vilke, Will D. Johnson III, Edward M. Castillo, Christian Sloane, and Theodore C. Chan, Tactical and subject considerations of in-custody deaths proximal to use of conductive energy devices, American Journal of Forensic Med Pathol, March 2009, 30 (1):23–25.

    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."

6. (04/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

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

7. (06/30/2008 Nova Scotia) Report of the Advisory Panel to the Minister of Justice on the use of the Conducted Energy Device by Law Enforcement Agencies in Nova Scotia.

    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"):

1. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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[9,10] or respiratory dysfunction[11] following exposures less than 45 seconds."

2. (03/2009 Vilke) Vilke G, Johnson W, Castillo E, et al. Tactical and Subject Considerations of In-Custody Deaths Proximal to Use of Conductive Energy Devices. Am J Forensic Med Pathol. Mar 2009;30(1):23–25.

    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.

3. (02/2009 Kroll/Ho) Brewer, J.E., Kroll, M.W. Chapter 24: Field Statistics Overview. Kroll M, Ho J, eds. TASER® Conducted Electrical Weapons: Physiology, Pathology, and Law. Springer, 2009.

    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.

Figure 12 2009 Brewer Number of CEW exposures

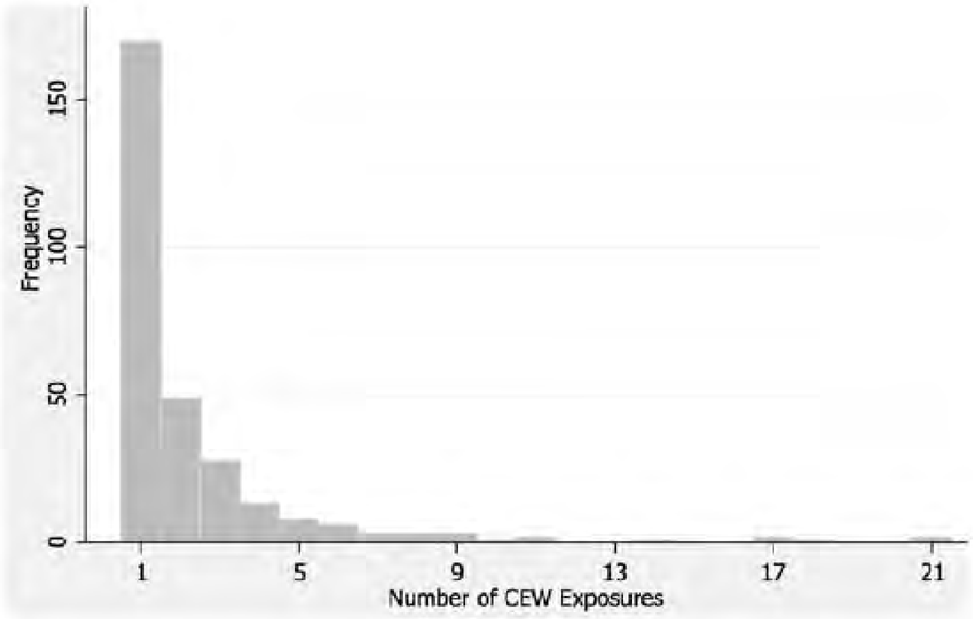


Fig. 24.4 Frequency of various numbers of exposures in 292 reported deaths

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:

1. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

   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."

2. (09/2008 Mesloh) (NIJ funded study) Mesloh, Wolf, Henych & Thompson, Less Lethal Weapons for Law Enforcement: A Performance-Based Analysis, Law Enforcement Executive Forum, 2008.

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):

1. (04/2009 Bozeman) Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480–489, April 2009.

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

2. (03/24/2008) Report of the Fifth International Law Enforcement Forum for Minimal Force Options and Less-Lethal Technologies, Washington & Fairfax, November 2006, International Law Enforcement Forum.

    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:

1. (09/2014 Ho) Ho JD, Williams MF, Coplen MJ. Conducted electrical weapons within healthcare: a comprehensive use of force model. *Journal of Healthcare Protection Management*. 2014;30(2):47-56.

2. (04/2014 Lefton) Lefton, C. The TASERs Are Coming, The TASERs Are Coming - Conducted Electrical Weapons: Tools to Manage and Prevent ED Violence? *J Emerg Nurs*. 2014;40:174-6.

3. (04/2014 Bastianelli) Bastianelli B.T. TASERS in healthcare: myths and merits. *J Healthc Prot Manage.* 2014;30(1):30-4.

   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.

4. (02/2010 Ho) Ho J, Clinton J, Lappe, M, Heegaard W, Williams M, Miner J., Introduction of the conducted electrical weapon into a hospital setting. J Emerg Med. Feb 1 2010.

   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:

1. (06/2013 Levy) Levy, K. 2013. Multiple and prolonged Taser deployments. Crime and Misconduct Commission (CMC). Brisbane, Queensland, Australia. June 2013.

   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:

1. (Note:) In some instances, stating that a person is "mentally ill" is like saying someone is "ill" or in need of "medical care or assistance." "Ill" can range from having a headache or a cold to a person having Ebola or HIV. Medical care or assistance can range from a band aid to attempts to treat a terminal bullet wound or a highly traumatic vehicle crash. Being "mentally ill" can likewise be a very broad and misleading term.

2. (2014 Mulvey) P. Mulvey and M. White, "The potential for violence in arrests of persons with mental illness," *Policing: An International Journal of Police Strategies & Management*, vol. 37, pp. 404-419, 2014.

3. (10/2013) Hall, C. 2013. RESTRAINT. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

   a. "Preliminary analysis finds that of 830 subjects transported for ED assessment with retrievable medical record, 426 (51.0%) were documented by ED physicians to be suffering from mental distress, either alone or in combination with injury and/or intoxicants." pg 7 (highlighting added)

4. (12/2012 CRD/DOJ) Proposed Settlement Agreement, Attachment 1 to Memorandum in Support of Joint Motion to Enter Settlement Agreement and Conditionally Dismiss Action. December 17, 2012. U.S. v. City of Portland. U.S.D.Or., Portland Division. Case No. 3:12-cv-02265-SI.

   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).

5. (05/2011) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

   a. "... Further, extended CED exposure may not be effective in the subdual of some individuals with high levels of drug intoxication or mental illness. Therefore, if the CED is ineffective in subduing an individual after a prolonged exposure, law enforcement officers should consider other options." Page 3.

6. (12/2009 Strote) Strote J, Walsh M, Angelidis M, Basta A, Hutson HR., Conducted electrical weapon use by law enforcement: an evaluation of safety and injury, J Trauma. May 2010; 68(5):1239–1246.

a. "Results: Of 1,101 individuals subjected to (Taser M26 and X26) CEW use during the study period, 92.6% were male, the average body mass index was 26.2, and the age range was 9 to 73 years. Of the 886 (80.5%) with medical records, 46.8% had a psychiatric history and 72.9% had a substance abuse history. Emergency department (ED) evaluations occurred for 295 (26.8%) incidents. Of chief complaints, 41.7% were trauma related, 26.8% were for altered mental status, and 21.7% were for psychiatric evaluation." Page 3 (highlighting emphasis added).

b. "The most common chief complaint recorded was altered mental status (26.8%) (Table 4)." Page 3.

c. Table 3 (page 3):

TABLE 3. Psychiatric and Drug History

History (%)	Total (N = 886)	Adult (N = 805)	Ped/Adolesc (N = 81)
Psychiatric	415 (46.8)	386 (48.0)	29 (35.8)
Drug/alcohol	646 (72.9)	595 (73.9)	51 (63.0)
Psych or D/A	832 (93.9)	767 (95.3)	65 (80.2)
Psych and D/A	331 (37.4)	309 (38.4)	22 (27.2)

A history of psychiatric and drug or alcohol abuse history among all patients for whom medical records were found.

Ped/adolesc, pediatric/adolescent; Psych, psychiatric history; D/A and drug/alcohol, drug or alcohol abuse history.

7. (09/2007 Ho) Ho J, Dawes D, Johnson M, Johnson M, Lundin E, Miner J., Impact of conducted electrical weapons in a mentally ill population: a brief report. Am J Emerg Med. Sep 2007;25(7):780–785.

   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."

8. (06/2006 Munetz) Munetz MR, Fitzgerald A, Woody M., Police use of the Taser with people with mental illness in crisis. Psychiatr Serv. 2006 Jun;57(6):883.

   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.

9. (11/2009 Cronin) Association, N.S., America, U.S.o., Forum, P.E.R., and America, U.S.o.: 'Conducted Energy Devices: Use in a Custodial Setting', 2009.

    a. "A large majority (95.0 percent) of the [CED] activations did not involve a prisoner with an apparent mental illness." Page 9.

    b. Table 4. Percent of agencies that allow a Deputy to activate a CED in the following situations page 12 (also see page 11):

        (1) Against an individual with a civil mental commitment order 88.3%.

        (2) Against a prisoner who has obvious mental impairments 81.3%.

        (3) In a hospital or other medical facility 72.9%.

    c. "In drive-stun mode, the electrical contacts on the device are pressed directly onto a subject. The effect on the neuromuscular system in drive-stun mode is less severe than the effect in the probe mode (Donnelly et al, 2002)." Page 3.

10. (2002) The Police Response to Mental Illness (2002).

CEW Use on Children:

Table 32 CEW Use on Children

No.	Date	Document
1	Oct. 2013	Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.
2	Aug. 2012	Gardner AR, Hauda WE 2nd, Bozeman WP. Conducted Electrical Weapon (TASER) Use Against Minors: A Shocking Analysis. Pediatr Emerg Care. 2012 Aug 27. [Epub ahead of print].
3	Jan. 2012	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 Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).
4	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

1. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

2. (08/2012 Gardner) Gardner AR, Hauda WE 2nd, Bozeman WP. Conducted Electrical Weapon (TASER) Use Against Minors: A Shocking Analysis. Pediatr Emerg Care. 2012 Aug 27. [Epub ahead of print].

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.

3. (01/2012 UK DSAC DOMILL) 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 Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).

4. (05/2011 NIJ/Laub) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

CEW Use on Pregnant Woman:

Table 33 CEW Use on Pregnant Woman

No.	Date	Document
6	Oct. 2013	Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.
5	Jan. 2012	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 Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).
4	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.
3	May 2011	Vilke GM, Bozeman WP, Chan TC. 2011. Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. J Emerg Med. May 2011;40(5):598–604.
2	1997	Einarson, A., Bailey, B., Inocencion, G., Ormond, K., & Koren, G. (1997). Accidental electric shock in pregnancy: A prospective cohort study. American Journal of Obstetrics & Gynecology, 176(3), 678-681.
1	Feb. 1992	Mehl, L. E. (1992). Electrical injury from Tasering and miscarriage. Acta Obstetricia et Gynecologica Scandinavica, 71(2), 118-123.

1. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

    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).

2. (01/2012 UK DSAC DOMILL) 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 Weapons (DOMILL). United Kingdom Defence Scientific Advisory Council. April 4 2011 (Amended Jan 27, 2012).

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.[18] 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.[19]

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[20], 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." (Page 7).

c. "80. The medical implications of exposure of pregnant women to Taser discharge are not well-documented (paras. 29-35). DOMILL recommends that women who are pregnant, or who suspect they may be pregnant, receive specialist obstetric review as part of the post-incident medical assessment." (Pages 12-13).

3. (05/2011 NIJ-Laub) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

   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.2 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).

4. (05/2011 AAEM-Vilke) Vilke GM, Bozeman WP, Chan TC. 2011. Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. J Emerg Med. May 2011;40(5):598–604.

   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).

5. (1997 Einarson) Einarson, A., Bailey, B., Inocencion, G., Ormond, K., & Koren, G. (1997). Accidental electric shock in pregnancy: A prospective cohort study. American Journal of Obstetrics & Gynecology, 176(3), 678-681.

   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."

6. (02/1992 Mehl) Mehl, L. E. (1992). Electrical injury from Tasering and miscarriage. Acta Obstetricia et Gynecologica Scandinavica, 71(2), 118-123.

   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 34 CEW Use on Excited Delirium Syndrome (ExDS) Subjects

No.	Date	Document
9	Apr. 2013	Wilson, M.P., Vilke, G.M. 2013. Chapter 17: The patient with excited delirium in the emergency department. Behavioral Emergencies for the Emergency Physician. Edited by Leslie Zun. 2013.
8	Feb. 2012	Vilke, G.M., Bozeman, W.P., Dawes, D.M., DeMers, G., Wilson, M.P. 2012. Excited delirium syndrome (ExDS): Treatment options and considerations, Journal of Forensic and Legal Medicine (2012), doi:10.1016/j.jflm.2011.12.009.

No.	Date	Document
7	Dec. 2011	Hughes, E.L., Special Report, Special Panel Review of Excited Delirium, Less-Lethal Devices Technology Working Group, NIJ Weapons and Protective Systems Technologies Center, Penn State.
6	Aug. 2011	Vilke G. Pathophysiologic changes due to TASER devices versus excited delirium: Potential relevance to deaths-in-custody [LETTER]. J Forensic Leg Med. Aug 2011;18(6):291.
5	May 2011	Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.
4	Feb. 2011	Jauchem J. Pathophysiologic changes due to TASER devices versus excited delirium: Potential relevance to deaths-in-custody? J Forensic Leg Med. May 2011;18(4):145-153.
3	Dec. 2009	Review of Conducted Energy Weapons Use in Ontario, Report of the Policing Standards Advisory Committee, Minister of Community Safety and Correctional Services, Ontario, Canada, December 11, 2009.
2	Sep. 2009	White Paper Report on Excited Delirium Syndrome. ACEP Excited Delirium Task Force, http://ccpicd.com/Documents/Excited%20Delirium%20Task%20Force.pdf; September 10, 2009.
1	Jun. 2008	Hagy D., Study of Deaths Following Electro Muscular Disruption: Interim Report. U.S. Department of Justice. Office of Justice Programs. June 2008.

1. (04/2013 Wilson) Wilson, M.P., Vilke, G.M. 2013. Chapter 17: The patient with excited delirium in the emergency department. Behavioral Emergencies for the Emergency Physician. Edited by Leslie Zun. 2013.

    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.

2. (02/2012 Vilke) Vilke, G.M., Bozeman, W.P., Dawes, D.M., DeMers, G., Wilson, M.P. 2012. Excited delirium syndrome (ExDS): Treatment options and considerations, Journal of Forensic and Legal Medicine (2012), doi:10.1016/j.jflm.2011.12.009.

    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.[22–24] Thus, heavy exertion may make the patient more acidotic 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."

3. (12/2011 Hughes) Hughes, E.L., Special Report, Special Panel Review of Excited Delirium, Less-Lethal Devices Technology Working Group, NIJ Weapons and Protective Systems Technologies Center, Penn State.

    a. "A conducted energy device is a fast way to restrain an individual with ExDS, pointed out Lenexa and Seattle police officers.[143] "While the TASER [CEW] is cycling, have somebody restrain him and deliver him to medics, if medics are present," stated Officer Myers.[144]" page 30.

4. (08/2011 Vilke) Vilke G. Pathophysiologic changes due to TASER devices versus excited delirium: Potential relevance to deaths-in-custody [LETTER]. J Forensic Leg Med. Aug 2011;18(6):291.

5. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., Study of Deaths Following Electro Muscular Disruption, National Institute of Justice, May 2011.

    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.

6. (02/2011 Jauchem) Jauchem J. Pathophysiologic changes due to TASER devices versus excited delirium: Potential relevance to deaths-in-custody? J Forensic Leg Med. May 2011;18(4):145–153.

7. (12/2009 Ontario, Canada) Review of Conducted Energy Weapons Use in Ontario, Report of the Policing Standards Advisory Committee, Minister of Community Safety and Correctional Services, Ontario, Canada, December 11, 2009.

    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.’”

8. (09/2009 ACEP) White Paper Report on Excited Delirium Syndrome. ACEP Excited DeliriumTask Force, http://ccpicd.com/Documents/Excited%20Delirium%20Task%20Force.pdf; September 10, 2009.

9. (06/2008 Hagy) Hagy D., Study of Deaths Following Electro Muscular Disruption: Interim Report. U.S. Department of Justice. Office of Justice Programs. June 2008.

    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:

1. (06/2010 Moscati) Moscati R, Ho JD, Dawes DM, JR Miner. Physiologic effects of prolonged conducted electrical weapon discharge in ethanol-intoxicated adults. Am J Emerg Med. Jun 2010;28(5):582–7.

    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)

1. 08/2006 Lakkireddy) Lakkireddy D, Wallick D, Ryschon K, et al. *Effects of Cocaine Intoxication on the Threshold for Stun Gun Induction of Ventricular Fibrillation*. J Am Coll Cardiol. Aug 15 2006;48(4):805–811.

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."

2. (1996 Tisdale) Tisdale, J.E., Shimoyama, H., Sabbah, H.N. The Effect of Cocaine on Ventricular Fibrillation Threshold in the Normal Canine Heart. Phannacotherapy 1996;16(3):429-437.

   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)

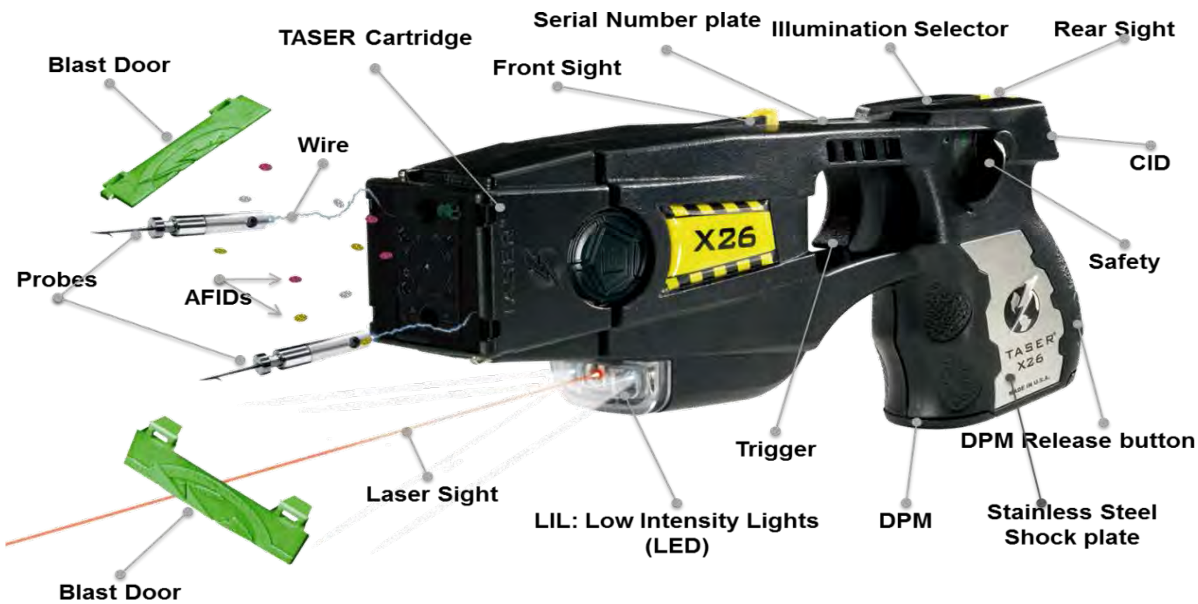
1. (2010 Dawes) Dawes D, Ho J, Cole J, et al. Effect of an Electronic Control Device Exposure on a Methamphetamine-intoxicated Animal Model. Acad Emerg Med. 2010;17:436–43.

   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

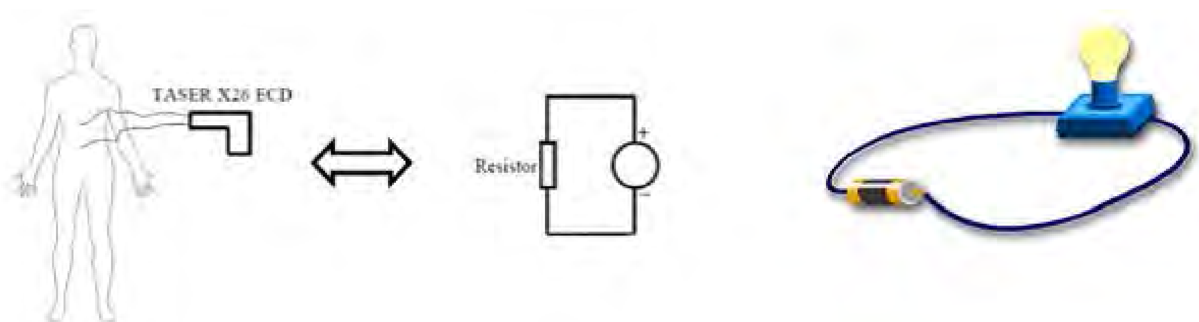
Graphic – TASER X26 CEW Basic Components:

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

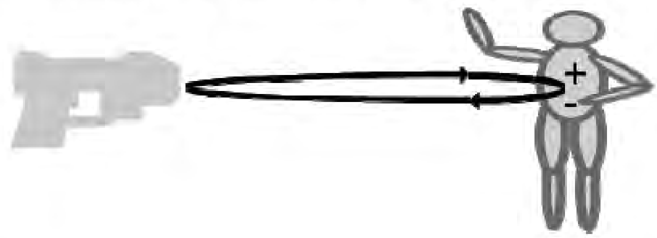


The New York Conducted Energy Device Course, Student Guide, includes:[89]

[89] Conducted Energy Device Course, Student Guide, Municipal Police Training Council, New York State Division of Criminal Justice Services, Office of Public Safety, State of New York, December 2009. Pg. 2.6.

Figure 15 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.



Necessity of Completed Circuit to Deliver Electrical Charge:

1. *Bussey-Morice v. Gomez*, 587 Fed.Appx. 621 (11th Cir. (Fla.) Oct 01, 2014).

    a. "FN4. "Dry stun mode" means that the Taser is pressed directly against the skin and produces a burning sensation."

    b. "The FDLE report included Taser download information indicating that Hewatt fired his Taser twice—once at 1:53:16 for a ten-second cycle; and again at 1:53:27 for a five-second cycle. The FDLE report also indicates that Gomez fired her Taser four times—once at 2:00:33 for a five-second cycle; once at 2:00:40 for a five-second cycle; once at 2:00:52 for a five-second cycle; and once at 2:01:01 for a five-second cycle. Defense expert, Dr. Mark Kroll, explained that although Gomez deployed her Taser multiple times, both prongs of the device did not make a complete connection with Bussey, so the Taser did not deliver any electrical charge. A report of information downloaded from the officers' Tasers and authored by Taser International confirms that the Taser's circuit was not completed and pulses were not delivered through one of the probes in Gomez's Taser. The report further notes that in order for energy to be transferred from the Taser via the probes, contact must be made with the individual by both probes to complete the circuit." (pages 10-11) (highlighting emphasis added)

X26 CEW Battery of Two Three-Volt (Duracell® CR123[90]) Cells:

Figure 16 CR123 cell and U.S. dime and battery and U.S. quarter comparison

Duracell CR123 and U.S. dime for comparison	Battery of two Duracell CR123 cells and U.S. quarter
	

In an X26 CEW the battery of two three-volt Duracell CR123 cells [same as used in some digital camera, such as the Nikon® F6] will provide 195+ five-second discharges. At 19 pulses per second (PPS) this equals 18,525+ pulses from a single battery of two three-volt cells (Duracell CR123s). The cells can be purchased at Best Buy, CVS, Walgreens, and many other retail stores.

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

The loaded X26 or M26 CEW 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 CEW. 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.

Figure 17 CEW cartridge wire (127 microns) and U.S. dime.

[90] See Duracell Ultra Photo, Ultra 123 Lithium/Manganese Dixoide (Li/MnO_2) cell specifications data sheet.

