Outline of Partial Selected CEW Research and Information

1, 2, 3, 4, 5, 6

Selected CEW Misconceptions Papers

Selected CEW Treatises, Organization Position and Review Papers

Epidemiological (Field) Studies

Cardiac – Selected CEW Medical/Scientific Literature

Swine CEW Cardiac Research

1 The most current version of this outline can be found at http://www.ecdlaw.info/1.pdf.
2 This document is intended to provide a basic selected overview and selected summary of injury related information and research concerning Axon Enterprise, Inc. (formerly as of April 5, 2017) Taser International, Inc. ("TASER") ("Axon") brand conducted energy weapons ("CEW"), formerly 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.axon.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 death, and injuries among the United States population, other populations, and law enforcement specific.
3 This document and its content do not create any relationship of any kind and no one is to act, fail to act, or rely on this document, its contents, or on the limited information contained herein. That which follows is not a full and fair disclosure of information. Everyone is strongly encouraged to do their own indepth, exhaustive, complete research; analysis; and develop their own conclusions. This document cannot possibly, and does not, include all possible issues, concepts, facts, theories, statements, opinions, papers, support, etc. Statements and opinions regarding the issues herein may vary broadly and are often subject to multiple interpretations of reports, facts, data, papers, books, and other materials. Nothing herein is special knowledge or confidential or privileged information, that which follows is in the public domain and thus available to anyone researching these areas. The statements herein are not positive assertions of fact, complete coverage of the issues, or opinions; and are not to be relied upon by anyone for any purpose.
4 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).
5 This document specifically supersedes, nullifies, and obsoletes any prior draft or version of this document.
6 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.
Law-Enforcement-Related Deaths ................................................................. 367
Police-Related Cardiac Arrest ..................................................................... 368
Mortality Example: Hospitals ....................................................................... 369
Mortality Example: Jails ............................................................................... 371
Mortality Example: Marijuana ..................................................................... 372
Medical Examiner Sudden Cardiac Death (SCD) Undetermined ............... 374
TASER International, Inc. Historic Information ........................................... 385
Selected General Numbers and Mortality/Injury Statistics ......................... 390
Chemical Aerosol Weapons (OC, CN, CS, Pava): ...................................