CEW Probes and Darts:

Figure 18 TASER CEW probes/darts

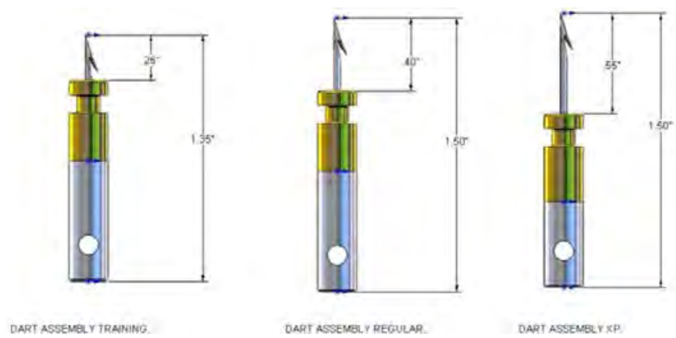


Figure 19 TASER CEW probes/darts comparisons with U.S. dime

TASER CEW probe with 13 mm dart	TASER CEW probe with 9 mm dart
	

Table 35 CEW dart length and dime and five pense comparisons

Length/Diameter (mm)	Description
9 mm	CEW dart
13 mm	XP CEW dart
17.91 mm	U.S. dime
18.0 mm	U.K. five pense
18.03 mm	Canadian dime

A U.S. dime is 17.91 millimeters (mm)[91] in diameter [United Kingdom five pense is 18.0 mm[92], and Canadian dime is 18.03 mm[93]]

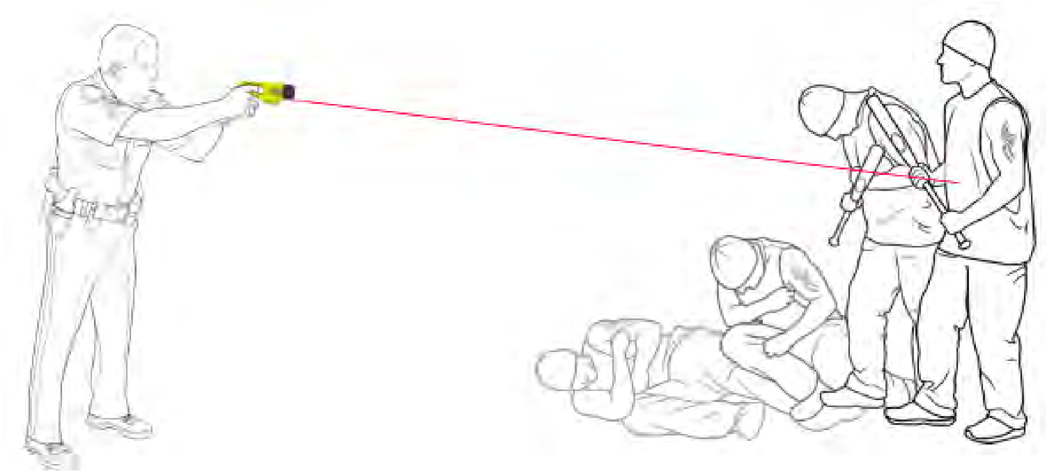
[91] http://www.usmint.gov/about_the_mint/?action=coin_specifications referenced on September 15, 2015.

[92] http://www.royalmint.com/discover/uk-coins/coin-design-and-specifications/five-pence-coin referenced on September 5 ,2015.

[93] http://www.mint.ca/store/mint/about-the-mint/10-cents-5300008#10_1 referenced on September 5, 2015.

Targeting (lower center mass):

Figure 20 CEW Pre-Probe Deployment LASER Aiming (targeting lower center mass).



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

M. Kroll, "Significance of Sound During CEW Application," Technical Report, pp. 1-3, 2013. DOI 10.13140/RG.2.1.2262.9925.

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 36 Sampling of sound levels from various sources.

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

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:

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/m^2). 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 Probe Spread and Incapacitation:

1. (10/2013 Dawes) Dawes, D., Ho, J. 2013. A Comparative Study of Conducted Electrical Weapon Incapacitation During A Goal-Directed Task. Police Physician’s Section Track, International Association of Chiefs of Police Annual Conference, Philadelphia, Pennsylvania. October 21, 2013.

2. (04/2012 Ho) Ho J, Dawes D, Miner, J, Kunz S, Nelson R, Sweeney J. Conducted electrical weapon incapacitation during a goal-directed task as a function of probe spread. *Forensic Sci Med Pathol*. Apr 2012.

    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.”

3. (09/2009 Beason) Beason C, Jauchem J, Clark C, Parker JE, Fines DA. Pulse Variations of a Conducted Energy Weapon (Similar to the TASER X26 Device): Effects on Muscle Contraction and Threshold for Ventricular Fibrillation*. J *Forensic Sci*. Sep 2009;54(5):1113–1118.

    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 21 CEW Probe Spread – Distance from CEW to Subject

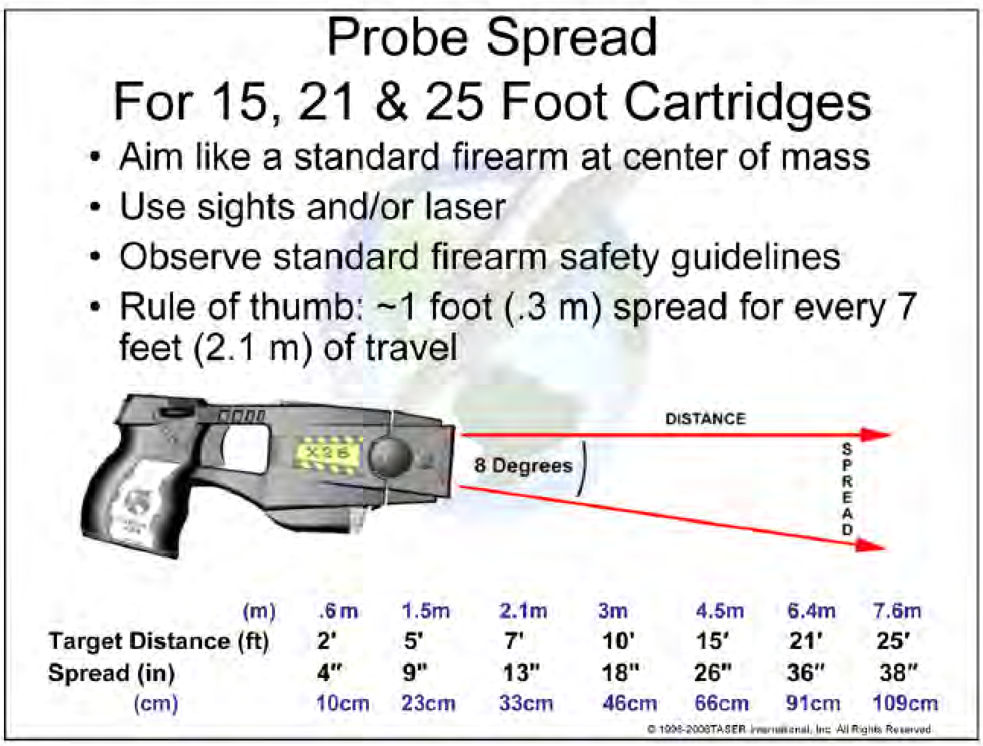
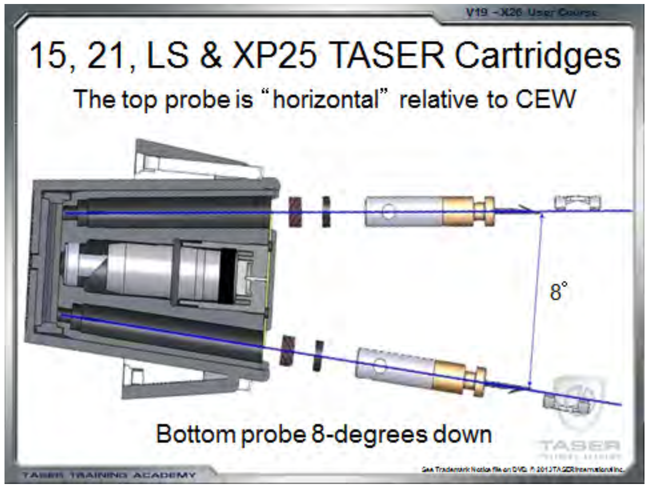


Figure 22 CEW Cartridge Showing Probe Discharge and Eight Degree Discharge Downward Angle.



X26 CEW Log Shows Only Discharges Not Delivered Charge:

1. *Hoyt v. Cooks*, 672 F.3d 972 (C.A.11 (Ga.), Feb. 27, 2012).

    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.

2. *Skelly v. Okaloosa County, Fla. Bd. of County Commissioners*, 2010 WL 1192515 (N.D.Fla. Mar 22, 2010), *order vacated by*, *Skelly v. Okaloosa County Bd. of County Com'rs*, 415 Fed.Appx. 153 (11th Cir.(Fla.) Feb 17, 2011), *after appeal remand*, *Skelly v. Okaloosa County Bd. of County Com'rs*, 456 Fed.Appx. 845 (11th Cir.(Fla.) Feb 03, 2012).

    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:

1. TASER X26 CEW specifications: 1,400–2,520 volts (delivered to subject)

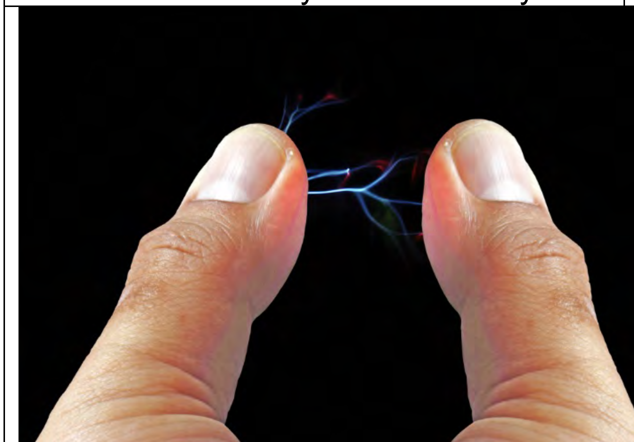
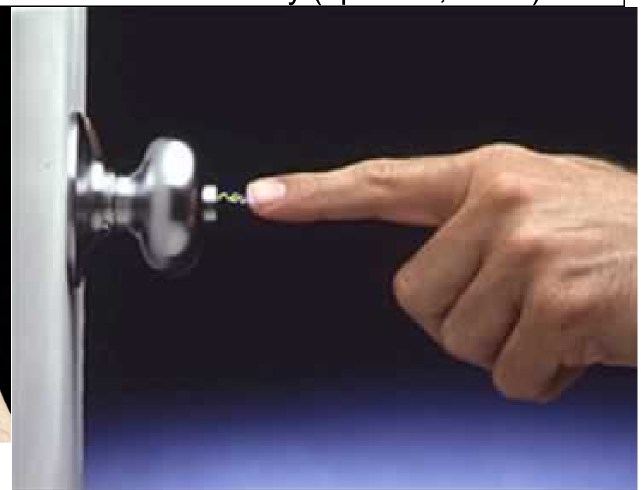
2. (03/2010 Dawes) Dawes DM, Ho JD, Kroll MW, Miner JR, Electrical characteristics of an electronic control device under a physiologic load: a brief report, Pacing Clin Electrophysiol, Mar 2010;33(3):330-6.

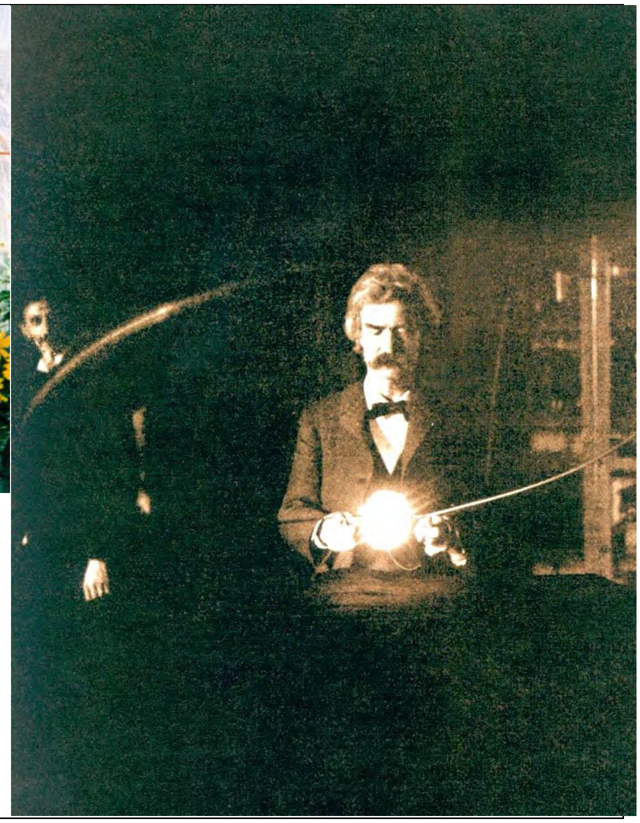
    a. "**Results:** For the eight subjects, the mean spread between top and bottom probes was 12.1 inches (30.7 cm). The mean resistance was 602.3 Ω with a range of 470.5–691.4 Ω. The resistance decreased slightly over the 5-second discharge with a mean decrease of 8.0%. The mean rectified charge per pulse 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."

3. *Michael Imp v. Chris Wallace, et al.*, CV-1-509, 2011 WL 4396941 (D.Minn. Sept. 21, 2011).

    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."

Table 37 Static electricity and Van de Graff generators

Static electricity in human body	Static electricity (up to 30,000 V)
	
Van de Graff Generator (up to 25 million V)	
	
Van de Graff Generator	Mark Twain and Nikola Tesla (1800s)



M26/X26/X26P CEW Drive-Stun Effects:

CEW Drive-Stun Path-of-Current Demonstrations:

A couple of easy, and clear, demonstrations of drive-stun mode, completed circuit, flow of electrical charge (taking path of lowest resistances) include, but are not limited to: (1) while wearing a metal watch band simply arcing the front electrodes on the CEW across the metal watch band (there is no electrical charge delivered to the demonstrator and no pain or other ill effects); and (2) while holding a 12 ounce soda can (either full or empty, does not matter) arcing the electrical charge between the electrodes and the soda can (same effect as metal watch band).[94] Similar demonstrations can be shown with CEW in probe mode.

Figure 23 Arrows Pointing to Electrodes on Front of CEW with No Expended Cartridge in Place.

Figure 24 Illustrating CEW Drive-Stun Discharge Across Front Electrodes and LASER.

Figure 25 X26 CEW Front Electrodes – No Cartridge in Place on CEW.

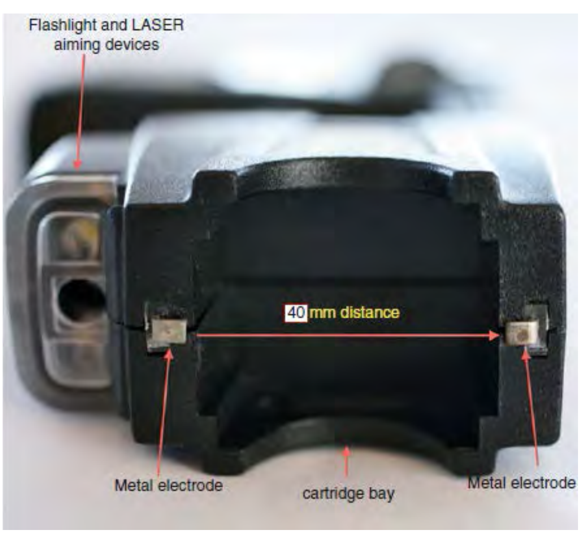
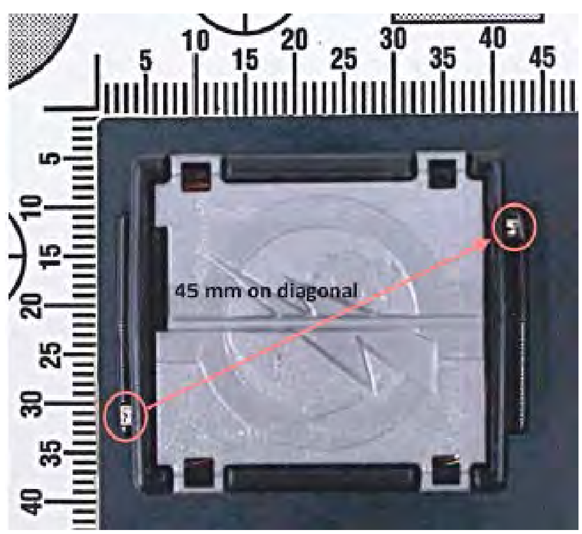


Figure 26 X26 CEW Cartridge Showing Front Electrodes Recessed on Cartridge.



Drive Stun Discharge vs Probe Deployment:

1. M. Kroll, "Conducted Electrical Weapon Drive-Stun Mode: Skin Rub vs. Injection," Technical Note, 2015. DOI 10.13140/RG.2.1.2488.2724.

Drive Stun Discharge Wounds:

1. Ho, J.D., Dawes, D.M. Chapter 4. Conducted Electrical Weapon Drive-Stun Wounds, pages 61-78, Atlas of Conducted Electrical Weapon Wounds and Forensic Analysis. Edited by Jeffrey D. Ho, Donald M. Dawes, and Mark W. Kroll, Springer Science Business Media. June 2012.

Drive-Stun: Medical Studies:

1. (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

    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).

2. (05/2011 NIJ) Five (5) year NIJ study: Laub, J., <u>Study of Deaths Following Electro Muscular Disruption</u>, National Institute of Justice, May 2011.

    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

[94] See my full list of electronic weapons demonstrations outline for additional demonstrations and greater depth of how to perform the various visuals and demonstrations.

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.

3. (05/2011 Pasquier) Pasquier, M., Electronic Control Device Exposure- A Review of Morbidity and Mortality, Annals of Emergency Medicine, May 2011.

    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]"

4. (01/2011 JEM) Vilke GM, Bozeman WP, Chan TC. **Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician**. J Emerg Med. May 2011;40(5):598–604. Position Paper Approved by the American Academy of Emergency Medicine Clinical Guidelines Committee.

    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."

5. (07/2010 Ho) Ho, J.D., Dawes, D.M., Nelson, R.S., Lundin, E.J., Ryan, F.J., Overton, K.G., Zeiders, A.J., Miner, J.R. 2010. Acidosis and Catecholamine Evaluation Following Simulated Law Enforcement "Use of Force" Encounters. Acad Emerg Med. July 2010;17(7)e60–68.

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

6. (04/2008 Ho) Ho J.D., Lapine A, Joing S, Reardon R, Dawes D. 2008. Confirmation of Respiration during Trapezial Conducted Electrical Weapon

Application. Acad Emerg Med. Apr 2008;15(4):398.

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

7. (01/2008 Ho) Ho, J., Dawes, D., Lapine, A., et al. 2008. Prolonged TASER® "Drive Stun" Exposure in Humans Does Not Cause Worrisome Biomarker Changes [POSTER]. Hennepin County Medical Center. National Association of EMS Physicians. 2008.

   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:

1. *De Boise v. Taser Intern., Inc.*, 760 F.3d 892 (8th Cir. (Mo.) Jul 28, 2014).

   a. "FN5. Deploying the taser in drive stun mode means that an officer removes the cartridge from the taser and applies the taser so as to make direct contact with the subject's body. When the taser is in drive stun mode, it only causes discomfort and does not incapacitate the subject." at 896. (highlighting emphasis added)

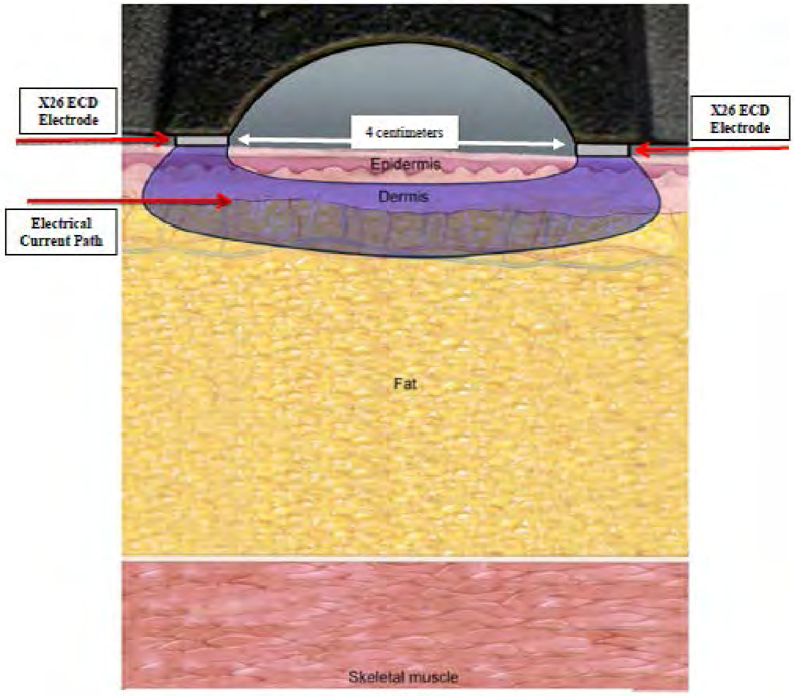
2. *Abbott v. Sangamon County, Ill.*, 705 F.3d 706 (7th Cir. (Ill.) Jan 29, 2013):

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

3. *Glowczenski v. TASER International, Inc.*, 2012 WL 976050, 2012 U.S. Dist. Lexis 39438 (E.D.N.Y. March 22, 2012):

   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.]

Figure 27 Epidermal Distance



4. *Hoyt v. Cooks*, 672 F.3d 972 (C.A.11 (Ga.) Feb. 27, 2012).

   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[TASER 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].

5. *Bussey-Morice v. Gomez*, 587 Fed.Appx. 621 (11th Cir. (Fla.) Oct 01, 2014).

   a. "FN4. "Dry stun mode" means that the Taser is pressed directly against the skin and produces a burning sensation."

   b. "The FDLE report included Taser download information indicating that Hewatt fired his Taser twice—once at 1:53:16 for a ten-second cycle; and again at 1:53:27 for a five-second cycle. The FDLE report also indicates that Gomez fired her Taser four times—once at 2:00:33 for a five-second cycle; once at 2:00:40 for a five-second cycle; once at 2:00:52 for a five-second cycle; and once at 2:01:01 for a five-second cycle. Defense expert, Dr. Mark Kroll, explained that although Gomez deployed her Taser multiple times, both prongs of the device did not make a complete connection with Bussey, so the Taser did not deliver any electrical charge. A report of information downloaded from the officers' Tasers and authored by Taser International confirms that the Taser's circuit was not completed and pulses were not delivered through one of the probes in Gomez's Taser. The report further notes that in order for energy to be transferred from the Taser via the probes, contact must be made with the individual by both probes to complete the circuit." (pages 10-11)

6. *Walker v. City of Cookeville*, Slip Copy, 2014 WL 919249 (M.D.Tenn., March 07, 2014).

   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").

7. The 9th Circuit *en banc* decision of *Mattos v. Agarano*, 661 F.3d 433 (C.A.9 (Hawaii) Oct. 17, 2011) (that included the combined *Brooks v. Seattle* case).

a. *Mattos v. Agarano*, 661 F.3d 433 (C.A.9 (Hawaii) Oct. 17, 2011) included:

(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.

b. [**Superseded – no longer good law**] *Mattos v. Agarano*, 661 F.3d 433 (C.A.9 (Hawaii) Oct. 17, 2011) *superseded Brooks v. City of Seattle*, 599 F.3d 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. a*t 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. a*t 1027.

8. **General Description of CEW firing modes: [This is NOT a quote from any case.]** 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.

9. *Michael Imp v. Chris Wallace, et al.*, CV-1-509, 2011 WL 4396941 (D.Minn. Sept. 21, 2011).

    a. Page 12: "FN 10. An X-26 Taser used in drive-stun mode directly contacts the subject without deployment of the darts. See Baker Aff. Ex. C, at 20 (expert report of Joshua Lego); McKenney v. Harrison, 635 F.3d 354, 364 (8th Cir. 2011) (Murphy, J., concurring) (citing Bryan v. MacPherson, 630 F.3d 805, 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:

1. *Hoyt v. Cooks*, 672 F.3d 972 (C.A.11 (Ga.) Feb. 27, 2012).

    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.

2. *Glowczenski v. TASER International, Inc.,* 2012 WL 976050, 2012 U.S. Dist. Lexis 39438 (E.D.N.Y. March 22, 2012).

    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."

3. *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).

    a. "In the drive stun mode, the Taser is physically placed in contact with the person and discharged. (Id. at 188.) The drive stun mode is used for pain compliance and works only on the area of the body to which the Taser is applied. (Id.)

4. *Green v. Garris*, 2008 WL 2222321, 2008 U.S. Dist. LEXIS 42302, *27 (M.D. Fla. 2008).

    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."

5. *Buckley v. Haddock*, Not Reported in F.Supp.2d, 2007 WL 710169 (N.D.Fla., March 6, 2007), *reversed by*, *Buckley v. Haddock*, 292 Fed.Appx. 791 (C.A.11 (Fla.) Sept. 9, 2008).

    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.

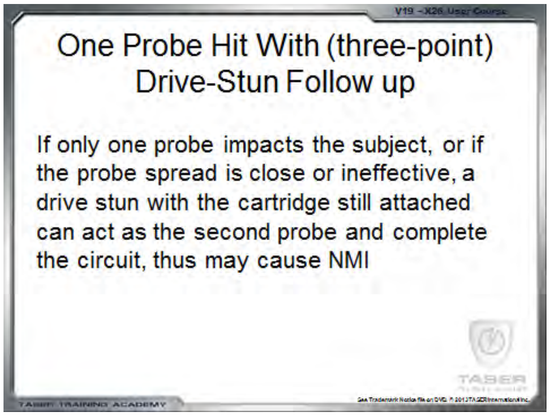
CEW Three-Point Deployment Mode:

Three-Point (and Four-Point) CEW Deployment Mode:

CEW three-point (and four-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 (and four-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 (and four-point) deployment mode is intended to create a wide electrode spread or separation in order to significantly increase the probability of achieving NMI.

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."[95]

Figure 28 Three-Point ECD Deployment TASER Training Version 19 User PowerPoint Slide 197.



The International Association of Chiefs of Police (IACP) April 2010 Electronic Control Weapon Model Policy includes:

> IV. Procedures. C. Deployment. … 5. An alternative method of close-range deployment involves firing the ECW cartridge at close range, then applying the ECW in "contact" mode to an alternate part of the body. This creates a "probe spread" effect between the impact location of the probes and the point where the ECW is placed in contact with the subject's body, resulting in an increased probability of subject control as compared to the standard "contact" mode. When the ECW is used in this manner, it is: a. potentially as effective at subject control as a conventional cartridge-type probe spread deployment, and b. subject to

---

[95] Panescu D, Kroll M, Stratbucker R. Medical safety of TASER conducted energy weapon in a hybrid 3-point deployment mode. Conf Proc IEEE Eng Med Biol Soc. 2009;1:3191-3194.

the same deployment guidelines and restrictions as any other ECW cartridge deployment.[96]

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."[97]

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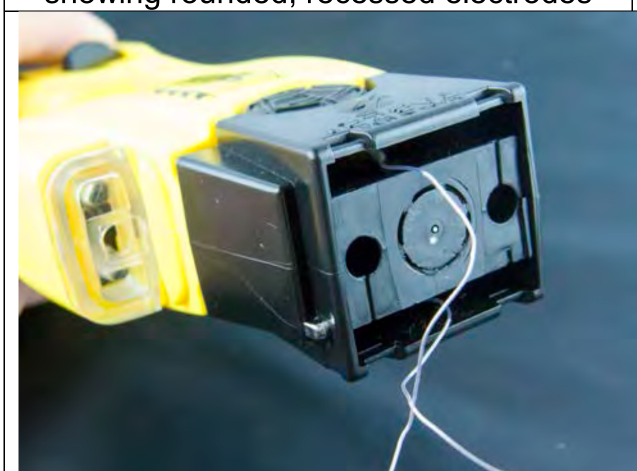
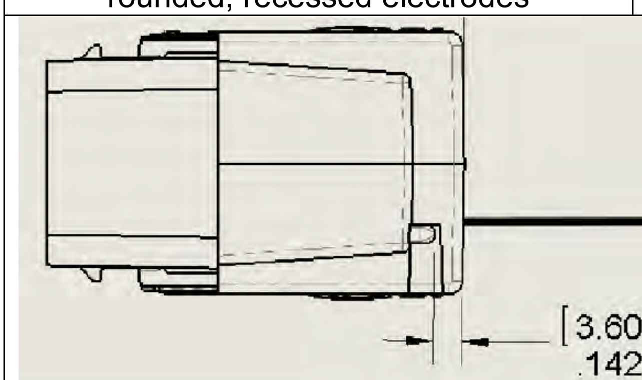
[96] Electronic Control Weapons, Model Policy, April 2010, International Association of Chiefs of Police.

[97] Panescu D, Kroll M, Stratbucker R. Medical safety of TASER conducted energy weapon in a hybrid 3-point deployment mode. Conf Proc IEEE Eng Med Biol Soc. 2009;1:3191-3194.

Table 38 X26 CEW Illustration, arcing with expended cartridge

<table>
<tr><td>X26 CEW with no cartridge attached</td><td>X26 with Silver door cartridge attached</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>X26 CEW with expended cartridge showing rounded, recessed electrodes</td><td>X26 CEW with expended cartridge showing rounded, recessed electrodes</td></tr>
<tr><td></td><td></td></tr>
<tr><td>X26/X26(P) CEW Cartridge showing rounded, recessed electrodes</td><td></td></tr>
<tr><td>
</td><td></td></tr>
</table>

M26 CEW Operational Information (TASER Training Version 11):

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

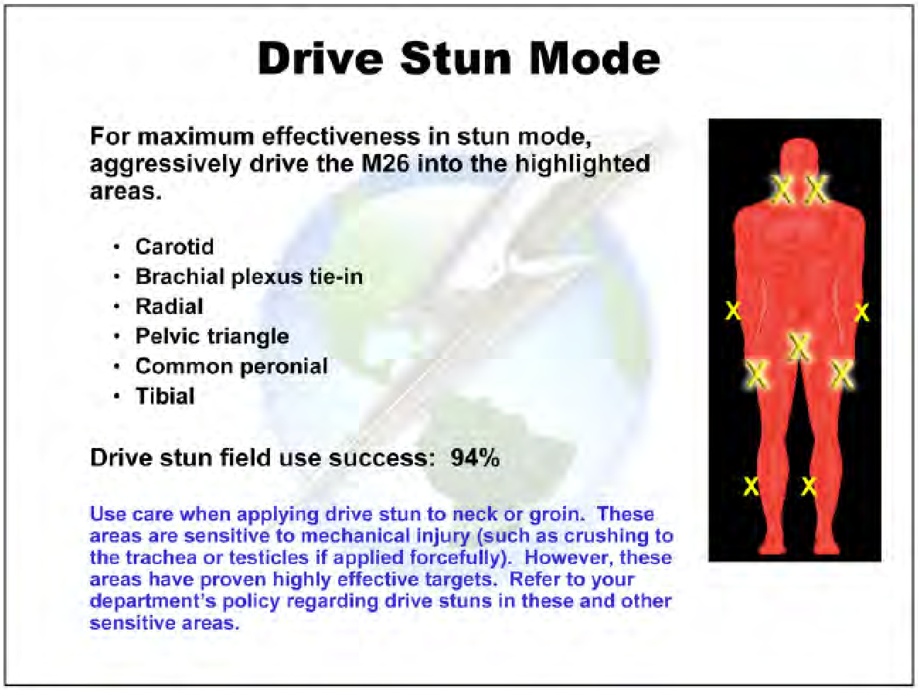
Figure 29 M26 CEW. TASER Training Version 11, M26 User Program, Slide 36.

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

Figure 30 CEW Field Success by Level of Use: TASER Training Version 11, M26 User, Slide 79.

3. M26 CEW Drive-Stun (TASER Training Version 11 (January 2004)):

Figure 31 M26 CEW Drive-Stun Mode, TASER Training Version 11, M26 User, Slide 104.



Selected Cardiac Issues and Concepts

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

Table 39 VFT for Swine, Canine, and Human (Electrode on Heart)

Species	Year		VFT (µC)	Calculation (time x current)
Pig[98]	2013	RV VFT	38.8 ± 8.4	4 ms x 9.7 ± 2.1 mA
Dog[99]	1977	LV epicardium	43.2 ± 25	4 ms x 10.8 ± 6.2 mA
Human[100]	1979	RV VFT	85 ± 21	4 ms x 24.3 ± 5.2 mA

Typical Electrical Charges Required for Human Cardiac Effects:

Table 40 Typical Electrical Charges Required for Human Cardiac Effects

	Intracardiac Electrode	Transcutaneous Electrodes
Low rate cardiac pacing	1 µC = 1 mA • 1 ms	2400 µC[101]
VF from cardiac pacing	85 µC[102]	Not reported
VF from single pulse	25,000 µC[103]	100,000 µC[104]

Human VFT: Electrodes Applied to Epicardial Surface of Ventricle:

1. Horowitz, L.N., Spear, J.F., Josephson, M.E., Kastor, J.A., Moore, E.N. 1979. The Effects of Coronary Artery Disease on the Ventricular Fibrillation Threshold in Man. *Circulation*. VoL 60. No 4, 792–797, October 1979.

    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."

---

[98] Personal communication.

[99] Gaum, W.E., Elharrar, V., Walker, P.D., Zipes, D.P. 1977. Influence of Excitability on the Ventricular Fibrillation Threshold in Dogs. The American Journal of Cardiology, December 1977, Volume 40, pages 929–935.

[100] Horowitz LN, Spear JF, Josephson ME, Kastor JA, Moore EN. The effects of coronary artery disease on the ventricular fibrillation threshold in man. Circulation. Oct 1979;60(4):792–797.

[101] 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. See generally, Transcutaneous Cardiac Pacing Thresholds and VF Safety Margins in this outline.

[102] Horowitz LN, Spear JF, Josephson ME, Kastor JA, Moore EN. The effects of coronary artery disease on the ventricular fibrillation threshold in man. Circulation. Oct 1979;60(4):792–797.

[103] Sharma AD, Fain E, O'Neill PG, et al. Shock on T versus direct current voltage for induction of ventricular fibrillation: a randomized prospective comparison. Pacing Clin Electrophysiol. Jan 2004;27(1):89–94.

[104] Mazer CD, Greene MB, Misale PS, Newman D, Dorian P. Transcutaneous T wave shock: a universal method for ventricular fibrillation induction. Pacing Clin Electrophysiol. Dec 1997;20(12 Pt 1):2930–2935.

Table 41 1979 Horowitz VF thresholds

Normal Heart	VFT (mA)	VFT Range (mA)	VFT (µC)	VFT Range (µC)
Right Ventricle	24.3 ± 5.2 mA	19.1 – 29.5 mA	97.2 ± 20.8 µC	76.4 – 118.0 µC
Left Ventricle	33.6 ± 9.5 mA	24.1 – 43.1 mA	134.4 ± 38.0 µC	96.4 – 172.4 µC

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

1. (01/2015 Walcott) Walcott, G. P., M. W. Kroll, and R. E. Ideker, 2015, Ventricular fibrillation: are swine a sensitive species?: *J Interv Card Electrophysiol*.

    a. "*Conclusions* Swine are about three times as sensitive to the electrical induction of VF as are humans."

    b. "7. **Conclusions** Swine are about three times as sensitive to the electrical induction of VF by a series of 24 rapid pulses during the vulnerable period as are humans."

2. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

    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)

3. (09/10/2010 Biria) Biria M, Bommana S, Kroll M, Lakkireddy D. Multi-Organ Effects of Conducted Electrical Weapons (CEW) – A Review. Conf Proc IEEE Eng Med Biol Soc. September 2010:1266–70.

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

4. (06/2009 AMA) Carolyn B. Robinowitz, MD, Chair, Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D), American Medical Association.

    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.[20]" Pg. 4.

5. (2007 Pippin) Pippin JJ. Taser research in pigs not helpful. J Am Coll Cardiol. 2007;49:731–732.

6. (1968 Dalziel) Dalziel CF, Lee WR. Reevaluation of lethal electric currents. IEEE Transactions on Industry and General Applications 1968;IGA-4:467–476.

7. (1935 Ferris) Ferris LP, King BG, Spence PW, Williams HB. Effect of electric shock on the heart. Electrical Engineering 1936;55:498–515.

Drug Effects on Action Potential Repolarisation in Sheep Cardiac Purkinje Fibres

1. Sheridan, Robert D., Simon R. Turner, Graham J. Cooper, and John EH Tattersall. "Effects of seven drugs of abuse on action potential repolarisation in sheep cardiac Purkinje fibres." *European journal of pharmacology* 511, no. 2 (2005): 99-107.

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.[105]

      (1) Given a full minute, responder will find the pulse with 97% accuracy.[106]

   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.[107]

[105] Bahr J, Klingler H, Panzer W, Rode H, Kettler D. Skills of lay people in checking the carotid pulse. Resuscitation. Aug 1997;35(1):23–26.

[106] Bahr J, Klingler H, Panzer W, Rode H, Kettler D. Skills of lay people in checking the carotid pulse. Resuscitation. Aug 1997;35(1):23–26.

[107] Dick WF, Eberle B, Wisser G, Schneider T. The carotid pulse check revisited: what if there is no pulse? Crit Care Med. Nov 2000;28(11 Suppl):N183–185.

Medical Device Litigation:[108]

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."

4. Paper discusses Kim/Franklin (2005 – Akeem Watson) and Naunheim (2010 – Colin Fahy) case reports.

The Stability of Electrically Induced Ventricular Fibrillation:[109]

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

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[108] Kroll, W. Realities of biomedical product liability suits and the role of junk science: from breast implants to TASER weapons. *IEEE Pulse*. 2012 Sep-Oct;3(5):27–32. doi:10.1109/MPUL.2012.2205778.

[109] Kroll M, Walcott GP, Ideker RE, et al. The Stability of Electrically Induced Ventricular Fibrillation. Conf Proc IEEE Eng Med Biol Soc. 2012 Aug;2012:6377–81. doi:10.1109/EMBC.2012.6347453.

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 49–70 minutes.

Defibrillation Success Rates for Electrically-Induced Fibrillation:[110]

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

[110] Kroll M, Fish R, Calkins H, Halperin H, Lakkireddy D, Panescu D. Defibrillation Success Rates for Electrically-Induced Fibrillation: Hair of the Dog. Conf Proc IEEE Eng Med Biol Soc. 2012 Aug;2012:689–93. doi:10.1109/EMBC.2012.6346025.

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:[111]

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).

[111] Kroll M, Fish R, Lakkireddy D, Luceri R, Panescu D. Essentials of Low-Power Electrocution: Established and Speculated Mechanisms. Conf Proc IEEE Eng Med Biol Soc. 2012 Aug;2012:5734–40. doi:10.1109/EMBC.2012.6347297.

CEW Latency Signs and Symptoms Checklists

Autopsy/Forensic Pathology Papers:

1. (11/2014 Graham) Graham, M.A. Investigation of Deaths Temporally Associated with Law Enforcement Apprehension. *Acad Forensic Pathol*. 2014 4 (3): 366-389.

    a. "**ABSTRACT:** The investigation of a death that occurs in custody requires a careful and methodical approach since concerns of police or institutional misconduct may be raised. The medicolegal official charged with the investigation and ultimate certification of death bears heavy responsibility to the decedent's family, the public, law enforcement and other institutions. A wide variety of causes of death and manners of death are seen in these deaths. This paper reviews causes, mechanisms, manners, findings, and evaluation of persons who have died in temporal relation to legal apprehension."

    b. "A 2011 report from the National Institute of Justice (NIJ) concluded that risk of human death due primarily to the electrical effects of an ECD have not been conclusively demonstrated (116). If an ECD can induce VF in a human adult, it must be a very rare event. Although the issue as to whether an ECD under normal use conditions has caused the death of a human has not been definitively settled, there does seem to be general agreement that such an event, if it happens, is rare." (highlighting emphasis added)

NAME Presentation 2014:

1. (Sept. 23, 2014 Kroll) Graham, M., Kroll, M.W., Karch, S.B., Wetli, C.V., Brave, M. Medical Examiner Collection of Comprehensive, Objective Medical Evidence for Conducted Electrical Weapons and Their Temporal Relationship to Sudden Arrest. National Association of Medical Examiners (NAME) Annual Conference Abstract and PowerPoint Presentation, Portland, Oregon, September 23, 2014.

    a. "Conclusion: We have developed an evidenced-based checklist that can be used by MEs and their staffs to assist them in identifying, collecting, documenting, maintaining, and objectively analyzing the role, if any, played by a CEW in any specific case of sudden death temporally associated with the use of a CEW. Even in cases where the collected information is deemed by the ME as insufficient for formulating an opinion or diagnosis to a reasonable degree of medical certainty, information collected as per the checklist will often be adequate for other stakeholders to use as a basis for informed decisions."

Figure 32 September 23, 2014 NAME Presentation Conclusion.

Conclusions

- CEWs can contribute to death by:
  - Causing uncontrolled falls
  - Igniting flammable fumes
- CEW-induced VF (electrocution) is a theoretical possibility
  - Actual occurrence is controversial; rare, if any, instances
  - Animal studies suggest that the risk would be restricted to thin person, precordial probe, short probe-heart distance, immediate onset of VF
- CEW-induced changes in pH, lactate, and other markers are comparable to that induced by exercise of the same duration
  - No evidence of dangerous respiratory or metabolic effects CEW discharges up to 45 seconds
  - No clinically significant biochemical or physiologic changes

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Latency for Signs and Symptoms of Electrocution:

Table 42 Latency for Signs and Symptoms of Electrocution

Sign	Time from shock
Loss of pulse	Instantaneous. [112] There is no pulse after VF induced.
Loss of blood pressure	3 seconds.[113]
Loss of consciousness	1–5 seconds if standing. About 13 ± 4 s if supine.[114]
Cessation of normal breathing	15–60 seconds.[115] Note: agonal breathing can persist for < 6 minutes with a rate around 1–3 BPM (Breaths Per Minute).[116]
Defibrillation success	Electrically-induced VF is defibrillated with a 95% success rate at 10 minutes with any chest compressions with 3 or fewer defibrillating shocks.[117]

[112] Schipke JD, Heusch G, Sanii AP, Gams E, Winter J. Static filling pressure in patients during induced ventricular fibrillation. Am J Physiol Heart Circ Physiol. Dec 2003;285(6):H2510–2515.

[113] Schipke JD, Heusch G, Sanii AP, Gams E, Winter J. Static filling pressure in patients during induced ventricular fibrillation. Am J Physiol Heart Circ Physiol. Dec 2003;285(6):H2510–2515.

[114] Lukl J, Marek D, Bulava A, et al. Prolonged burst as a new method for cardioverter-defibrillator testing. *Europace*. 2013;15(1):55–59.

[115] Zuercher M, Ewy GA, Otto CW, et al. Gasping in response to basic resuscitation efforts: observation in a Swine model of cardiac arrest. *Crit Care Res Pract.* 2010;10(36):1-7. Haouzi P, Ahmadpour N, Bell HJ, et al. Breathing patterns during cardiac arrest. *J Appl Physiol*. Aug 2010;109(2):405–411.

[116] Zuercher M, Ewy GA, Otto CW, et al. Gasping in response to basic resuscitation efforts: observation in a Swine model of cardiac arrest. *Crit Care Res Pract*. 2010;10(36):1–7.

[117] Kroll MW, Fish RM, Calkins H, Halperin H, Lakkireddy D, Panescu D. Defibrillation success rates for electrically-induced fibrillation: hair of the dog. Conf Proc IEEE Eng Med Biol Soc. 2012;2012:689-693. Perret JN, Sanders TW, d'Autremont SB, Patrick HC. Ventricular fibrillation initiated by an electrocution injury and terminated by an implantable cardioverter-defibrillator. J La State Med Soc. Nov-Dec 2009;161(6):343–347.

Necessary, but not Sufficient, CEW Electrocution Diagnostic Criteria:

Table 43 Necessary, not Sufficient, CEW Electrocution Diagnostic Criteria (all must be satisfied)

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

Transcutaneous Cardiac Pacing Thresholds and VF Safety Margins

Transthoracic Pacing Thresholds Modeling

1. (08/2015 Panescu) Panescu, D., Kroll, M., Andrews, C., Pratt, H., Transthoracic Ventricular Fibrillation Charge Thresholds, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 7208-7213.

    a. Panescu, D., Kroll, M., Andrews, C., Pratt, H., Transthoracic Ventricular Fibrillation Charge Thresholds, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 7208-7213, PowerPoint, August 26, 2015.

    b. "Conclusions—Presenting the first charge-based transthoracic VFT model covering stimuli durations over 1 µs – 300 s, we found 3 behavioral regions of charge VFT vs. duration. For short stimuli durations, 1 µs – 10 ms, VFTs followed a classic Weiss charge strength-duration curve. For long stimuli, longer than 5 s, charge VFTs can be approximated using a 38 mA_{rms} constant current model. From 10 ms to 5 s, charge VFTs tracked through a transition zone that could be approximated as a constant charge model Q ≈ 100 mC."

2. (08/2014 Panescu) Panescu, D., Kroll, M., and Brave, M. Transthoracic Cardiac Stimulation Thresholds for Short Pulses, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 4471-4474.

    a. Panescu, D., Kroll, M., and Brave, M. Transthoracic Cardiac Stimulation Thresholds for Short Pulses, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 4471-4474, PowerPoint®, August 29, 2014.

    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."

(CEWs Pacing Theory) Mortality and Timing Death: Runaway Pacemakers

1. (2014 Castillo) E. Castillo, A. Dang, T. Chan, and G. Vilke, "313 Mortality and Timing of Death in Patients With Runaway Pacemakers," *Annals of Emergency Medicine*, vol. 64, p. S111, 2014.

    a. *"Conclusion:* There were no published cases identified that demonstrated that runaway pacemakers lead to cardiac arrest in less than 20 minutes, even in a population of elderly cardiac patients, thus there appears to be no consistent data to support the published theory that CEWs can pace the heart into cardiac arrest."

Adult Transcutaneous Cardiac Pacing Thresholds

Table 44 Human Adult Transcutaneous Cardiac Pacing Threshold Literature

Source Information	Minimum (µC)	Minimum Range (in µC)	Comments/Notes
TASER X26 CEW	–	–	Delivers ~100 µC
(1961) Zoll[118] (1964) Zoll[119] (2009) Grimnes[120]	100	100–600	Using "long subcutaneous precordial needles"[121]
(1983) Falk[122]	1680	1680–3200	–
(1984) White[123]	3000	–	2 of 20 patients experienced capture at 150 milliamperes (mA) and 20 milliseconds (ms)
(1984) Geddes[124]			
(1985) Dalsey[125]	4000	–	26 of 52 patients experienced capture at 200 mA and 20 ms
(1985) Berliner[126]	1000	1000–2000	There were no arrhythmias of any type, including ventricular fibrillation (VF), induced by transcutaneous pacing.
(1985) Zoll[127]	800	800–5600	Most commonly ranged from 1600–2800 µC
(1985) Paris[128] (1983) Falk[129]	2000	2000–4000	52% of patients experienced electrical capture
(1985) Clinton[130]	2000	2000–5200	–

[118] Zoll, P. M., H. A, Frankl,. R. N. Zarskya, . J. Linenthal & A. H. Belgard. 1961. Long-term electric stimulation of the heart for Stokes-Adam disease. Ann. Surg. 154: 330.

[119] Zoll, Paul M. and Linenthal, Arthur J., External Electric Stimulation of the Heart, *Annals of the New York Academy of Sciences,* Volume 111, Issue 3, June 1964, Pages 932–937.

[120] Grimnes S, Martinsen OG. Clinical applications of bioelectricity. In: Biomedical Engineering Desk Reference. 1st ed. New York, NY: Elsevier; 2009:241–382.

[121] In the 1964 Zoll paper, cited in the Grimnes treatise, the statement that the researchers used "long subcutaneous precordial needles" references endnote 4 (of the 1964 Zoll paper). Endnote 4 is: Zoll, P. M., H. A, Frankl,. R. N. Zarskya, . J. Linenthal & A. H. Belgard. 1961. Long-term electric stimulation of the heart for Stokes-Adam disease. Ann. Surg. 154: 330.

[122] Falk RH, Zoll PM, Zoll RH. Safety and efficacy of noninvasive cardiac pacing: a preliminary report. N Engl J Med. 1983;309:1166–1168.

[123] White JM, Nowak RM, Martin GB, Best R, Carden DL, Tomlanovich MC. Immediate Emergency Department External Cardiac Pacing for Prehospital Bradyasystolic Arrest. *Annals of Emergency Medicine*, 1985; 14: 298–302.

[124] Geddes LA, Voorhees WD 3rd, Babbs CF, et al. Precordial pacing windows. Pacing Clin Electrophysiol. 1984;7:806–812.

[125] Dalsey WC, Syverud SA, Hedges JR. Emergency Department use of Transcutaneous Pacing for Cardiac Arrests. *Critical Care Medicine.* 1985; 13: 399–401.

[126] Berliner D, Okun M, Peters RW, Carliner NH, Plotnick D, Fisher ML. Transcutaneous Temporary Pacing in the Operating Room. *JAMA*. 1985; 254: 84–86.

[127] Zoll PM, Zoll RH, Falk RH, Clinton JE, Eitel DR, Antman EM. External noninvasive temporary cardiac pacing: clinical trials. *Circulation.* 1985; 71: 937–944.

[128] Paris PM, Stewart RD, Kaplan RM, Whipkey R. Transcutaneous Pacing for Bradyasystolic Cardiac Arrests in Prehospital Care. *Annals of Emergency Medicine.* 1985; 14: 320–323.

[129] Falk RH, Jacobs L, Sinclair A, Madigan-McNeil C. External Noninvasive Cardiac pacing in ut-of-Hospital Cardiac Arrest. *Critical Care Medicine.* 1983; 11: 779–782.

[130] Clinton JE, Zoll PM, Zoll R, Ruiz E. Emergency Noninvasive External Cardiac Pacing. *The Journal of Emergency Medicine.* 1985; 2: 155–162.

Source Information	Minimum (μC)	Minimum Range (in μC)	Comments/Notes
(1986) Noe[131]	2000	–	–
(1987) Barold[132]	3200	–	1 patient. Termination of all 5 episodes of ventricular tachycardia (VT) was accomplished without rate acceleration or degeneration into VF.
(1988) Klein, Zipes[133]	1800	1800–4000	Mean of 2440 μC
(1989) Heller[134]		2660 Zoll NTP 1440 PaceAid 53 1600 Redipace 1720 Transpace 2080 LifePak 8	5 Transcutaneous pacing devices tested Mean capture thresholds of 1740–2660 μC 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
(1990) Luck[135]	1600	1600–3200	Close "double" captures with max output (5600 μC = 140 mA * 40 ms). Researchers never had VF induced.
(1993) Vukmir[136]	25 mA ≥ 500 μC	25–107mA ≥ 500–2140 μC	Pulse widths of 20 to 40 ms were used but were not correlated to specific mA outputs

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).

    a. In the 1964 Zoll paper, cited in the Grimnes treatise, statement that the researchers used "***long subcutaneous precordial needles***" (emphasis added) references endnote 4 (of the 1964 Zoll paper). Endnote 4 is: Zoll, P. M., H.A, Frankl,. R.N. Zarskya, J. Linenthal & A.H. Belgard. 1961. Long-term electric stimulation of the heart for Stokes-Adam disease. *Ann. Surg.* 154: 330.

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.

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[131] Noe R, Cockrell W, Weston Moses H, Dove JT, Batchelder JE. Transcutaneous Pacemaker Use in a Large Hospital. *Pace*. 1986; 9: 101–104.

[132] Barold Serge S, Falkoff MD, Ong LS, Heinle RA. Termination of ventricular tachycardia by transcutaneous cardiac pacing. *Brief Communications.* 1987; 114: 180–182.

[133] Klein LS, Miles WM, Heger JJ, Zipes DP. Transcutaneous pacing: patient tolerance, strength-interval relations, and feasibility for programmed electrical stimulation. Am J Cardiol. 1988;62:1126–1129.

[134] Heller MB, Peterson J, Ilkhanipour K, et al: A comparative study of five transcutaneous pacing devices in unanesthetized human volunteers. Prehospital Disaster Med 1989;4:15–20.

[135] Luck, J.C., Grubb, B., Markel, M.L. 1990. Description of the Strength-Interval Relation with External Noninvasive Pacing. PACE, Vol. 13, Dec. 1998, Part II, pgs 2031–2037.

[136] Vukmir RB. Emergency Cardiac Pacing. *American Journal of Emergency Medicine*. 1993; 11: 166–176.

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 45 Pediatric Transcutaneous Pacing Thresholds

Source Information	Minimum (µC)	Minimum Range (in µC)	Pad Size	Comments/Notes
Béland 1987[137]	1160 µC 1440 µC 1580 µC	1160–3280 µC 1440–3680 µC 1680–3920 µC	Small Med Large	53 of 56 patients (ages 0.9–17.9 years) resulted in successful capture No complications of NTP were noted. No arrhythmias were produced.

137 Béland MJ, Hesslein PS, Finlay CD, Faerron-Angel JE, Williams WG, Rowe RD. Noninvasive Transcutaneous Cardiac Pacing in Children. *Pace*. 1987; 10: 1262–1270.

Transcutaneous Pacing Threshold to VF Safety Margins:

Table 46 Transcutaneous Pacing Threshold to VF Safety Margins

Source Information	Safety Factor (mean)	Comments/Notes
1984 Voorhees[138]	12.6 ± 2.9 (x)	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.
09/2007 Ideker[139]	12.6–28 (x)	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. [Voohees] 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.
1964 Zoll[140]	12x	"The current required to produce fibrillation was 12 times the stimulating threshold at 1 millisecond and about 25 fold at 2 to 3 milliseconds."

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

1. (03/2013 Dawes) Dawes, D.M., Ho, J.D., Moore, J.C., Miner J.R. 2013. An evaluation of two conducted electrical weapons and two probe designs using a swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.

[138] Voorhees WD, Foster KS, Geddes LA, Baabs CF. Safety Factor for Precordial Pacing: Minimum Current Thresholds for Pacing and for Ventricular Fibrillation by Vulnerable-Period Stimulation. *Pace*. 1984; 7: 356–360.

[139] 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.

[140] Zoll, Paul M. and Linenthal, Arthur J., External Electric Stimulation of the Heart, *Annals of the New York Academy of Sciences,* Volume 111, Issue 3, June 1964, Pages 932–937, at 935.

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:

1. (08/2007 Cao) Cao M, Shinbane JS, Gillberg JM, Saxon LS, Swerdlow CD. Taser-induced rapid ventricular myocardial capture demonstrated by pacemaker intracardiac electrograms. J Cardiovasc Electrophysiol. Aug 2007;18(8):876–9.

   a. (12/2007 Cao) Cao, M., Shinbane, J., Gillberg, J. Reply to Letter to the Editor, J Cardiovasc Electrophysi, 18 (12), E29–E30. doi:10.1111/j.1540–8167.2007.00989.x. (December 2007).

      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:

1. (12/1990 Schuchert) Schuchert, A., Kuck, K-H, Bleifeld, W. Stability of Pacing Threshold, Impedance, and R Wave Amplitude at Rest and During Exercise. PACE, Vol. 13, Dec. 1990, Pt 1, pages 1602–1608.

   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.”

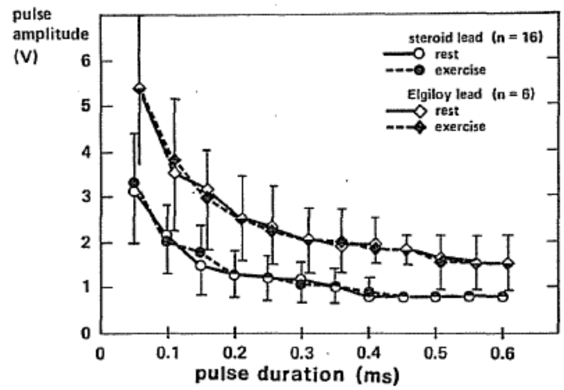


Figure 2. *Strength-duration curves. There were no significant differences in pacing thresholds between rest and exercise for either the steroid lead or Elgiloy leads.*

b. "… None of the investigated parameters showed a significant difference between rest and exercise, neither for the steroid eluting lead nor for the Elgiloy 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

3. (08/2015 Panescu) Panescu, D., Kroll, M., and Brave, M. Cardiac Fibrillation Risks with TASER Conducted Electrical Weapons, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 323-329.

    a. Panescu, D., Kroll, M., and Brave, M. Cardiac Fibrillation Risks with TASER Conducted Electrical Weapons, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 323-329, PowerPoint, August 26, 2015.

    b. "Conclusions—While not risk-free, the use of TASER X26 CEWs implies an extremely low cardiac risk profile."

    c. "CONCLUSIONS: To-date, there has been no undisputed medical evidence linking causation of VF to use of TASER X26 CEWs. In general, CEWs should not be considered risk-free force options. However, the use of TASER X26 CEWs implies an extremely low cardiac risk profile. The overall theoretical VF risk was estimated not to exceed 1 in 2,873,147, consistent with epidemiological CEW statics. Given their reduced output delivered charge levels, newer CEW models, such as TASER X26P and X2 CEWs, are expected to pose even lower cardiac risk."

4. (08/2015 Panescu) Panescu, D., Kroll, M., Andrews, C., Pratt, H., Transthoracic Ventricular Fibrillation Charge Thresholds, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 7208-7213.

    a. Panescu, D., Kroll, M., Andrews, C., Pratt, H., Transthoracic Ventricular Fibrillation Charge Thresholds, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 7208-7213, PowerPoint, August 26, 2015.

    b. "Conclusions—Presenting the first charge-based transthoracic VFT model covering stimuli durations over 1 μs – 300 s, we found 3 behavioral regions of charge VFT vs. duration. For short stimuli durations, 1 μs – 10 ms, VFTs followed a classic Weiss charge strength-duration curve. For long stimuli, longer than 5 s, charge VFTs can be approximated using a 38 mA_{rms} constant current model. From 10 ms to 5 s, charge VFTs tracked through a transition zone that could be approximated as a constant charge model Q ≈ 100 mC."

5. (08/2015 Kroll) Kroll, M.W., Perkins, P.E., Panescu, D. Electric Fence Standards Comport with Human Data and AC Limits, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 1343-1348.

    a. Kroll, M.W., Perkins, P.E., Panescu, D. Electric Fence Standards Comport with Human Data and AC Limits, Conf Proc IEEE Eng Med Biol Soc, 2015, 37, pp. 1343-1348, Poster.

    b. "Conclusions: The IEC and UL electric fence energizer normal rate standards are conservative in comparison with actual human laboratory experiments. The IEC and UL electric fence energizer rapid-pulsing standards are consistent with accepted IEC AC current limits for commercially used pulse durations."

6. (08/2014 Panescu) Panescu, D., Kroll, M., and Brave, M. Transthoracic Cardiac Stimulation Thresholds for Short Pulses, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 4471-4474.

    a. Panescu, D., Kroll, M., and Brave, M. Transthoracic Cardiac Stimulation Thresholds for Short Pulses, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 4471-4474, PowerPoint®, August 29, 2014.

    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."

7. (08/2014 Panescu) Panescu, D., Kroll, M., and Brave, M. Limitations of Animal Electrical Cardiac Safety Models, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 6483-6486.

    a. Panescu, D., Kroll, M., and Brave, M. Limitations of Animal Electrical Cardiac Safety Models, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 6483-6486, PowerPoint®, August 30, 2014.

    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."

8. (08/2014 Panescu) Panescu, D., Kroll, M., Iverson, C., and Brave, M. The Sternum as an Electrical Shield, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 4464-4470.

    a. Panescu, D., Kroll, M., Iverson, C., and Brave, M. The Sternum as an Electrical Shield, Conf Proc IEEE Eng Med Biol Soc, 2014, 36, pp. 4464-4470, PowerPoint®, August 29, 2014.

    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."

9. (04/2014 Kunz) Kunz, S.N., Aronshtam, J., Tränkler, H-R, Kraus, S., Graw, M., Peschel, O. Cardiac Changes Due to Electronic Control Devices? A Computer-Based Analysis of Electrical Effects at the Human Heart Caused by an ECD Pulse Applied to the Body's Exterior. *J Forensic Sci, 2014.* doi: 10.1111/1556-4029.12383.

    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."

10. (2007 Holden) Holden SJ, Sheridan RD, Coffey TJ, Scaramuzza RA, Diamantopoulos P. Electromagnetic modelling of current flow in the heart from TASER devices and the risk of cardiac dysrhythmias. *Phys Med Biol* 2007;52 (24):7193–209.

11. (2006 Stratbucker) Stratbucker RA, Kroll MW, McDaniel W, Panescu D. Cardiac current density distribution by electrical pulses from TASER devices. Conf Proc IEEE *Eng Med Biol Soc* 2006;1:6305–7.

12. (2006 Panescu) Panescu D, Kroll MW, Efimov IR, Sweeney JD. Finite element modeling of electric field effects of TASER devices on nerve and muscle. Conf Proc IEEE *Eng Med Biol Soc* 2006;1:1277–9.

13. (06/2005 Webster) Webster JG. Electromuscular incapacitating devices. Proceedings of IFMBE, 13th Nordic Baltic Conference on Biomedical Engineering and Medical Physics; 2005 June 13–17; Umea, Sweden: Springer, 2005;150–1.

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

Electrical Standards Safety Summary:

Table 47 CEW-Related Electrical Safety Standards Primary References

No.	Date	Document
10	Jul. 2013	Panescu, M. Nerheim and M. Kroll, "Electrical Safety of Conducted Electrical Weapons Relative to Requirements of Relevant Electrical Standards," Conf. Proc. IEEE Eng. Med. Biol. Soc., vol. 2013, pp. 5342–5347, 2013.
9	Jan. 2013	Adler, A., Dawson, D., Evans, R., Garland, L., Miller, M., Sinclair, I., Youmaran, R. Toward a Test Protocol for Conducted Energy Weapons. Modern Instrumentation, 2013, 2, 7–15.[141]
8	Feb. 2013	Hughes, E.L., Jenkins, D.M., Welz, J.P., Miller, A.G., Hobbs, N.J. 2013. The Karbon Arms Multi-Purpose Immobilization Device (MPID) A Characterization Study. Weapons & Protective Services Technologies Center (WPSTC) and Penn State. February 7, 2013.
7	Sep. 2011	Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255-258.
6	Jan. 2009	Nimunkar AJ, Webster JG. Safety of pulsed electric devices. Physiol Meas. Jan 2009;30(1):101–114
5	Jul. 2004	Sherry C, Beason C, Brown GC et al. Variable Taser Parameters: Effectiveness (Muscle Contraction) and Cardiac Safety (Ventricular Fibrillation). United States Air Force Research Laboratory. AFRL-HE-BR-TR-2004-0094. July 2004.
4	Jun. 2004	Southwell, J. (2004) Taser X-26 Safety Analysis, Biomedical Engineering, The Alfred, Victoria, Australia
3	Sep. 2003	Southwell J. (2004) Advanced TASER M-26 [CEW] Safety Analysis. The Alfred Hospital. Sept 22 2003.
2	Jul. 1999	Kenny J, Murray B, Sebastianelli W, et al. Report of Findings: Sticky Shocker Assessment. Penn State Applied Research Laboratory. July 29 1999.
1	1990	Robinson, M.N., Brooks, C.G., Renshaw, G.D. 1990. Electric Shock Devices and their Effects on the Human Body. Med. Sci. Law (1990) Vol. 30, No. 4, 285–300.

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.

[141] 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 48 Electrical Standards Safety Summary Table

X26 CEW Meets[142]		Electrical Safety Standard
Yes	No	
Definitions Only		(IEC) Transitions, pulses and related waveforms - Terms, definitions and algorithms, IEC 60469 {Ed. 1.0}, IEC Geneva, Switzerland, 2013 [Published April 23, 2013]
Yes		(IEC) Effects of Current on Human Beings and Livestock, IEC 60479-1: General Aspects, 4th Edition, IEC, Geneva, Switzerland, 2005.
Yes		(IEC) Effects of current on human beings and livestock: Part 2: Special aspects. AS/NZS 60479.2:2002. IEC 60479-2:1987. " [IEC title: Effects of current passing through the human body—Part 2: Special aspects] [Also see, Adler, Modern Instrumentation[143]]
Yes		(IEC) IEC 60335-2-76, edn 2.1: Household and Similar Electrical Appliances—Safety—Part 2—76: Particular Requirements for Electric Fence Energizers, 2006 (Geneva: IEC).
Yes		(AS/NZS) Effects of current on human beings and livestock: Part 1: General aspects. AS/NZS 60479.1:2010. IEC/TS 60479-1, Ed. 4.0 (2005).
Yes		(AS/NZS) Effects of current on human beings and livestock: Part 2: Special aspects. AS/NZS 60479.2:2002. IEC 60479-2:1987. [IEC title: Effects of current passing through the human body—Part 2: Special aspects]
Yes		(AS/NZS) AS3S59•19131; IEC479-l & IEC479-2 Australian Standard [IEC title: Effects of current passing through the human body]
Yes		(BS) EN 60601-1:2006 Medical electrical equipment. General requirements for basic safety and essential performance. 2006 (including corrigenda up to March 2010).
Yes		(UL) Standard for Electric-Fence Controllers, UL 69 10th edn (Northbrook, IL: UL Laboratories), 2009.
Yes		Webster's Proposed Safety Test Standard (01/2009).

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

1. Panescu, M. Nerheim and M. Kroll, "Electrical Safety of Conducted Electrical Weapons Relative to Requirements of Relevant Electrical Standards," Conf. Proc. IEEE Eng. Med. Biol. Soc., vol. 2013, pp. 5342–5347, 2013.
    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."

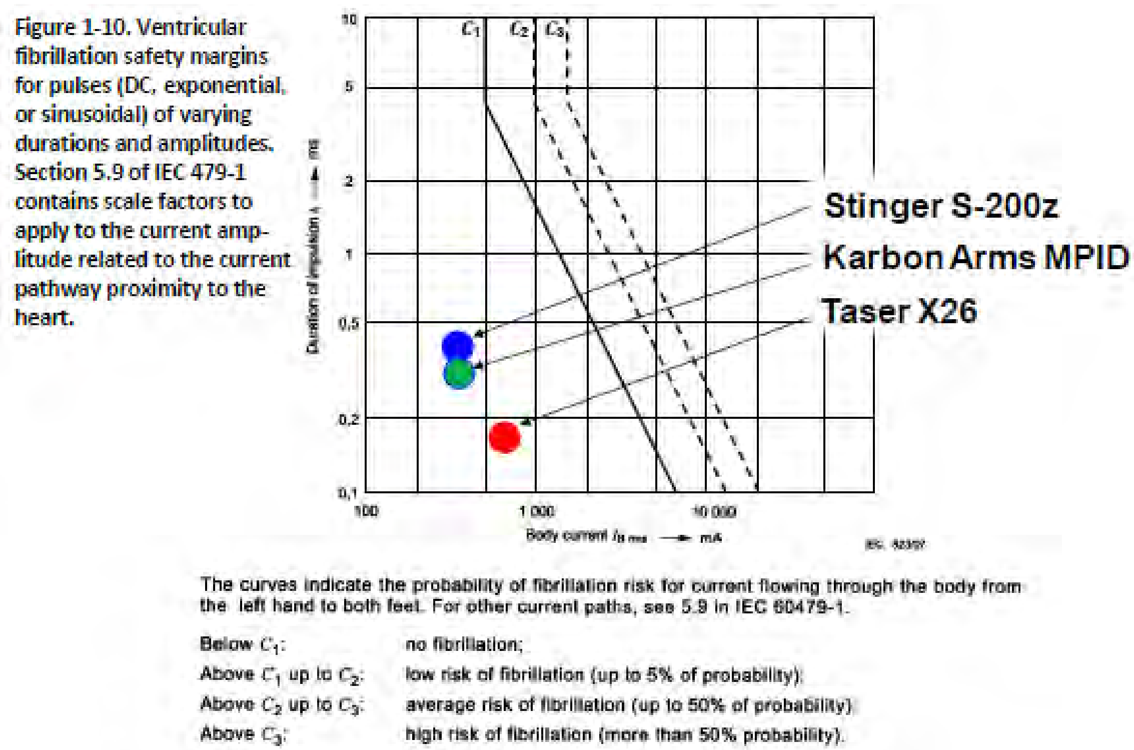
(02/2013) Hughes, et. al. Ventricular Fibrillation Safety Margins:

1. (02/2013 Hughes) Hughes, E.L., Jenkins, D.M., Welz, J.P., Miller, A.G., Hobbs, N.J. 2013. The Karbon Arms Multi-Purpose Immobilization Device (MPID) A Characterization Study. Weapons & Protective Services Technologies Center (WPSTC) and Penn State. February 7, 2013. (below chart from page 1–7)

[142] 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.

[143] Adler, A., Dawson, D., Evans, R., Garland, L., Miller, M., Sinclair, I., Youmaran, R. Toward a Test Protocol for Conducted Energy Weapons. Modern Instrumentation, 2013, 2, 7-15.

Figure 33 (02/2013) Hughes, E.L., et. al. Karbon Arms IEC 479-1 Graphic Illustration



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:

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Q … "Hence if the X26 Taser were to be
assessed according to IEC 2006[144] and UL 2003[145]
standards for electric fence energizers it
would pass the safety test," is that correct?
A That's correct.
Q Was that correct when you wrote it?

[144] *IEC 2006 Household and Similar Electrical Appliances—Safety—Part 2—76: Particular Requirements for ElectricFence Energizers* IEC 60335-2-76, edn 2.1 (Geneva: IEC).

[145] Underwriters Laboratories 2003 *UL Standard for Electric-Fence Controllers, UL 69* 9th edn (Northbrook, IL: ULLaboratories).

A Yes.

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Q Was that correct when it was published?
A Yes.
Q Is that correct today?
A Yes.
Q And then on that same page on 162 you begin to propose a new standard; is that correct?
A Correct.
Q And that new standard on page 166, the third paragraph down, it starts, “A similar”?
A Right.
Q “A similar standard could be developed for the Taser and similar devices. If the maximum voltage does not exceed 0.5 volts the device is not as harmful as an X26 Taser and passes the test,” is that correct?
A Yes.
Q So therefore at the time you wrote this an X26 Taser electronic control device would pass your proposed standard that you put into this paper, Exhibit No. 91, correct?
A Correct.
Q Is that still true today?
A Yes.

2. (01/2009 Nimunkar) Nimunkar AJ, Webster JG. Safety of pulsed electric devices. Physiol Meas. Jan 2009;30(1):101–114.

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

    b. **I**n his 2009 paper[146], “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.

[146] A J Nimunkar and J G Webster, “Safety of pulsed electric devices,” *Physiol. Meas.* 30 (2009) 101–114.

Table 49 2009 Nimunkar/Webster paper electrical device outputs

Table 1. Approximate electrical outputs for all devices.

EUTs Parameters	Units	EFE1	EFE2	EFE3	EFE4	EFE5	Taser	Leak detector
A. Without 2 μF (IEC)								
Total energy	A^2 ms	7.94	4.04	3.10	0.42	4.69	NA	NA
95% energy duration	μs	129	346	91	253	138		
I_{rms}	A	7.65	3.33	5.69	1.25	5.69		
IEC standard I_{rms}	A	13.0	6.21	15.7	7.85	12.3		
Safety factor (SF) = IEC standard I_{rms}/I_{rms}	A/A	1.70	1.86	2.76	6.28	2.16		
Pass IEC standard	Yes/No	Yes	Yes	Yes	Yes	Yes		
B. With 2 μF (UL)								
Total energy	A^2 ms	58.7	21.9	22.6	1.00	18.9	NA	NA
95% energy duration	μs	120	210	140	393	118		
I_{rms}	A	21.6	9.95	12.4	1.55	12.3		
UL standard I_{rms}	A	8.82	5.96	7.92	3.85	8.93		
Pass UL standard	Yes/No	No	No	No	Yes	No		
C. Proposed standard								
Voltage	V	3.88	2.91	NAv	NAv	NAv	0.469	0.0113
Duration	μs	233	132				170	1390
Current	A	3.33	4.41				0.55	0.00163
Charge	μC	776	582				93.76	2.26
Voltage × SF (1.70)	V	6.60	4.95				NA	NA

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):

   a. Effects of current on human beings and livestock: Part 1: General aspects. AS/NZS 60479.1:2010. IEC/TS 60479-1, Ed. 4.0 (2005).

   b. Effects of current on human beings and livestock: Part 2: Special aspects. AS/NZS 60479.2:2002. IEC 60479-2:1987. [IEC title: Effects of current passing through the human body—Part 2: Special aspects]

   c. AS3S59•19131; IEC479-l & 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.

2. (06/29/2004 AS/NZS Standard) Southwell, J. (2004) Taser X-26 Safety Analysis, Biomedical Engineering, The Alfred, Victoria, Australia.

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.

3. Southwell J. (2004) Advanced TASER M-26 [CEW] Safety Analysis. The Alfred Hospital. Sept 22 2003.

X26 CEW Meets British Safety Standards:

1. BSI British Standards[147]. BS EN[148] 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[149]. 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[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_{rms} *for safety to a lead inserted directly inside the heart*. While the 10 μA_{rms} limit does not apply to TASER X26 devices, as they are

[147] 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 andDecember 2007. It supersedes BS EN 60601-1:1990 andBS 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.

[148] European standard are approved bythe CENELEC (French: Comité Européen de Normalisation Électrotechnique; 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.

[149] 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 TechnischerÜberwachungs-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[150]:

   a. Specific IEC Standards:

      i. Effects of Current on Human Beings and Livestock, IEC 60479-1: General Aspects, 4th Edition, IEC, Geneva, Switzerland, 2005.

      ii. Effects of Current on Human Beings and Livestock, IEC 60479-2: Special Aspects, 3rd Edition, IEC, Geneva, Switzerland, 2007. (see also Adler, Modern Instrumentation[151])

      iii. IEC 60335-2-76, edn 2.1: Household and Similar Electrical Appliances—Safety—Part 2—76: Particular Requirements for Electric Fence Energizers, 2006 (Geneva: IEC).

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

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[150] International Electrotechnical Commission (IEC) (French: Commission électrotechniqueinternationale (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.

[151] Adler, A., Dawson, D., Evans, R., Garland, L., Miller, M., Sinclair, I., Youmaran, R. Toward a Test Protocol for Conducted Energy Weapons. Modern Instrumentation, 2013, 2, 7-15.

The IEC 60479 standard deals with effects of electrical current on human beings and livestock[152,153]. 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[2]. It states that "for 50% probability of fibrillation, Fq is of the order of 0.005 As." Fq 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 (µC). The first peak of the TASER X26 CEW current (and by far the largest) carries a charge of about 100 µC. 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_{Cms} as being I_{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_{Crms} 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_{Crms} 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_{Crms} 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_{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,

[152] Effects of Current on Human Beings and Livestock, IEC 60479-1: General Aspects, 4th Edition, IEC, Geneva, Switzerland, 2005.

[153] Effects of Current on Human Beings and Livestock, IEC 60479-2: Special Aspects, 3rd Edition, IEC, Geneva, Switzerland, 2007.

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.

c. Review of TASER X26 CEW delivered electrical output with respect to requirements of standard IEC 60335-2-76 ed2.1b: 2006.

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_{rms} for an impulse duration of not greater than 0.1 ms;

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:

1. Underwriters Laboratories (UL) Standard for Electric-Fence Controllers, UL 69 10th edn (Northbrook, IL: UL Laboratories), 2009.

   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:

     current (mA) = 2000 × (pulse duration (ms))$^{-0.7}$.

     For a single impulse with a duration of 0.1 ms, the equation yields:

     $I_{single\_pulse\_UL\_limit} = 10023\ mA_{rms}$

     Abnormal operation restrictions are specified as:

     - *current (mA) = 2000 × (pulse duration (ms))$^{-0.7}$. (pps)$^{-0.5}$*
     - *For an impulse with a duration of 0.1 ms and a repetition rate of 19 pps,* $I_{repetitive\_UL\_limit} = 2300\ mA_{rms}$

   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_{rms}. This value is much lower than the *10,023* mA_{rms} and than the *2300* mA_{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_{rms}. This value is still much lower than the *10,023* mA_{rms} standard limit for single pulses and lower than the *2300* mA_{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:

1. (01/2013 Adler) Adler, A., Dawson, D., Evans, R., Garland, L., Miller, M., Sinclair, I., Youmaran, R. Toward a Test Protocol for Conducted Energy Weapons. Modern Instrumentation, 2013, 2, 7–15.

    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).

2. (09/2011 Walcott) Walcott G, Kroll M, Ideker R. Ventricular Fibrillation Threshold of Rapid Short Pulses. EMBS. IEEE International Conference; Sept 2011:255–258.

    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.

3. (07/2004 Sherry/AFRL) Sherry C, Beason C, Brown GC et al. Variable Taser Parameters: Effectiveness (Muscle Contraction) and Cardiac Safety (Ventricular Fibrillation). United States Air Force Research Laboratory. AFRL-HE-BR-TR-2004-0094. July 2004.

4. (07/1999 Kenny) Kenny J, Murray B, Sebastianelli W, et al. Report of Findings: Sticky Shocker Assessment. Penn State Applied Research Laboratory. July 29 1999.

5. (1990 Robinson) Robinson, M.N., Brooks, C.G., Renshaw, G.D. 1990. Electric Shock Devices and their Effects on the Human Body. Med. Sci. Law (1990) Vol. 30, No. 4, 285–300.

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).[154]

2. Amnesty International report has been deemed inadmissible and unreliable. See:

    a. *Glowczenski v. TASER Intl, Inc.*, CV04-4052 WDW, 2013 WL 802912 (E.D.N.Y. Mar. 5, 2013) (excluding Amnesty International report as inadmissible);

    b. *Bachtel v. TASER Intl., Inc.*, 2:11-CV-00069 JCH, 2013 WL 317538 (E.D. Mo. Jan. 28, 2013) (same); and

    c. *Parker v. City of S. Portland*, CIV 06-129-P-S, 2007 WL 1468658 (D. Me. May 18, 2007) aff'd, 2007 WL 2071815 (D. Me. July 18, 2007) (same).

[154] http://www.amnestyusa.org/research/reports/annual-report-united-states-of-america-2013?page=show. [accessed 9/20/2013 5:36:02 PM].

Dziekanski / Braidwood / Williams Timeline:

Table 50 Dziekanski / Braidwood / Williams Timeline

Date	Event
Oct. 14, 2007	Date of Death: Robert Dziekanski
Jan. 29, 2008	Dziekanski autopsy report received by Ministry of Solicitor General
Feb. 15, 2008	Braidwood was appointed as sole Commissioner
May–June 2008	Braidwood convened for 15 days of informal, non-adversarial public forums
Dec. 12, 2008	Canadian public statements regarding Dziekanski death
June 18, 2009	Braidwood 1 released
June 2012	Williams' Paper[155]

1. January 29, 2008: Dziekanski Autopsy Report received by Ministry of Solicitor General on January 29, 2008.

   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.

2. (06/2012 Williams) Williams H. 2012. The Braidwood Commission reports on TASER use in Canada: an evidence-based policy review. Policing. July 2011;35(2):356-381.

   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)

[155] Williams H. 2012. The Braidwood Commission reports on TASER use in Canada: an evidence-based policy review. Policing. July 2011;35(2):356-381.

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").

Sudden Cardiac Death: Law Enforcement

1. (11/2014 Varvarigou) V. Varvarigou, A. Farioli, M. Korre, S. Sato, I. J. Dahabreh, and S. N. Kales, "Law enforcement duties and sudden cardiac death among police officers in United States: case distribution study," *BMJ*, vol. 349, p. g6534, 2014.

    a. **Bottom Line:** Compared with routine/non-emergency activities, the risk of sudden cardiac death (SCD) was:

        i. 34-69 times higher during restraints/altercations,

        ii. 32-51 times higher during pursuits,

        iii. 20-23 times higher during physical training, and

        iv. 6-9 times higher during medical/rescue operations.

    b. "Law enforcement is a dangerous occupation. In 2011-12, the fatality rate among patrol officers in the United States was 15-16 per 100 000 full time workers, about 3-5 times the national average for private sector employees …"

        i. Fatality rate among U.S. patrol officers: 15-16 per 100,000 full-time workers is a rate of one (1) in 6,250 – 6,666

    c. **Basic Numbers** – 441 of 4500 officer deaths were sudden cardiac death (SCD)

        i. 25% (n=108) of SCD associated with restraints/altercations

        ii. 20% (n=88) of SCD associated with physical training

        iii. 12% (n=53) of SCD associated with pursuits of suspects

        iv. 8% (n=34) of SCD associated with medical/rescue operations

        v. 23% (n=101) of SCD associated with routine duties

        vi. 11% (n=57) of SCD associated with other activities

    d. **Results** 441 sudden cardiac deaths were observed during the study period. Sudden cardiac death was associated with restraints/altercations (25%, n=108), physical training (20%, n=88), pursuits of suspects (12%, n=53), medical/rescue operations (8%, n=34), routine duties (23%, n=101), and other activities (11%, n=57). Compared with routine/non-emergency activities, the risk of sudden cardiac death was 34-69 times higher during restraints/altercations, 32-51 times higher during pursuits, 20-23 times higher during physical training, and 6-9 times higher during medical/rescue operations. Results were robust to all sensitivity and stability analyses.

e. **Conclusions** Stressful law enforcement duties are associated with a risk of sudden cardiac death that is markedly higher than the risk during routine/non-emergency duties. Restraints/altercations and pursuits are associated with the greatest risk. Our findings have public health implications and suggest that primary and secondary cardiovascular prevention efforts are needed among law enforcement officers.

Medical Examiner Sudden Cardiac Death (SCD) Undetermined:

Deaths Undermined or Sudden Unexplained Death ("SUD")

Table 51 % of Deaths Undetermined or Sudden Unexplained Death ("SUD")

Date	% of Deaths Undetermined or Sudden Unexplained Death ("SUD")	Paper
May 2015	25% AN SUD	Harmon[156], autopsy negative (AN) sudden unexplained death (SUD)
Jan. 2015	53% SUD	Krexi[157], Sudden cardiac death with stress and restraint (n=110)
Apr. 2014	31% SUD	Risgaard[158], Sudden cardiac death in persons aged 1-49 years
Apr. 2014	28% SUD	Winkel[159], Sudden cardiac death in children (1-18 years)
Mar. 2014	20% undetermined	Harmon[160], Etiologies of SCD in NCAA Athletes
Feb. 2014	9% unresolved	Maron[161], U.S. college athletes
Sep. 2011	41.3% < 35 years 20.7% unexplained	Eckart[162], young athletes; < 35 years of age sudden unexplained death
Dec. 2004	35% undetermined	Eckart[163], military 25 year study
1995	5% undetermined	Van Camp[164], Nontraumatic sports death high school/college athletes

[156] Harmon, K.G., Asif, I.M., Maleszewski, J.J., Owens, D.S., Prutkin, J.M., Salerno, J.C., Zibman, M.L., Ellenbogen, R., Rao, A., Ackerman, M.J., Drezner, J.A. Incidence, Etiology, and Comparative Frequency of Sudden Cardiac Death in NCAA Athletes: A Decade in Review. *Circulation*. Originally published May 14, 2015. doi: 10.1161/CIRCULATIONAHA.115.015431.

[157] Krexi, L., et al., Sudden cardiac death with stress and restraint: *The association with sudden adult death syndrome, cardiomyopathy and coronary artery disease*. Medicine, Science and the Law, 2015: p. 0025802414568483.

[158] Risgaard B, Winkel BG, Jabbari R, Glinge C, Ingemann-Hansen O, Thomsen JL, Ottesen GL, Haunso S, Holst AG and Tfelt-Hansen J. Sports Related Sudden Cardiac Death in a Competitive and Non-competitive Athlete Population aged 12-49 years: Data from an unselected Nationwide study in Denmark. *Heart Rhythm*: the official journal of the Heart Rhythm Society. 2014.

[159] Winkel BG, Risgaard B, Sadjadieh G, Bundgaard H, Haunso S and Tfelt-Hansen J. Sudden cardiac death in children (1-18 years): symptoms and causes of death in a nationwide setting. *European Heart Journal*. 2014;35:868-75.

[160] Harmon, K.G., Drezner, J.A., Maleszewski, J.J., Lopez-Anderson, M., Owens, D., Prutkin, J.M., Asif, I.M., Klossner, D., Ackerman, M.J. Etiologies of Sudden Cardiac Death in National Collegiate Athletic Association Athletes. *Circ Arrhythm Electrophysiol*. published online March 1, 2014.

[161] Maron BJ, Haas TS, Murphy CJ, Ahluwalia A, Rutten-Ramos S, Incidence and Causes of Sudden Death in U.S. College Athletes, *Journal of the American College of Cardiology* (2014), doi: 10.1016/j.jacc.2014.01.041.

[162] Eckart, R.E., Shry, E.A., Burke, A.P., McNear, J.A., Appel, D.A., Castillo-Rojas, L.M., Avedissian, L., Pearse, L.A., Potter, R.N., Tremaine, L., Gentlesk, P.J., Huffer, L., Reich, S.S., Stevenson, W.G. Sudden Deaths in Young Adults: An Autopsy-Based Series of a Population Undergoing Active Surveillance. *JACC* Vol. 58, No. 12, 2011, September 13, 2011:1254–61..

[163] Eckart RE, Scoville SL, Campbell CL, Shry EA, Stajduhar KC, Potter RN, Pearse LA and Virmani R. Sudden death in young adults: a 25-year review of autopsies in military recruits. *Ann Intern Med*. 2004;141:829-34.

[164] Van Camp, S.P., Bloor, C.M., Mueller, F.O., Cantu, R.C., Olson, H.G. Nontraumatic sports death in high school and college athletes. *Medicine and Science in Sports and Exercise*. Official Journal of the American College of Sports Medicine. 1995, pages 641-647.

Black Athletes at Higher Risk of Sudden Death

Table 52 Black athletes at Higher Risk of Sudden Death

Date	Paper	Black athletes at Higher Risk of Sudden Death
July 2015	Reinier[165]	Sudden cardiac death (SCD) two-fold higher among black men and women compared to white men and women.
May 2015	Harmon[166]	Black athletes were at higher risk than white athletes 1:21,491 AY vs. 1:68,354 AY (IRR 3.2, 95% CI, 1.9-5.2, p < .00001).
Mar. 2015	Ellison[167]	Up to 25% of these deaths occur during sports. More than 50% of athletic deaths owing to SCD occur in black athletes.
Feb. 2014	Maron[168]	U.S. college athletes, "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)."

1. (07/2015 Reinier) Reinier, Kyndaron, Gregory A. Nichols, Adriana Huertas-Vazquez, Audrey Uy-Evanado, Carmen Teodorescu, Eric C. Stecker, Karen Gunson, Jonathan Jui, and Sumeet S. Chugh. "Distinctive Clinical Profile of Blacks Versus Whites Presenting With Sudden Cardiac Arrest." *Circulation* (2015): CIRCULATIONAHA-115.
    a. "Conclusions—In this US Community, the burden of SCA was significantly higher in blacks compared to whites. Blacks with SCA had a higher pre-arrest prevalence of risk factors beyond established CAD, providing potential targets for race-specific prevention."
    b. "Age-adjusted rates were two-fold higher among black men and women (175 and 90 per 100,000, respectively), compared to white men and women (84 and 40 per 100,000, respectively)."
2. (05/2015 Harmon) Harmon, K.G., Asif, I.M., Maleszewski, J.J., Owens, D.S., Prutkin, J.M., Salerno, J.C., Zibman, M.L., Ellenbogen, R., Rao, A., Ackerman, M.J., Drezner, J.A. Incidence, Etiology, and Comparative Frequency of Sudden Cardiac Death in NCAA Athletes: A Decade in Review. *Circulation*. Originally published May 14, 2015. doi: 10.1161/CIRCULATIONAHA.115.015431.

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[165] Reinier, Kyndaron, Gregory A. Nichols, Adriana Huertas-Vazquez, Audrey Uy-Evanado, Carmen Teodorescu, Eric C. Stecker, Karen Gunson, Jonathan Jui, and Sumeet S. Chugh. "Distinctive Clinical Profile of Blacks Versus Whites Presenting With Sudden Cardiac Arrest." *Circulation* (2015): CIRCULATIONAHA-115.

[166] Harmon, K.G., Asif, I.M., Maleszewski, J.J., Owens, D.S., Prutkin, J.M., Salerno, J.C., Zibman, M.L., Ellenbogen, R., Rao, A., Ackerman, M.J., Drezner, J.A. Incidence, Etiology, and Comparative Frequency of Sudden Cardiac Death in NCAA Athletes: A Decade in Review. *Circulation*. Originally published May 14, 2015. doi: 10.1161/CIRCULATIONAHA.115.015431.

[167] Ellison, S.R. Sudden Cardiac Death in Adolescents Review Article, *Primary Care: Clinics in Office Practice*, Volume 42, Issue 1, March 2015, Pages 57-76.

[168] Maron BJ, Haas TS, Murphy CJ, Ahluwalia A, Rutten-Ramos S, Incidence and Causes of Sudden Death in U.S. College Athletes, *Journal of the American College of Cardiology* (2014), doi: 10.1016/j.jacc.2014.01.041.

a. The most common medical cause of death was SCD [sudden cardiac death] (79, 15%, 1:53,703 AY [athlete-years]).

b. Males were at higher risk than females 1:37,790 AY vs. 1:121,593 AY (IRR 3.2, 95% CI, 1.9-5.5, $p < .00001$), and

c. Black athletes were at higher risk than white athletes 1:21,491 AY vs. 1:68,354 AY (IRR 3.2, 95% CI, 1.9-5.2, $p < .00001$).

d. The incidence of SCD in Division 1 male basketball athletes was 1:5,200 AY.

e. The most common findings at autopsy were autopsy negative sudden unexplained death (AN-SUD) in 16 (25%)

    i. The most common finding in athletes with SCD was a structurally (gross and histologically) normal heart (AN-SUD) in 16 (25%),

    ii. In this study the most common finding at death was AN-SUD (16, 25%)

f. Incidence of SCD

    i. The overall incidence of SCD in NCAA athletes was 1:53,703 AY.

    ii. Males were at higher risk than females (1:38,390 AY vs.1:121,593 AY; IRR 3.2, 95% CI, 1.8-6.0, $p < 0.00001$),

    iii. Black athletes at higher risk than white athletes (1:21,491,147 AY vs. 1:68,354 AY; IRR 3.2, 95% CI, 1.9-5.2, $p < 0.00001$), and

    iv. Black male athletes at higher risk than white male athletes (1:15,829 AY vs. 1:45,514 AY; IRR 2.9, 95% CI, 1.6-5.2, $p = 0.0001$).

g. Basketball athletes (male and female) had the highest risk of SCD with a rate of 1:15,462 AY.

h. Male basketball athletes were at significantly higher risk than female basketball athletes (1:8,978 AY vs. 1:77,061 AY; IRR 8.6, 95% CI, 2.1-76, $p = 0.0003$).

i. There were 10 SCDs over 10 years in Division I male basketball athletes for a rate of 1:5,200 AY. (Table 4).

j. Other sports at higher risk included men's soccer (1:23,689 AY), men's football (1:35,951 AY), and men's/women's cross country (1:44,973 AY). (Table 5)

k. The incidence of SCD over an athletes' NCAA career (considered to be 4 years) was 1:13,426 (A4Y).

l. The risk of SCD over 4 years in a men's basketball athlete was 1:2,245 A4Y, and in a Division I male basketball player 1:1,300 A4Y.

m. The career risk of SCD in a male soccer player was 1:5,922 A4Y.

n. Activity at time of death could be characterized in 72 of the 79 SCDs.

   i. 56% occurred with exertion,

   ii. 22% at rest,

   iii. 14% during sleep, and

   iv. activity in 9% was unknown.

o. Male basketball athletes were actually more likely to die from SCD (1:8,978 AY) than from an automobile accident (1:13,122 AY).

p. Sickle cell trait was associated with 10 deaths (2%, 1:424,252 AY)

q. Studies in athletes in other countries,12-16 the US military, and in US college athletes have found autopsy-negative sudden unexplained death (AN-SUD) to be the most frequent finding associated with SCD.

r. This study presents incidence rates per athlete-year, however, it has been suggested that looking at the 4 year time frame of an average college athlete's career is a more accurate way to consider risk. For example

   i. the risk of SCD in an entering Division I male basketball player over the span of an average 4 year career is 1 in 1,300 AY,

   ii. while the rate of SCD for that same time frame in male soccer players 1 in 5,922 AY, and

   iii. in male football players 1 in 8,988 AY.

s. All of the athletes who died in this study had a PPE [preparticipation physical evaluation].

3. (03/2005 Ellison) Ellison, S.R. Sudden Cardiac Death in Adolescents Review Article, *Primary Care: Clinics in Office Practice*, Volume 42, Issue 1, March 2015, Pages 57-76.

   a. Up to 25% of these deaths occur during sports.

   b. More than 50% of athletic deaths owing to SCD occur in black athletes.

4. (01/2015 Krexi) Krexi, L., et al., *Sudden cardiac death with stress and restraint: The association with sudden adult death syndrome, cardiomyopathy and coronary artery disease*. Medicine, Science and the Law, 2015: p. 0025802414568483.

   a. **Results:** "Fifty-three per cent of cases died with a negative autopsy and a morphologically normal heart, indicating sudden adult death which is linked to cardiac channelopathies predisposing to stress-induced SCD. …" (highlighting emphasis added)

Abstract

Objective: The aim of this study was to report on sudden cardiac death (SCD) during or immediately after a stressful event in a predominately young cohort.

Methods: This study used retrospective non-case-controlled analysis. A total of 110 cases of SCD in relation to a stressful event such as altercation (45%), physical restraint (31%) in police custody (10%), exams/school/job stress (7.27%), receiving bad news (4%), or a car accident without injuries (2.73%) were retrospectively investigated. The majority of the subjects experiencing SCD were male (80.91%). The mean age was 36 ± 16 years (range 5–82 years). Twenty-three cases (20.91%) were psychiatric patients on antipsychotic medication.

Results: Fifty-three per cent of cases died with a negative autopsy and a morphologically normal heart, indicating sudden adult death which is linked to cardiac channelopathies predisposing to stress-induced SCD. Cardiomyopathy was found in 16 (14.5%) patients and coronary artery pathology in 19 (17%) patients, with atherosclerosis predominating in older patients.

Conclusions: This study highlights SCD during psychological stress, mostly in young males where the sudden death occurred in the absence of structural heart disease. This may reflect the proarrhythmic potential of high catecholamines on the structurally normal heart in those genetically predisposed because of cardiac channelopathy. Structural cardiomyopathies and coronary artery disease also feature prominently. Cases of SCD associated with altercation and restraint receive mass media attention especially when police/other governmental bodies are involved. This study highlights the rare but important risk of SCD associated with psychological

stress and restraint in morphologically normal hearts and the importance of an expert cardiac opinion where prolonged criminal investigations and medico-legal issues often ensue.

5. (10/2014 Wong) Wong, L.C., Roses-Noguer, F., Till, J.A., and Behr, E.R.: 'Cardiac Evaluation of Pediatric Relatives in Sudden Arrhythmic Death Syndrome (SADS): A 2-Center Experience', *Circulation: Arrhythmia and Electrophysiology*, 2014, pp. CIRCEP. 114.001818

    a. "Sudden arrhythmic death syndrome (SADS) defines a sudden unexpected cardiac death that remains unexplained after comprehensive postmortem examination, histology, and toxicology studies.[1] It accounts for ≈500 deaths in the United Kingdom every year, corresponding to an annual incidence of 1.38/100 000 population.[2] International estimates vary partly because of different populations and inclusion criteria. The incidence of SADS in other white populations ranges from 0.81/100 000 (Danish) to 1.2/100 000 (United States).[3]"

        i. Rate of SADS in white U.S. population is 1.2/100,000 or 1:83,333 [EN 3 - Raju H, Behr ER. Unexplained sudden death, focussing on genetics and family phenotyping. *Curr Opin Cardiol.* 2013;28:19–25.]

6. (03/2014 Harmon) Harmon, K.G., Drezner, J.A., Maleszewski, J.J., Lopez-Anderson, M., Owens, D., Prutkin, J.M., Asif, I.M., Klossner, D., Ackerman, M.J. Etiologies of Sudden Cardiac Death in National Collegiate Athletic Association Athletes. *Circ Arrhythm Electrophysiol.* published online March 1, 2014.

    a. 20% the cause could not be determined

7. (2014 Toresdahl) Toresdahl BG, Rao AL, Harmon KG and Drezner JA. Incidence of sudden cardiac arrest in high school student athletes on school campus. *Heart Rhythm: the official journal of the Heart Rhythm Society*. 2014.

    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.

8. (2014 Maron) Maron BJ, Haas TS, Murphy CJ, Ahluwalia A and Rutten-Ramos S. Incidence and causes of sudden death in U.S. college athletes. *Journal of the American College of Cardiology*. 2014;63:1636-43.

   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.

9. (2013 Drezner) Drezner JA, Toresdahl BG, Rao AL, Huszti E and Harmon KG. Outcomes from sudden cardiac arrest in US high schools: a 2-year prospective study from the National Registry for AED Use in Sports. *British journal of sports medicine*. 2013;47:1179-83.

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.

10. (2009 Maron) Maron, BJ, Doerer, BS, Haas, TS, et. al., Sudden Deaths in Young Competitive Athletes Analysis of 1866 Deaths in the United States, 1980–2006, *Circulation*. 2009; 119: 1085–1092.
    a. "an estimated 30% of these causes of death cannot be identified reliably by preparticipation screening, even with ECG. Page 1090.
11. (12/2004 Eckart) Eckart RE, Scoville SL, Campbell CL, Shry EA, Stajduhar KC, Potter RN, Pearse LA and Virmani R. Sudden death in young adults: a 25-year review of autopsies in military recruits. *Ann Intern Med*. 2004;141:829-34.
    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 and 2014 "Case Series" and Selected Related Documents

(Zipes' CEW Pacing → VF Theory) Mortality and Timing Death: Runaway Pacemakers

1. (2014 Castillo) E. Castillo, A. Dang, T. Chan, and G. Vilke, "313 Mortality and Timing of Death in Patients With Runaway Pacemakers," *Annals of Emergency Medicine*, vol. 64, p. S111, 2014.

    a. *"Conclusion:* There were no published cases identified that demonstrated that runaway pacemakers lead to cardiac arrest in less than 20 minutes, even in a population of elderly cardiac patients, thus there appears to be no consistent data to support the published theory that CEWs can pace the heart into cardiac arrest." [highlighting emphasis added]

January 2014 Kroll and Zipes Controversies in Cardiovascular Medicine:

1. (01/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., Luceri, R.M. 2014. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? *Circulation*. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including online Supplement]

    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.

2. (01/2014 Zipes) Zipes, D.P. 2014. TASER Electronic Control Devices Can Cause Cardiac Arrest in Humans. *Circulation*. 2014;129:101-111. doi: 10.1161/CIRCULATIONAHA.113.005504. [Including online Supplement]

3. (11/2014) Letters regarding Kroll and Zipes' papers:

    a. (11/2014 Sheridan) Sheridan, R.D.: 'Letter by Sheridan Regarding Articles, "TASER Electronic Control Devices Can Cause Cardiac Arrest in Humans" and "TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal?"', *Circulation*, 2014, 130, (19), pp. e167.

b. (11/2014 Kroll) Kroll, M.W., Lakkireddy, D.R., Stone, J.R., and Luceri, R.M.: 'Response to Letter Regarding Article, "TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal?"', *Circulation*, 2014, 130, (19), pp. e168.

c. (11/2014 Zipes) Zipes, D.P.: 'Response to Letter Regarding Article, "TASER Electronic Control Devices Can Cause Cardiac Arrest in Humans"', *Circulation*, 2014, 130, (19), pp. e169.

4. (01/2015 Myerburg) Myerburg R. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? Practice Update. 2014:http://www.practiceupdate.com/journalscan/7641.

   a. On January 15 2015, Dr. Myerburg followed up his May 22, 2012, editorial with a review of the Kroll, et. al. rebuttal paper that included: "I do not believe that there are major safety flaws in the design or intent of ECDs."

   b. The associated headline was: "Take-home message: This article refutes the reliability of case reports associating use of ECDs with cardiac arrest. The author notes that ECD use clearly prevents the need for lethal force by law enforcement."

   c. "In a previous statement, I offered the opinion that, while I could not support a specific causation argument in each of the cases in which a suggestion of a fatal outcome was associated with the use of an ECD, …"

October 15, 2013 Canada Study Quote:[169]

"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

[169] (10/2013 Canada) Council of Canadian Academies and Canadian Academy of Health Sciences, 2013. The Health Effects of Conducted Energy Weapons. Ottawa (ON): The Expert Panel on the Medical and Physiological Impacts of Conducted Energy Weapons Council of Canadian Academies and Canadian Academy of Health Sciences.

the outcome (Swerdlow et al., 2009; Zipes, 2012).” (emphasis added) (pg 36)

October 2013 (Canada) Hall RESTRAINT Quote:[170]

> “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.[171] 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.[172]
>
> 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.[173] Whether such combination functions as a marker for the severity of the agitation or as a causative factor is unstudied.” (Page 15-16).

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[170] Hall, C. 2013. RESTRAINT. Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

[171] [EN 57] Zipes DP. Sudden cardiac arrest and death following application of shocks from a TASER electronic control device. Circulation 2012; 125(20):2417-2422.

[172] [ENs 58-62] 58. Bozeman WP, Hauda WE, Heck JJ, Graham DD, Jr., Martin BP, Winslow JE. Safety and injury profile of conducted electrical weapons used by law enforcement officers against criminal suspects. Ann Emerg Med 2009; 53(4):480-489. 59. William P Bozeman MD JEWMMWEHIMDGMBPMMMJJHD. Injury Profile of TASER Electrical Conducted Energy Weapons (CEWs). Departments of Emergency Medicine: Wake Forest University, Virginia Commonwealth University, Louisiana State University, University of Nevada Medical Center. Annals of Emergency Medicine. 2007. Ref Type: Abstract. 60. Bozeman WP, Teacher E, Winslow JE. Transcardiac conducted electrical weapon (TASER) probe deployments: incidence and outcomes. J Emerg Med 2012; 43(6):970-975. 61. Bozeman WP. Additional information on taser safety. Ann Emerg Med 2009; 54(5):758-759. 62. Bozeman WP, Barnes DG, Jr., Winslow JE, III, Johnson JC, III, Phillips CH, Alson R. Immediate cardiovascular effects of the Taser X26 conducted electrical weapon. Emerg Med J 2009; 26(8):567-570.

[173] [EN 63] 63. Manojlovic D, Hall C, Laur D et al. Technical Report TR-01-2006. Review of Conducted Energy Devices. TR-01-2006. 2005. Canadian Police Research Centre. Ref Type: Report

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."[174] In the hierarchy of scientific evidence a ***case series***, such as Zipes', has very important weaknesses, including: "[l]ack of comparison group markedly limits conclusions about causality" and "[r]isk, 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."[175]

Zipes' "Case Series" Related Documents:

1. (04/30/2012 Zipes) Zipes D.P. 2012. Sudden Cardiac Arrest and Death ***Associated With*** Application of Shocks From a TASER Electronic Control Device. *Circulation* AHA. May 2012. [emphasis added: causal, not temporal.]

    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.

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[174] Ho, M.P., Peterson, P.N., Masoudi, F.A. 2008. Evaluating the Evidence. Is There a Rigid Hierarchy? *Circulation*. 2008;118:1675-1684.

[175] http://circ.ahajournals.org/site/misc/about.xhtml. (accessed September 22, 2013).

2. (04/30/2012 Myerburg) Myerburg, R.J., Goodman, K.W., Ringe, III, T.B.K. 2012. Editorial: Electronic Control Devices Science, Law, and Social Responsibility. *Circulation. 2012*;125:2406–2408, published online before print April 30 2012, doi:10.1161/CIRCULATIONAHA.112.107359.

    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."

3. (05/22/2012) Zipes D.P. 2012. Sudden Cardiac Arrest and Death ***Following Application of*** Shocks from a TASER Electronic Control Device. *Circulation*. 2012; 125:2417-2422. [emphasis added; changed causal to temporal]. Erratums:

    a. (07/10/2012 Zipes) *Circulation*. 2012 Jul 10;126(2):e27.

    b. (06/11/2013 Zipes) *Circulation*. 2013 Jun 11;127(23):e839.[176]

4. (07/10/12 Zipes) Zipes, D.P. 2012. Correction to: Zipes D.P. Correction, *Circulation*. 2012;126:e27, Sudden Cardiac Arrest and Death Following Application of Shocks from a TASER Electronic Control Device. *Circulation*. 2012; 125:2417-2422.

[176] (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."

5. (01/01/2013 Vilke) Vilke GM, Chan TC, Karch S. 2013. Letter by Vilke et al Regarding Article, "Sudden Cardiac Arrest and Death Following Application of Shocks From a TASER Electronic Control Device." *Circulation*. 2013;127:e258.

6. (01/01/2013 Nanthakumar) Nanthakumar K, Waxman M. 2013. Letter by Nanthakumar and Waxman Regarding Article, "Sudden Cardiac Arrest and Death Following Application of Shocks From a TASER Electronic Control Device." *Circulation*. 2013;127:e257.

    a. (06/11/2013) Correction. *Circulation*. 2013;127:e839.

    b. (06/11/2013) Correction. *Circulation*. 2013;127:e840.[177]

7. (01/01/2013 Ho) Ho, J.D., Dawes, D.M. 2013. Letter by Ho and Dawes Regarding Article," Sudden Cardiac Arrest and Death Following Application of Shocks From a TASER Electronic Control Device." *Circulation*. 2013;127:e259.

8. (01/01/2013 Heegaard) Heegaard, W.G., Halperin, H.R., Luceri, R. 2013. Letter by Heegaard et al Regarding Article,"Sudden Cardiac Arrest and Death Following Application of Shocks From a TASER Electronic Control Device." *Circulation*. 2013;127:e260.

9. (01/01/2013 Zipes) Zipes, D.P. 2013. Response to letters regarding article, "sudden cardiac arrest and death following application of shocks from a TASER electronic control device. *Circulation*. 2013 Jan 1;127(1):e261-2.

10. (2013 Zipes) Zipes, D.P. *Circulation* Editor's Picks Most Read Articles in Arrhythmia and Electrophysiology. *Circulation*. 2013;127:e514.

11. (01/2015 Myerburg) Myerburg R. TASER Electronic Control Devices and Cardiac Arrests: Coincidental or Causal? . Practice Update. 2014:http://www.practiceupdate.com/journalscan/7641.

    a. I do not believe that there are major safety flaws in the design or intent of ECDs.

    b. "TAKE-HOME MESSAGE: This article refutes the reliability of case reports associating use of ECDs with cardiac arrest. The author notes that ECD use clearly prevents the need for lethal force by law enforcement."

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177 (June 11, 2013 – Correction) "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."

c. “In a previous statement, I offered the opinion that, while I could not support a specific causation argument in each of the cases in which a suggestion of a fatal outcome was associated with the use of an ECD …”

Zipes: (1975) Epinephrine Initially ↓ Then ↑ VFT:

1. Zipes, D.P. 1975. Electrophysiological Mechanisms Involved in Ventricular Fibrillation. Supplement III to Circulation, Vols. 51 and 52, December, 1975, pages III-120 - III-300.

    a. Epinephrine initially decreased VFT, then increased VFT. (Figure 1).

Table 53 Zipes, 1975 Epinephrine increased VFT. (pg III-123)

Table 1

Some Factors that Alter Refractory Period Dispersion or Ventricular Fibrillation Threshold

Increased RPD or decreased VFT	Decreased RPD or increased VFT
Myocardial ischemia[34–36]	Epinephrine (initial ↓ VFT)[39, 45]
Slower heart rates without ischemia[37]	Slower heart rates with ischemia[38]
Faster heart rates with ischemia[38]	Faster heart rates without ischemia[37]
Sympathetic nerve stimulation[39]	Vagal stimulation[46, 47]
Ventricular premature systoles[40]	Drugs: lidocaine,[48] bretylium,[49] procainamide,[50] diphenylhydantoin,[51] propranolol,[42] quinidine,[45] nitroglycerin,[52] edrophonium[47]
Acidosis[41, 42]	Aminophylline[42] (after first 30 min following i.v. administration)
Ouabain toxicity[43]	Digitalis in intact dog or after stellate stimulation[42, 44]
Aminophylline[42] (for first 30 min after i.v. administration)	Respiratory acidosis with hypoxia[53]
Digitalis with autonomic denervation or propranolol[44]	
Hypothermia[43]	
Quinidine (high doses)[43]	
Chloroform[43]	

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

Zipes: (1988) Transcutaneous Cardiac Pacing Thresholds (1800-4000 µC):

1. Klein LS, Miles WM, Heger JJ, Zipes DP. 1988. Transcutaneous pacing: patient tolerance, strength-interval relations, and feasibility for programmed electrical stimulation. Am J Cardiol. 1988;62:1126–1129.

    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):

1. Gaum, W.E., Elharrar, V., Walker, P.D., Zipes, D.P. 1977. Influence of Excitability on the Ventricular Fibrillation Threshold in Dogs. The American Journal of Cardiology, December 1977, Volume 40, pages 929–935.

    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.

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Selected CEW Deployment and Use Guidance Information

CEW Policy Studies:

1. (09/2014 Ferdik) Ferdik, F.V., Kaminski, R.J.,Cooney, M.D., Sevigny, E.L. The Influence of Agency Policies on Conducted Energy Device Use and Police Use of Lethal Force. *Police Quarterly*, 0(0) I 31, 2014. DOI: 10.1177/ 10986111145480.

   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:

1. (04/2015 Kroll) M. Kroll, "Baseball, Poison, and Soup Recipes: The TASER Trio of Popular Myths," Technical Note, pp. 1-3, 1 March 2015 2015. DOI 10.13140/RG.2.1.3348.4320.

2. (12/2012 CRD/DOJ) Proposed Settlement Agreement, Attachment 1 to Memorandum in Support of Joint Motion to Enter Settlement Agreement and Conditionally Dismiss Action. December 17, 2012. *U.S. v. City of Portland*. U.S.D.Or., Portland Division. Case No. 3:12-cv-02265-SI.

   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.

3. (03/2011 PERF/DOJ) 2011 Electronic Control Weapon Guidelines, Police Executive Research Forum (PERF) and Community Oriented Policing Services, U.S. Department of Justice (DOJ).

   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):

9. (12/2012 CRD/DOJ) Proposed Settlement Agreement, Attachment 1 to Memorandum in Support of Joint Motion to Enter Settlement Agreement and Conditionally Dismiss Action. December 17, 2012. U.S. v. City of Portland. U.S.D.Or., Portland Division. Case No. 3:12-cv-02265-SI.

   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.

10. (05/2011 Laub/NIJ) Laub J. Study of Deaths Following Electro Muscular Disruption. National Institute of Justice. May 2011.

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 dysrhythmias[9,10] or respiratory dysfunction[11] following exposures less than 45 seconds.” Page 27.

11. (05/2011 Vilke) Vilke GM, Bozeman WP, Chan TC. Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician. J Emerg Med. May 2011;40(5):598–604.

    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.

12. (03/2011 PERF/DOJ) 2011 Electronic Control Weapon Guidelines, Police Executive Research Forum (PERF) and Community Oriented Policing Services, U.S. Department of Justice (DOJ).

    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.

13. (04/2010 IACP) International Association of Chiefs of Police (“IACP”) Model Policy, Electronic Control Weapons, April 2010, and IACP National Law Enforcement Policy Center, Electronic Control Weapons, Concepts and Issues Paper, April 2010.

    “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:

1. Ho, M.P., Peterson, P.N., Masoudi, F.A. 2008. Evaluating the Evidence: Is There a Rigid Hierarchy? *Circulation*. 2008;118:1675–1684.

    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:

1. Karch, S.B. Review. Peer review and the process of publishing of adverse drug event reports. *Journal of Forensic and Legal Medicine*, 14 (2007) 79–84.

    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 54 Possible Quantum of Force Table: Probe versus Drive Stun.

Probe Deployment (*Bryan v. MacPherson*[178])	Drive–Stun (single set of electrodes)
" [TASER CEW], in general, is more than a non-serious or trivial use of force but less than deadly force," • Intermediate quantum of force • Significant quantum of force • Justified by a strong government interest Factors: • Pain was intense, felt throughout the body, • CEW effectively commandeered the person's muscles and nerves Holding: • X26 CEW is "an intermediate or medium, though not insignificant, quantum of force." • 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." Injuries in *Bryan* (as stated in *Brooks v. Seattle*): • excruciating pain throughout his entire body, • temporary paralysis, [resulting in fall to hard surface] • facial abrasions, • shattered teeth, and • a sharp barb lodged into his flesh.	Factors: • painful, only transitory, localized pain • non-incapacitating effect • without incapacitating muscle contractions • without significant lasting injury • has markedly different physiological effects Basics: • Less-than-intermediate quantum of force • Amount of force more on par with pain compliance techniques

[178] "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:

- *Watson v. City of Marysville*, 518 Fed.Appx. 390 (C.A.6 (Ohio), Mar. 26, 2013) (quoting *Hagans*):
    - 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:

- *Newman v. Guedry*, 703 F.3d 757 (C.A.5 (Tex.) December 21, 2012):
    - 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.”

Manufacturer recommendations, while relevant, do not equal constitutional requirements.

- Order and Judgment dated January 27, 2015, The Estate of Ronald H. Armstrong v. The Village of Pinehurst, et. al., USDC MDNC, File No. 1:13-CV-407.
  - “The officer used the taser on “drive stun,” which did not involve any probes and is non-deadly force. Manufacturer recommendations, while relevant, do not equal constitutional requirements.”

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 4981591, at *5 (D. Utah Dec. 14, 2009). Judge Campbell denied summary 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.

- *Rosen v. King*, 913 F.Supp.2d 666 (N.D.Ind., December 18, 2012):

  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]

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:

- *Ostling v. City of Bainbridge Island*, 2012 WL 4480550 (W.D.Wash. September 28, 2012):
  - "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:

- *Harrison v. City of Dickson, Tenn.*, Slip Copy, 2013 WL 1482950 (M.D.Tenn., April 11, 2013):
  - o 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."
  - o 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):
  - o "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):
  - o 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.
    - o 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):
  - o "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."

    FN7. The Commission sets minimum training standards for all California law enforcement personnel. See The Commission on Peace Officer Standards and Training, Commission on POST--Home, http://post.ca.gov/ (last visited August 19, 2011).

    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:

- *Marquez v. City of Phoenix*, 693 F.3d 1167, 1175-76 (C.A.9 (Ariz.), Sept. 11, 2012):
  - o finding the use of at least nine cycles from a TASER X26 CEW in drive-stun mode was reasonable under the circumstances, where the plaintiff was actively

resisting arrest and appeared to pose an immediate threat to the officers and others.

- *Turner v. City of Toledo*, No. 3:07CV274, 2012 WL 1669836 (N.D.Ohio May 14, 2012):
  - o 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.
- *Sheffey v. City of Covington*, 564 Fed.Appx. 783, 2014 WL 1663063 (C.A.6 (Ky) April 28, 2014):
  - o "Mr. Hughes received an electrical current from the responding officers' tasers a total of twelve separate times."
  - o "For the foregoing reasons, the district court's grant of summary judgment in favor of the responding officers is AFFIRMED."
- *Jackson v. Wilkins*, 517 Fed.Appx. 311 (C.A.6 (Mich.) Mar 06, 2013):
  - 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):

- 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):
  - "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."
  - 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
  - *State v. Barragan*, 9 P.3d 942, 945 (Wash. App. 2000) (treating pencil as a deadly weapon).

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:

- *Scott v. Harris*, 550 U.S. 372, 127 S.Ct. 1769 (2007):
  - "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 "drive stun" "is non-deadly force"

- Order and Judgment dated January 27, 2015, The Estate of Ronald H. Armstrong v. The Village of Pinehurst, et. al., USDC MDNC, File No. 1:13-CV-407.
  - "The officer used the taser on "drive stun," which did not involve any probes and is non-deadly force. Manufacturer recommendations, while relevant, do not equal constitutional requirements."

TASER CEW is not "deadly" force:

- *Sandberg v. City of Torrance,* 456 Fed.Appx. 711, 713, 2011 WL 5154229, at * *2 (9th Cir. Nov. 1, 2011) (referring to use of TASER CEW as "use of non-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")

- *Bernat v. California City Police Dept.,* 1:10-CV-00305-OWW, 2011 WL 1103130 (E.D. Cal., Mar. 22, 2011) (citing *Bryan v. MacPherson*) (taser in dart mode constitutes intermediate non-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)

- *Marella v. City of Bakersfield*, 1:09-CV-00453, 2010 WL 3386465 (E.D. Cal. Aug. 26, 2010) (citing *Bryan v. MacPherson*)

TASER CEW is "non-deadly force":

- *McGee v. City of Cincinnati Police Dept.*, 1:06-CV-726, 2007 WL 1169374 (S.D. Ohio Apr. 18, 2007)

- *Carter v. Colerain Twp.*, 105-CV-163, 2007 WL 869727 (S.D. Ohio Mar. 20, 2007)

TASER CEW is "less-than-lethal" force:

- *Sheffey v. City of Covington*, 564 Fed.Appx. 783 (C.A.6 (Ky) April 28, 2014):

    - "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."

- *De Contreras v. City of Rialto*, 894 F.Supp.2d 1238 (C.D.Cal., September 25, 2012):

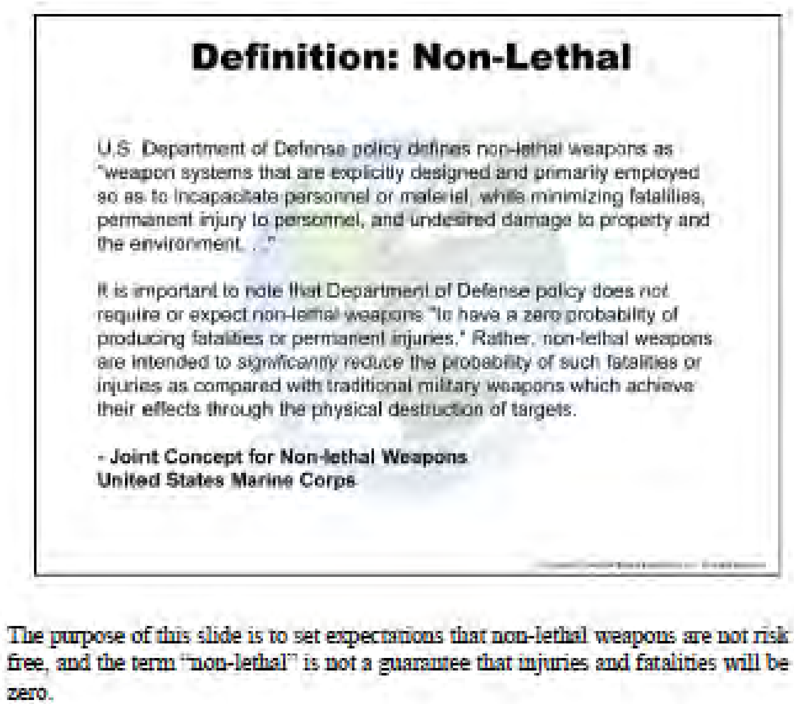
    - FN10. All circuits that have considered the question, including the Ninth Circuit, designate taser use generally as non-lethal or less-than-lethal force. See *Bryan*, 630 F.3d at 825 (citing similar findings from other circuits). There nevertheless have been numerous cases in Ninth Circuit courts in 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":

- *McKenney v. Harrison*, 635 F.3d 354, 362 (8th Cir. (Neb.) March 28, 2011) (citing *Mattos v. Agarano*), (use of 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)
- *Meyers v. Baltimore County, Maryland*, 814 F.Supp.2d 552 (D.Md. Sept. 28, 2011), (citing *Mattos v. Agarano*, 590 F.3d 1082, 1087 (9th Cir. (Haw.) 2010), *superseded* by *Mattos v. Agarano*, 661 F.3d 433 (9th Cir. (Haw.), Oct. 17, 2011).)

TASER CEW is "non-lethal":

Figure 34 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. U.S. Department of Defense, Dir. 3000.3, Policy for Non-Lethal Weapons (9 July 1996).

- *Gandy v. Robey*, 520 Fed.Appx. 134 (C.A.4 (Va.) Apr 04, 2013)

- *State v. Herr*, 346 Wis.2d 603, 828 N.W.2d 896 (Wis.App., February 6, 2013)

- *De Contreras v. City of Rialto*, 894 F.Supp.2d 1238 (C.D.Cal., September 25, 2012):

  - 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).

- *Austin v. Redford Tp. Police Dept.*, 690 F.3d 490 (C.A.6 (Mich.), August 8, 2012)
- *Batiste v. Theriot*, 458 Fed.Appx. 351 (C.A.5 (La.), Jan. 10, 2012)
    - 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)
- *Helfrich v. Lakeside Park Crestview Hills Police Auth.*, CIV. 08-210-WOB, 2010 WL 3927514 (E.D. Ky. Aug. 18, 2010) *report and recommendation adopted in part, rejected in part sub nom. Helfrich v. City of Lakeside Park*, CIV.A. 2008-210 WOB, 2010 WL 3927475 (E.D. Ky. Oct. 4, 2010)
- *Higgs v. Sanford*, CIV.A. 5:07CVP77R, 2009 WL 805121 (W.D. Ky. Mar. 25, 2009)
- *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.[FN32] *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 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 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." *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." *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 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 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.

- *Buckley v. Haddock*, 292 F.Appx. 791 (C.A.11 (Fla.) September 9, 2008)

- *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.

- *Henry v. Purnell*, 428 F. Supp. 2d 393 (D. Md. 2006), *aff'd in part, vacated in part*, 501 F.3d 374 (C.A.4 (Md.) September 20, 2007)

- *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:

- *Marquez v. City of Phoenix*, CV-08-1132-PHX-NVW, 2010 WL 3342000 (D. Ariz. Aug. 25, 2010), *aff'd by*, *Marquez v. City of Phoenix*, 693 F.3d 1167 (C.A.9 (Ariz.) September 11, 2012).

- *Rocha v. Schroeder*, 283 F.App'x 305 (C.A.5 (Tex.) June 27, 2008)

TASER CEW is "less-lethal" weapon:

- *Phillips v. Community Ins. Corp.*, 678 F.3d 513 (C..A.7 (Wis.) April 27, 2012):

  - "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):

  - TASER X26 CEW is "a less intrusive [force] alternative to the beanbag shotgun." *Glenn*, 673 F.3d at 878, fn 10.

  - [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):
    - o 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:

- *Russell v. Wright*, 916 F.Supp.2d 629 (W.D.Va. January 04, 2013); citing *Hagans v. Franklin County Sheriff's Office*, 695 F.3d 505, 510 (C.A.6 (Ohio) August 23, 2012)
- *Reid v. State*, 428 Md. 289, 51 A.3d 597, 2012 WL 3639058 (Md. August 24, 2012)
- *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)
- *Cockrell v. City of Cincinnati*, 468 Fed.Appx. 491. 497 (C.A.6 (Ohio), February 23, 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).

- *Mattos v. Agarano*, 661 F.3d 433 (C.A.9 (Hawai'i), October 17, 2011) (Kosinski, C.J., concurring in part, dissenting in part).

"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."
        (1) *Skube v. Williamson*, Not Reported in F.Supp.2d, 2013 WL 980333 (C.D.Ill. March 13, 2013)
            (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 - *Clarett 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 March 25, 2015:[179]
  - TASER has sold approximately 800,000 CEWs worldwide (does not include civilian TASER CEWs)
  - 18,000 law enforcement, private security, and military agencies deploy TASER CEWs
    - 7,293 of these agencies deploy CEWs to all of their patrol officers
  - TASER has sold CEWs in 107 countries (195 recognized countries in the world)
  - Approximately 275,000 civilian TASER CEWs have been sold to the general public since 1994
- Estimated CEW exposure numbers:
  - CEW Field Use/Suspect Applications: 2,735,000 ± 2% (as of April 12, 2015)
  - CEW Training/Voluntary Applications: 1,899,265 ± 7% (as of March 25, 2015)

    Total CEW Human Applications: 4.63 + million

[179] TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®), dated March 9, 2015. 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 55 Law Enforcement Officer (LEO) Temporal Related Deaths Per Category Summary Table

Category of deaths (mortality)	Deaths per temporal factor	Deaths per 100,000 of specific incident
LEOs use of weapons deaths	1 death per 323 arrests using weapons	
Pepper spray deaths per uses	1 death per 600 uses of pepper spray	
Jail inmates deaths per year	1 death per 658–709 jail inmates	150 per 100,000 inmates
LEOs deaths per year	1 death per year for every 5,521 LEOs	18 per 100,000 LEOs
Arrests deaths per arrests	1 death per 15,384.6 arrests	6.5 per 100,000 arrests

Temporal Arrest–Related Deaths Per Uses of Force (estimates):

Table 56 Estimates: Temporal Arrest–Related Deaths per Uses of Force

	# Uses of Force	Deaths	Ratio	Rate (%)
2015 Hall[180] (all uses of force)	4,828	1	1:4,828	0.02
2013 Hall[181] (all uses of force)	4,992	7	1:713	0.14
2012 Hall[182] (all uses of force)	1,269	1	1:1,269	0.07
2010 Strote[183] (CEW study)	1,101	0	0:1,101	0.00
2009 Bozeman[184] (CEW study)	1,201	2	1:600	0.01
2008 Eastman[185] (CEW study	426	1	1:426	0.02
2003 Koehler[186] (all uses of force)				

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[180] Hall C, Votova K, Heyd C, Walker M, MacDonald S, Eramian D, Vilke GM, Restraint in police use of force events: Examining sudden in custody death for prone and not-prone positions, *Journal of Forensic and Legal Medicine* (2015), doi: 10.1016/j.jflm.2014.12.007.

[181] Hall, C. 2013. RESTRAINT . Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

[182] Hall, C.A., McHale, A., Kader, A.S., Stewart, L.C., MacCarthy, C.S., Fick, G.H. 2012. Incidence and outcome of prone positioning following police use of force in a prospective, consecutive cohort of subjects. Journal of Forensic and Legal Medicine xxx (2012) 1–7.

[183] Strote J, Walsh M, Angelidis M, Basta A, Hutson HR., Conducted electrical weapon use by law enforcement: an evaluation of safety and injury, J Trauma. May 2010; 68(5):1239–1246.

[184] Bozeman, W.P., Hauda, W.E., Heck, J.J., Graham, D.D., Martin B.P., Winslow, J.E. 2009. Safety and Injury Profile of Conducted Electrical Weapons Used by Law Enforcement Officers Against Criminal Suspects. Annals of Emergency Medicine. Volume 53, Issue 4, Pages 480-489, April 2009.

[185] Eastman, A.L., et al., Conductive electrical devices: a prospective, population-based study of the medical safety of law enforcement use, J Trauma, 2008, 64(6): p. 1567–72.

[186] Steven A. Koehler, MPH, PhD, et. al., Deaths Among Criminal Suspects, Law Enforcement Officers, Civilians, and Prison Inmates: A Coroner-Based Study, The American Journal of Forensic Medicine and Pathology, pages 334–338, Volume 24, Number 4, December 2003.

Table 57 Estimates: Law Enforcement Encounters, Arrests, Force, Deaths

Event (estimates)	**Total Number**	**Ratio**	**Rate**
US Population (2010)	308,745,538	1:1	100%
Police-Public Face-to-Face (FTF) Contacts (total) (2008)	39,914,000	1:6	16.9%
Force Used or Threatened on those FTF Contacts (2008)	776,000	1:51	1.4%
Force Used Against Them Felt Force Excessive (2008)	447,000	1:1.74	74.3%
Force, Person Believed Excessive Filed Complaint	61,249	1:7.3	13.7
Arrest – Force – Death Numbers (estimates)			
US Population 2010	308,745,538	1:1	100%
Arrests (2010) (BJS FBI statistics and definitions)	13,122,000[187]	1:23.5	4.2%
Force Used Per Arrests (calculated 1.5%)	196,830	1.5–2:100	
Deaths Per BJS/FBI Arrests (estimated)	600	1:328	0.003%

Police-Person Contacts, Use of Force, and Excessive Force (2008): [188]

Table 58 Police-Person Contacts, Use of Force, and Excessive Force (2008)

Event	**Total Number**	**Ratio**	**Rate**
Police-Public Face-to-Face (FTF) Contacts (total)	39,914,000		100%
Force Used or Threatened on those FTF Contacts	776,000	1:51	1.4%
Force Used Against Them Felt Force Excessive	447.000		74.3%
Force, Person Believed Excessive Filed Complaint	61.249		13.7%

- "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.2 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

[187] Snyder, H.N., Arrest in the United States, 1990-2010. Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice. October 2012, NCJ 239423.

[188] Eith, C., Durose, M.R.. 2011. Contacts between Police and the Public, 2008. Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice. October 2011. NCJ 234599.

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): [189]

Table 59 Police-Person Contacts, Use of Force, and Excessive Force (2005)

Event	Total Number	Ratio	Rate
Police-Public Face-to-Face (FTF) Contacts (total)	43500000		100%
Force Used or Threatened on those FTF Contacts		1:62.5	2.3%
Force Used Against Them Felt Force Excessive			83%

- "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."
  - o "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: [190]

Table 60 Hall (2013): Police Interactions, Use of Force, Death Statistics

Event	Total Number	Ratio	Rate
Police-Public Interactions (total)	3,594,812		
Police Use of Force Occurred (total)	4,992	1:720	0.14%
Deaths Per Use of Force (7 deaths)	7	1:713	0.14%
Sudden In Custody Death (1 death)	1	1:4.992	0.02%

Hall (2012) Law Enforcement Officer (LEO) Interactions, Use of Force, Deaths:[191]

Table 61 Hall (2012): Police Interactions, Use of Force, Death Statistics

Event	Total Number	Ratio	Rate
Police-Public Interactions (total)	1566908		
Police Use of Force Occurred (total)	1 269	1:1 234	0.08%
Deaths Per Use of Force (1 death)	1	1:1 269	0.002%

- (2012 Hall) Hall, C.A., McHale, A., Kader, A.S., Stewart, L.C., MacCarthy, C.S., Fick, G.H. 2012. Incidence and outcome of prone positioning following police use of force

[189] Matthew R. Durose, Erica L. Smith, and Patrick A. Langan, Ph.D., BJS Statisticians, Contacts Between Police and the Public, 2005, Special Report, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, April 2007, NCJ 215243.

[190] Hall, C. 2013. RESTRAINT . Canadian Police Research Centre, Canadian Safety and Security Program, Government of Canada. October 2013.

[191] Hall, C.A., McHale, A., Kader, A.S., Stewart, L.C., MacCarthy, C.S., Fick, G.H. 2012. Incidence and outcome of prone positioning following police use of force in a prospective, consecutive cohort of subjects. Journal of Forensic and Legal Medicine xxx (2012) 1–7.

in a prospective, consecutive cohort of subjects. Journal of Forensic and Legal Medicine xxx (2012) 1–7.

- "During the study interval, there were 1 566 908 total police-public interactions. Police use of force occurred in 1269 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
- "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
  - "The study of in-custody deaths concluded that pepper spray contributed to death in two of the 63 cases, both involving people with asthma."[192]
  - "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."[193]
- **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.[194]

Pre-Arrest/Arrest Risk of Death (no listing of CEW)**:**[195]

- 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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[192] 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.

[193] Pepper Spray Update: More Fatalities, More Questions, ACLU of Southern California, page 2, June 1995.

[194] 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.

[195] Steven A. Koehler, MPH, PhD, et. al., Deaths Among Criminal Suspects, Law Enforcement Officers, Civilians, and Prison Inmates: A Coroner-Based Study, The American Journal of Forensic Medicine and Pathology, pages 334–338, Volume 24, Number 4, December 2003.

Table 62 Pre-Arrest/Arrest risk of death

	No. of Deaths (n=77)	%	Risk of Death per 100,000	Rate
Events Prior / During Arrest	14 deaths	18.1 %	6.5 per 100,000 arrests	1:15,384
Police Pursuits or Chases	10 deaths	12.9 %		
Transport of Suspects	2 deaths	2.6 %	0.93 per 100,000 arrests	1:107,527
During Incarceration	51 deaths	66.2%	268 per 100,000 inmates	1:323

Selected (US) Societal Problems Influencing Force Response:

Table 63 Selected (US) Societal Problems Influencing Force Response

Societal Problem	Number	%	Rate
Current Illicit Drug Abusers (2009)	21,800,000	8.7%	1:11
DSM-IV Substance Dependence (2009)	22,500,000	8.9%	1:11
Drug Caused Emergency Department Visits (2007)	1,900,000		
People in Serious Psychological Distress (2007)	23,400,000	10.9%	1:9
Drunk/Drugged Driving	10,200,000	13.2%	1:8
Mental Disorder: Children (13–20%) [up to 1 in 5]		13–20%	1:5–7
Suicide: Children (annually) (4.5 per 100,000)	1,926	0.0045%	1:22,222

Current Illicit Drug Abusers ("CIDA"):

- increasing annually (current drug use means use of an illicit drug during the month prior to the survey interview):

  - (2009) 21,800,000 CIDA age 12 and older (8.7% of population)[196]
  - (2004) 19,100,000 CIDA age 12 and older (7.9% of population)[197]

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).[198]

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."[199]

People in serious psychological distress ("SPD") annually in the U.S.:

- (2007) 23,400,000 SPD (10.9% of adults)[200]

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[196] Substance Abuse and Mental Health Services Administration. (2010). Results from the 2009 National Survey on Drug Use and Health: Volume I. Summary of National Findings (Office of Applied Studies, NSDUH Series H-38A, HHS Publication No. SMA 10-4586Findings). Rockville, MD.

[197] Substance Abuse and Mental Health Services Administration. (2005). Results from the 2004 National Survey on Drug Use and Health: National Findings (Office of Applied Studies, NSDUH Series H-28, DHHS Publication No. SMA 05-4062). Rockville, MD.

[198] Substance Abuse and Mental Health Services Administration. (2010). Results from the 2009 National Survey on Drug Use and Health: Volume I. Summary of National Findings (Office of Applied Studies, NSDUH (National Survey on Drug Use and Health) Series H-38A, HHS Publication No. SMA 10-4586Findings). Rockville, MD.

[199] Substance Abuse and Mental Health Services Administration, Office of Applied Studies. Drug Abuse Warning Network, 2007: National Estimates of Drug-Related Emergency Department Visits. Rockville, MD, 2010.

[200] 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.

- (2004) 21,400,000 SPD (9.9% of adults)[201]

Drunk or Drugged Driving (2006–2009):[202]

- "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 Amoung Children – United States (2005–2011):[203]

- 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%)

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[201] Substance Abuse and Mental Health Services Administration. (2005). Results from the 2004 National Survey on Drug Use and Health: National Findings (Office of Applied Studies, NSDUH Series H-28, DHHS Publication No. SMA 05-4062). Rockville, MD.

[202] State Estimates of Drunk and Drugged Driving, The NSDUH (National Survey on Drug Use and Health) Report, December 9, 2010, NSDUH_205.

[203] Centers for Disease Control and Prevention. 2013. Mental Health Surveillance Among Children — United States, 2005–2011. MMWR 2013;62(Suppl 2).

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- 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):[204]

- 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:[205]

- Overall incidence of 2.28 SCA per 100 000 person-years [1 in 43,859]:
    - o 2.1 per 100 000 in those 0–2 years of age [1 in 47,619],
    - o 0.61 per 100 000 in those 3–13 years of age [1 in 163,934]

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[204] Eckart RE, Shry EA, Burke AP, et al. Sudden death in young adults: an autopsy-based series of a population undergoing active surveillance. J Am Coll Cardiol. Sep 13 2011;58(12):1254–1261.

[205] 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.

- o 1.44 per 100 000 in those 14–24 years of age [1 in 69,444], and
- o 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:[206][207]

- 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)[208]
- 1 SCD death per 15,698 children age 12–18 (in patient years)[209]

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

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[206] Maron, BJ, Doerer, BS, Haas, TS, et. al., Sudden Deaths in Young Competitive Athletes Analysis of 1866 Deaths in the United States, 1980–2006, *Circulation*. 2009; 119: 1085–1092.

[207] See also, Leiken, S.M., Pierce, A., Nelson, M. 2013. Sudden cardiac death in young athletes. *Disease-a-Month* 59 (2013) 97–101.

[208] Atkins DL, Everson-Stewart S, Sears GK, Daya M, Osmond MH, Warden CR, Berg RA. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. *Circulation*. 2009;119:1484–1491.

[209] Atkins DL, Everson-Stewart S, Sears GK, Daya M, Osmond MH, Warden CR, Berg RA. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. Circulation. 2009;119:1484–1491.

- 1 SCD death per 43,770 NCAA participants per year

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.),[210] and Harvard Center for Risk Analysis.[211]
- 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.

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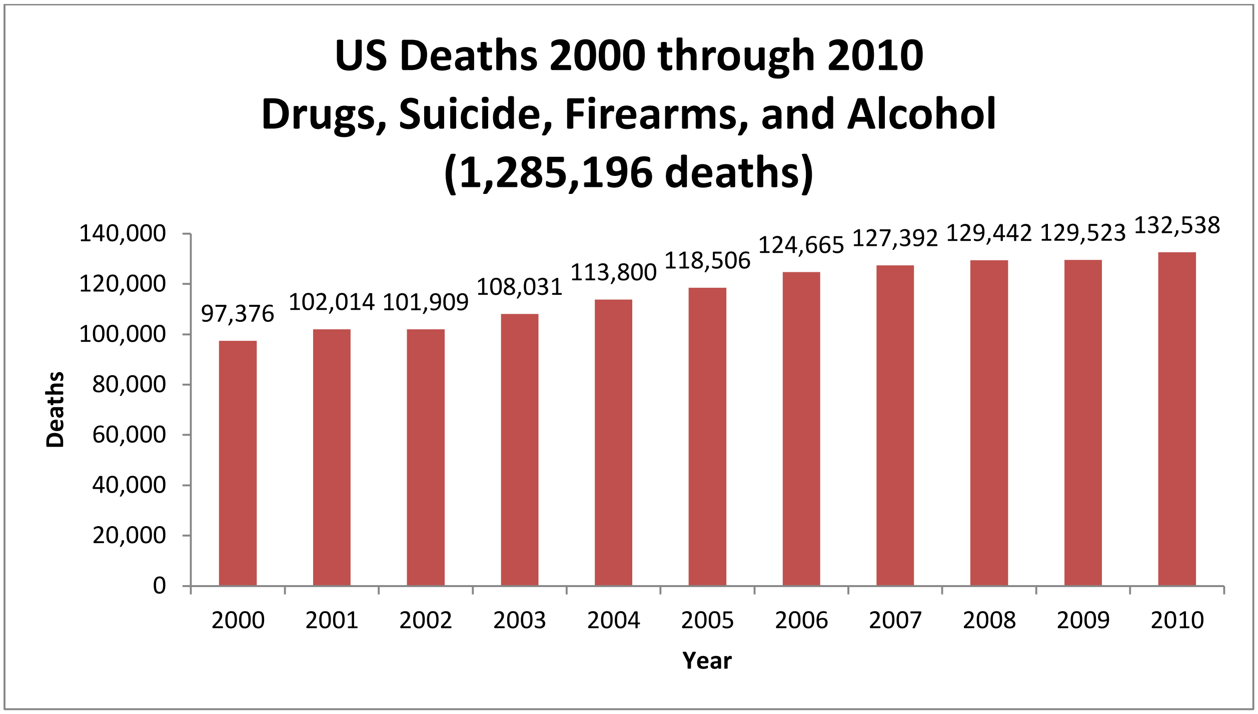
[210] Available at http:// www.nsc. org/ NSC% 20Picture% 20Library/News/web_ graphics/Injury_Facts_37.pdf.

[211] Available at http://www.hcra.harvard.edu/quiz. html.

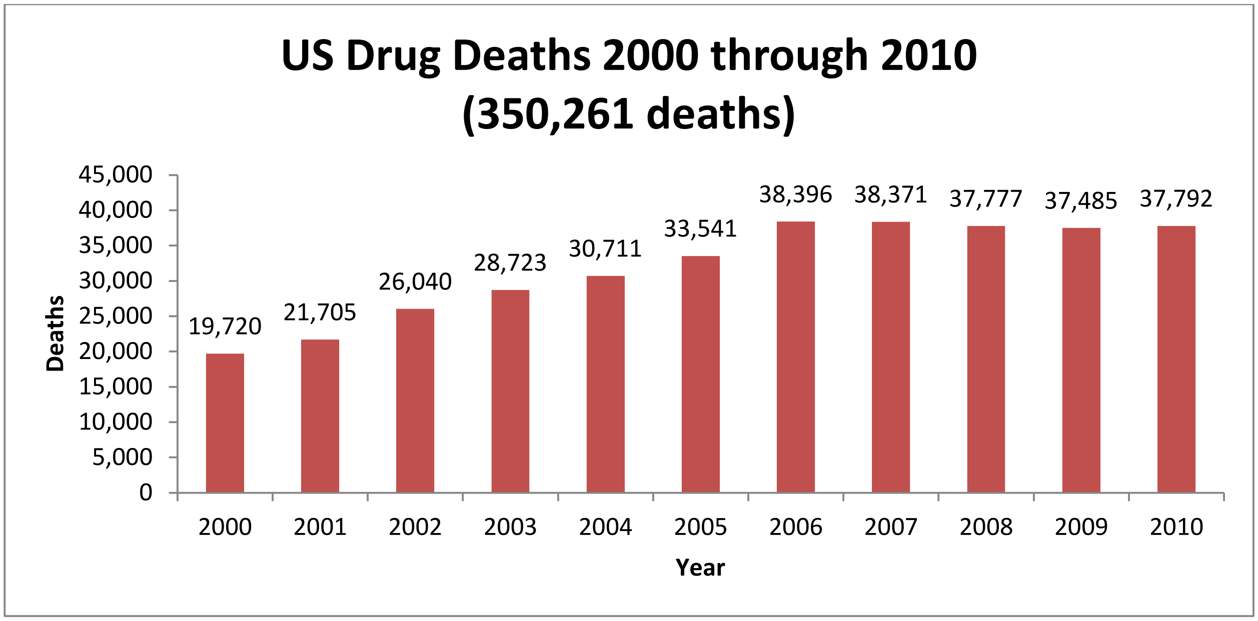
- National Vital Statistics Reports ("NVSR"), National Center for Health Statistics ("NCHS"), Centers for Disease Control and Prevention ("CDC"), U.S. Department of Health and Human Services ("DHS"):[212]

Figure 35 US Deaths 2000–2010 Drugs, Suicide, Firearms, and Alcohol



[212] Multiple separate resources for 2000–2010 Division of Vital Statistics, Deaths: National Vital Statistics Reports ("NVST"), Centers for Disease Control and Prevention ("CDC"), National Center for Health Statistics, Department of Health and Human Services ("DHS").

Figure 36 US Drug Deaths 2000–2010



- 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.

Basic 2009 U.S. Death Rates (U.S. Population 2009: 307,006,550): [213]

Table 64 Cause of death rates per 100,000 of general population

Cause of Death (death rates per 100,000 of general population)	2010	2009	2008
All causes of Death	798.7	793.7	813.2
Infant Death Rate All Causes	614.0	642.1	659.3
Major Cardiovascular Diseases	251.8	253.9	264.7
Pneumonia	16.0	16.5	18.0
Transport Accidents	12.2	12.7	14.1
Drugs	12.2	12.2	12.4
Suicide	12.2	11.9	11.8
Firearm	10.2	10.2	10.4
Alcohol	8.2	7.9	7.9
Falls	8.4	8.1	7.9
HIV	2.7	3.1	3.4
Injury at Work	1.6	1.7	1.9
Peptic Ulcer	1.0	1.0	1.0
Influenza	0.2	0.9	0.6
Complications of Medical and Surgical Care	0.8	0.8	0.9
Hernia	0.6	0.6	0.6
Pregnancy, Childbirth, and the Puerperium	0.3	0.3	0.3
Tuberculosis	0.2	0.2	0.2
Malnutrition	0.9	0.1	0.1

Death Rate in Jails (no listing of ECD):

- Local U.S. Jails 2010 (BJS/OJP/DOJ[214]):
  - 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

[213] Kenneth D. Kochanek, M.A.; Jiaquan Xu, M.D.; Sherry L. Murphy, B.S.; Arialdi M. Minino M.P.H.; and Hsiang-Ching Kung, Ph.D., Division of Vital Statistics, Volume 59, Number 4, National Vital Statistics Reports, National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, March 16, 2011. (Preliminary data for 2009.)

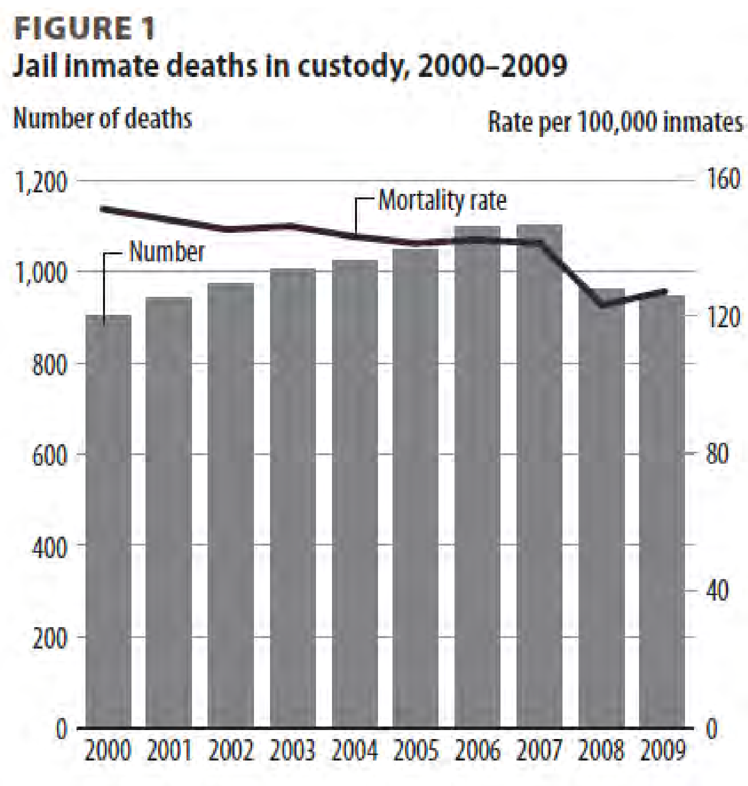
[214] Noonan, M.E. 2012. Mortality in Local Jails and State Prisons, 2000-2010 - Statistical Tables. Bureau of Justice Statistics, Office of Justice Programs. U.S. Department of Justice. December 2012, NCJ 239911. (http://bjs.ojp.usdoj.gov/content/pub/pdf/mljsp0010st.pdf)

deaths.

- o 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).
- o 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[215]):
  - o 2009 – 948 deaths, 127 deaths per 100,000 inmates (1 death per 787 detainees).
  - o 2008 – 960 deaths, 123 deaths per 100,000 inmates (1 death per 813 detainees).

Figure 37 Jail inmate deaths in custody, 2000–2009

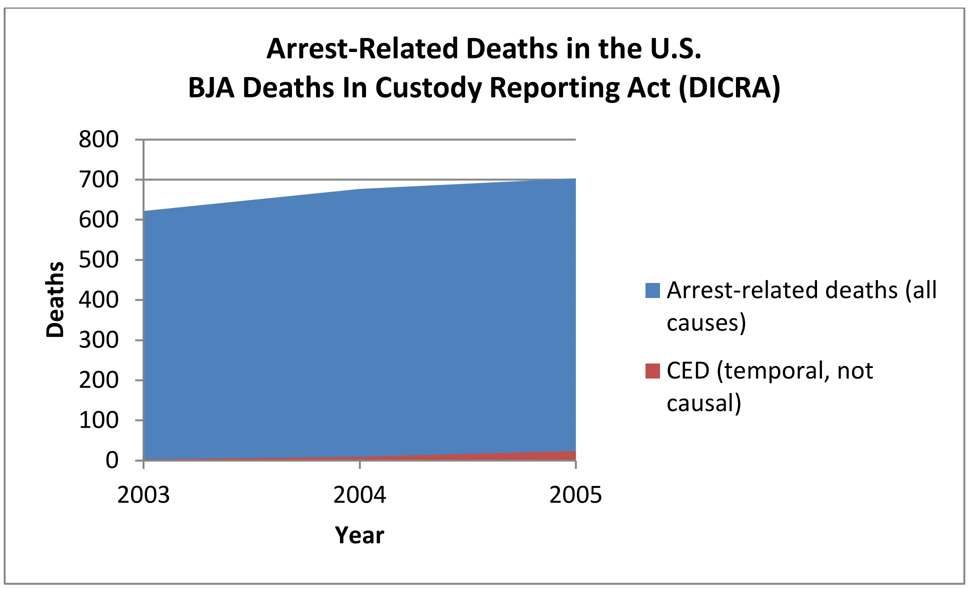


[215] Margaret E. Noonan and E. Ann Carson, BJS Statisticians, Prison and Jail Deaths in Custody, 2000–2009 - Statistical Tables, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, December 2011, NCJ 236219.

- Local U.S. Jails (in-custody deaths) – from 2000 through 2007 (NIJ/BJS Report[216]):
  - 8,110 persons died in local jails from 2000 through 2007
    - Approximately 1 death per 658–709 inmates (depending on year)
  - 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)."[217]
- 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."[218]

US ARDs, BJS, Deaths in Custody Reporting Act ("DICRA"):[219]

Figure 38 US ARDs, BJS, Deaths in Custody Reporting Act ("DICRA")



[216] Margaret Noonan, BJS Statistician, Mortality in Local Jails, 2000–2007, Deaths in Custody Reporting Program, Special Report, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, July 2010, NCJ 222988.

[217] Brian R. Brehman, Terance D. Miethe, Ph.D., and Timothy C. Hart, Ph.D., Deaths in Custody in Nevada, Center for Analysis of Crime Statistics, Department of Criminal Justice, College of Urban Affairs, University of Las Vegas, 2001–2006, State Data Brief, July 2009, CACS 2009-01-01 CR.

[218] Wendy L. Wobeser, Jason Datema, Benoit Bechard, Peter Ford, Causes of death among people in custody in Ontario, 1990–1999, Canadian Medical Association Journal, November 12, 2002; 167 (10) 1109–1113.

[219] Christopher J. Mumola, BJS Policy Analyst, Arrest-Related Deaths in the United States, 2003–2005, Special Report, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, October 2007, NCJ 219534.

- January 2003-December 2009 DICRA Report:[220]
    - A total of 4,813 deaths were reported to the Arrest-Related Deaths program from January 2003 through December 2009.
    - 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.

(2004) U.S. Medical Examiners and Coroners' Numbers:[221]

- 2,000 Medical Examiner ("ME") / Coroner ("C") Offices in U.S.:
    - 7,320 ME/C full-time equivalent ME/C employees
    - $718,500,000.00 total ME/C annual budgets
- 2,398,000 human deaths:
    - 956,000 deaths referred to ME/C offices
        - 487,000 deaths accepted for investigation
            - 677 Arrest Related Deaths ("ARDs") (all causes)[222]
                - 9 ARDs involved the use of ECDs or other conducted-energy devices[223]

Additional Mortality Numbers:

Hospital Emergency Department Mortality Rates:[224]

- 1.8 out of 100 – hospital emergency department mortality rate on weekends

[220] Andrea M. Burch, Arrest-Related Deaths, 2003–2009 - Statistical Tables, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, November 2011, NCJ 235385.

[221] Matthew J. Hickman, Ph.D., Kristen A. Hughes, MPA. Bureau of Justice Statistics, Kevin J. Strom, Ph.D., Jeri D. Ropero-Miller, Ph.D., DABFT, RTI International, Medical Examiners and Coroners' Offices, 2004, Special Report, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, June 2007, NCJ 216756.

[222] Christopher J. Mumola, BJS Policy Analyst, Arrest-Related Deaths in the United States, 2003–2005, Special Report, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, October 2007, NCJ 219534.

[223] Christopher J. Mumola, BJS Policy Analyst, Arrest-Related Deaths in the United States, 2003–2005, Special Report, Bureau of Justice Statistics, Office of Justice Programs, U.S. Department of Justice, October 2007, NCJ 219534.

[224] Chaim M. Bell, M.D., Donald A. Redelmeier, M.D., Mortality Among Patients Admitted to Hospitals on Weekends as Compared With Weekdays, N.Eng.J. Med., Vol 345, No. 9, August 30, 2001, pages 663–668. See also, Goodacre et al., What do hospital mortality rates tell us about quality of care?, Emerg Med J, 2013, 0 (2013), p. emermed-2013-203022v1.

- 1.6 out of 100 – hospital emergency department mortality rate on weekdays
- "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:[225]

- 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.

[225] Eckart RE, Shry EA, Burke AP, et al. Sudden death in young adults: an autopsy-based series of a population undergoing active surveillance. *J Am Coll Cardiol.* Sep 13 2011;58(12):1254–1261.

Table 65 Specific Activities Exertional and Sudden Cardiac Death

Table 2 Specific Activities at Time of Exertional Sudden Death in 361 Young Adults

Recreational sports	186 (51.5%)
Running	114 (31.6%)
Basketball	20 (5.5%)
Walking	14 (3.9%)
Swimming	11 (3.0%)
Weightlifting	5 (1.4%)
Baseball	4 (1.1%)
Biking	4 (1.1%)
Military training	150 (41.6%)
Organized physical training*	138 (38.2%)
Road march/land navigation	7 (2.0%)
Miscellaneous	5 (1.4%)
Miscellaneous	17 (4.8%)
Not specified	8 (2.2%)

*Organized physical training defined as group-level activity to include performance of physical fitness testing (sit-up, push-ups, and timed distance running). Additional recreational sports representing <1% included football (n = 3), racquetball (n = 3), soccer (n = 3), volleyball (n = 2), hiking (n = 1), paintball (n = 1), and tennis (n = 1). Miscellaneous causes included moving furniture and/or equipment (n = 8), mowing lawn (n = 4), dancing (n = 2), fighting (n = 2), and sexual intercourse (n = 1).

Table 3 Cause-Specific Findings in 902 Cases of Adjudicated Unanticipated Sudden Cardiac Death Stratified by Age <35 Years and ≥35 Years in a Cohort Undergoing Active Surveillance

Findings	<35 Yrs of Age (n = 298)	≥35 Yrs of Age (n = 604)	p Value
Sudden unexplained death	123 (41.3%)	64 (10.6%)	<0.001
Atherosclerotic disease	69 (23.2%)	442 (73.2%)	<0.001
Hypertrophic cardiomyopathy	38 (12.8%)	19 (3.1%)	<0.001
Myocarditis	17 (5.7%)	13 (2.2%)	0.009
Idiopathic dilated cardiomyopathy	14 (4.7%)	21 (3.5%)	0.478
Anomalous coronary artery	12 (4.0%)	1 (0.2%)	<0.001
Hypertensive cardiomyopathy	11 (3.7%)	15 (2.5%)	0.419
Arrhythmogenic RV dysplasia	4 (1.3%)	6 (1.0%)	0.737
Ischemic cardiomyopathy	2 (0.7%)	14 (2.3%)	0.135
Other*	8 (2.7%)	9 (1.5%)	—

Data presented as raw (columnar percent [incidence]). *Other cases (n = cases <35 years of age, cases ≥35 years of age, respectively): additional causes of death associated with coronary artery disease included coronary artery bridge (n = 6, 1), spontaneous coronary thrombosis (n = 1, 2%) and spontaneous coronary dissection (n = 0, 1); causes of death associated with valvular heart disease included aortic valve disease (n = 0, 3), mitral valve disease (n = 1, 1), and endocarditis (n = 0, 1).
RV = right ventricle.

Also see: Medical Examiner Sudden Cardiac Death (SCD) Undetermined Section Previous in this Outline (click to proceed).

Also See: Black Athletes at Higher Risk of Sudden Death

Sudden Cardiac Death (SCD) NCAA[226] Athletes:[227]

- 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:

[226] NCAA – National Collegiate Athletic Association.

[227] Harmon KG, Asif IM, Klossner D, Drezner JA. Incidence of sudden cardiac death in national collegiate athletic association athletes. *Circulation*. 2011;123:1594–1600. See also, Link MS, Estes NA 3rd., Sudden cardiac death in the athlete: bridging the gaps between evidence, policy, and practice. *Circulation*. 2012 May 22;125(20):2511–6.

- 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

o SCD incidence (risk) of NCAA Division I male – 1:3,126 per year

- 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 66 Incidence of SCD - NCAA Athletes 2004-2008

Table 1. Incidence of SCD in NCAA Athletes According to Sex, Ethnicity, and Division, 2004–2008

	No. of Athlete-Years	No. of Deaths	Death Rate (per Year)
NCAA athletes	1 969 663	45	1:43 770
Sex			
Male	1 126 557	34	1:33 134
Female	843 106	11	1:76 646
Ethnicity			
Black	300 835	17	1:17 696
White	1 583 635	27	1:58 653
By division			
Division I	788 023	27	1:29 186
Division II	424 572	10	1:42 457
Division III	760 258	8	1:95 032

SCD indicates sudden cardiac death; NCAA, National Collegiate Athletic Association.

- Incidence of NCAA SCD by Sport, 2004–2008:

Table 67 Incidence of NCAA SCD by sport 2004–2008

Table 2. Incidence of NCAA SCD by Sport, 2004–2008

Sport	Number of Deaths	Overall Incidence*	Incidence in Males	Incidence in Females	Incidence in African Americans	Incidence in Caucasians
Basketball	14	1:11,394	1:6,993	1:37,799	1:5,743	1:21,824
Division I	9	1:5,451	1:3,126	1:23,901	1:5,284	1:6,135
Division II	3	1:12,631	1:11,330	1:15,232	1:9,503	1:20,822
Division III	2	1:24,681	1:13,646	†	1:6,952	†
Swimming	4	1:21,293	1:34,552	1,16,457	†	1:20,981
Lacrosse	3	1:23,357	1:19,770	1:30,531	†	1:23,357
Football	8	1:38,497	1:38,497	†	1:59,814	1:14,401
Cross-country	3	1:41,695	1:59,484	1:32,801	1:12,043	1:51,033

NCAA indicates National Collegiate Athletic Association; SCD, sudden cardiac death.
*SCD incidence is expresed as number of athletes per year.
†No deaths for incidence calculation.

Table 3. Capture-Recapture Analysis

	No. of Deaths in Aggregate Database	Cap-Recap Estimate of No. of Deaths	95% Confidence Interval	No. of Athletes	Aggregate Database Incidence*	Cap-Recap Incidence Estimate
Total	45	49.6	45.4–50.4	1 969 663	1:43 770	1:39 711
Division I	27	28.4	27.4–32.5	788 023	1:29 186	1:29 186
Division II/III	18	22.4	18.8–43.1	1 184 830	1:65 824	1:52 894

Cap-Recap indicates capture-recapture.
*SCD incidence rates are expressed in number of athletes per year.

SCD During Competitive Sports Activities in Minnesota High School Athletes:[228]

- "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

[228] Maron, Barry J., Gohman, Thomas E., Aeppli, Dorothee, Prevalence of Sudden Cardiac Death During Competitive Sports Activities in Minnesota High School Athletes, JACC Vol. 32, No. 7, December 1998:1881–4.

Out-of-Hospital Non-traumatic Cardiac Arrest (OHCA): Children:[229]

- The incidence of pediatric OHCA:
    - o 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);
    - o versus 126.52 per 100 000 person-years for adults (1:790).
- Survival for:
    - o all pediatric OHCA was 6.4%:
        - 3.3% for infants;
        - 9.1% for children; and
        - 8.9% for adolescents:
    - o versus 4.5% for adults.

Sudden Non-Traumatic Sudden Death in Military Recruits:[230]

- Non-traumatic sudden death rate: military recruit-years: 13.0/100,000 or 1 in 7,692
    - o "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.

[229] Atkins DL, Everson-Stewart S, Sears GK, Daya M, Osmond MH, Warden CR, Berg RA. Epidemiology and outcomes from out-of-hospital cardiac arrest in children: the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. Circulation. 2009;119:1484–1491.

[230] Eckart RE, Scoville SL, Campbell CL, Shry EA, Stajduhar KC, Potter RN, Pearse LA, Virmani R. Sudden death in young adults: a 25-year review of autopsies in military recruits. Ann Intern Med. 2004;141: 829–834.

Routine Cardiac Ablation Procedures Rates of Major Complications/Deaths:[231]

- 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: [232]

- 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."

Antipsychotics and the Risk of Sudden Cardiac Death:[233]

- 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."

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[231] 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, oi:10.1016/j.hrthm.2011.05.017.

[232] M. De Hert, J.M. Dekker, D. Wood, K.G. Kahl, R.I.G. Holt, H.-J. Möller, Cardiovascular disease and diabetes in people with severe mental illness position statement from the European Psychiatric Association (EPA), supported by the European Association for the Study of Diabetes (EASD) and the European Society of Cardiology (ESC), European Psychiatry xxx (2009) xxx–xxx, doi:10.1016/j.eurpsy.2009.01.005.

[233] Sabine M. J. M. Straus, MD; Gyse`le 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.

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."[234]
- "Approximately 2 million people in the United States have epilepsy."[235]
- "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."[236]
- "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."[237] [citation omitted]
- "People with epilepsy have a 2.6-fold increased risk of premature death compared with the general population."[238]
- "The risk of sudden death in young adults with epilepsy is increased 24-fold."[239]
- SUDEP "is the most frequent cause of epilepsy-related death with incidence rates of up to 9 per 1000 person-years in people with pharmacoresistant epilepsy."[240]
- "In children with epilepsy, the cumulative risk of dying suddenly is 7% within 40 years."[241]

Law Enforcement Officer (LEO) Mortality, Assaults, and Injuries:[242]

- Averages over 2000–2009 decade:
    - 900,000 LEOs

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[234] Velagapudi, M.D., Poonam, Turagam, M.D., Mohit, Laurence, M.D., Thomas, and Koceril, M.D., Abraham, Review: Cardiac Arrhythmias and Sudden Unexpected Death in Epilepsy (SUDEP), PACE, Vol 35, March 2012, pgs 363–370, doi: 10.1111/j.1540-8159.2011.03276.x.

[235] Id.

[236] Id.

[237] Id.

[238] Surges. R., Sander, J.W. Review: Sudden unexpected death in epilepsy: mechanisms, prevalence, and prevention, Curr Opin Neurol 2012, 25:201–207, DOI:10.1097/WCO.0b013e3283506714.

[239] Id.

[240] Id.

[241] Id. Citing: Sillanpää, M, Shinnar, S. Long-term mortality in childhood-onset epilepsy. N Engl J Med 2010; 363:2522–2529; a study reporting on long-term mortality in a Finnish population-based cohort of patients with a diagnosis of epilepsy in childhood with a follow-up of 40 years.

[242] National Law Enforcement Officers Memorial Fund: Deaths, Assaults & Injuries, http://www.nleomf.org/facts/officer-fatalities-data/daifacts.html [last updated 10/19/2011 2:32:30 PM]; Officer Safety Statistics, National Law Enforcement Officers Memorial Fund (NLEOMF), www.nleomf.org/facts.

- 163 LEO deaths per year
- 50,069 LEO assaults per year
- 16,041 LEO injuries per year

- Thus, annually:
  - 1 LEO death per year per 5,521 officers
  - 1 LEO injured per year per 56 officers
  - 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.[243]

[243] Morrison, D. (Responsible NASA Official) 2004. Nasa Ames Research Center. http://impact.arc.nasa.gov/intro_faq.cfm referenced on February 18, 2013..

Selected Bath Salt Papers

1. (01/2005 Karch) Karch SB. Cathinone Neurotoxicity ("The "3Ms"). *Curr Neuropharmacol*. 2015;13(1):21-25.

    a. "Abstract: Synthetic cathinones are designer drugs of the phenethylamine class, structurally and pharmacologically similar to amphetamine, 3,4-methylenedioxymethamphetamine (MDMA), cathinone and other related substances. New analogues, legal at least, until formally banned (a time consuming process), are introduced almost daily The United Nations estimates nearly 250 new drug analogues are produced per year. Various combinations of these drugs are sold under the name of "bath salts". They can be ingested by any route and some appear capable of causing great harm, mostly behavioral. One drug in particular, MDVP, appears to frequently cause symptoms indistinguishable from the classic findings in Excited Delirium Syndrome (ExDS). Little is known about the pathology or clinical toxicology of these drugs but their molecular mechanism of action seems to be identical with that of cocaine. This mini-review examines what little is known on the subject and explains the suspected mechanisms of excited delirium syndrome."

2. (01/2015 Stiles) Stiles, B.M, Fish, A.F. Cook, C.A., Silva, V. Bath Salt-Induced Psychosis: Nursing Assessment, Diagnosis, Treatment, and Outcomes. 2015 Perspectives in Psychiatric Care. ISSN 0031-5990.

    a. "FINDINGS: Of the 42 case reports found, only 18 confirmed the presence of bath salts through laboratory testing. Twelve of the confirmed cases died. In most of the case reports, law enforcement was involved prior to hospitalization due to bizarre behaviors, delusions, and hallucinations."

Prone, Maximal, Weight Force

Prone Restraint:

1. (07/2015 Karch) Karch SB, Brave MA, Kroll MW. On positional asphyxia and death in custody. Med Sci Law. 2015.

2. (01/2015 Hall) C. Hall, K. Votova, C. Heyd, M. Walker, S. MacDonald, D. Eramian, et al., "Restraint in police use of force events: Examining sudden in custody death for prone and not-prone positions," *Journal of Forensic and Legal Medicine*, 31 (2015) 29–35.

3. (07/ 2013 Barnett) R. Barnett, P. Hanson, C. Stirling, and A. D. Pandyan, "The physiological impact of upper limb position in prone restraint," *Med Sci Law*, vol. 53, pp. 161-5, Jul 2013.

4. (02/2012 Hall) C. A. Hall, A. M. McHale, A. S. Kader, L. C. Stewart, C. S. MacCarthy, and G. H. Fick, "Incidence and outcome of prone positioning following police use of force in a prospective, consecutive cohort of subjects," *J Forensic Leg Med*, vol. 19, pp. 83-9, Feb 2012.

Prone Maximal Restraint (PMR)

5. (2014 Sloane) C. Sloane, T. C. Chan, F. Kolkhorst, T. Neuman, E. M. Castillo, and G. M. Vilke, "Evaluation of the ventilatory effects of the prone maximum restraint (PMR) position on obese human subjects," *Forensic science international*, vol. 237, pp. 86-89, 2014.

6. (11/ 2013 Savaser) D. J. Savaser, C. Campbell, E. M. Castillo, G. M. Vilke, C. Sloane, T. Neuman, et al., "The effect of the prone maximal restraint position with and without weight force on cardiac output and other hemodynamic measures," *J Forensic Leg Med*, vol. 20, pp. 991-5, Nov 2013.

Physical Restraint:

7. (07/2012 Barnett) R. Barnett, C. Stirling, and A. D. Pandyan, "A review of the scientific literature related to the adverse impact of physical restraint: gaining a clearer understanding of the physiological factors involved in cases of restraint-related death.," *Med Sci Law*, vol. 52, pp. 137-142, Jul 2012.

8. (01/2007 Michalewicz) B. A. Michalewicz, T. C. Chan, G. M. Vilke, S. S. Levy, T. S. Neuman, and F. W. Kolkhorst, "Ventilatory and metabolic demands during aggressive physical restraint in healthy adults," *J Forensic Sci*, vol. 52, pp. 171-5, Jan 2007.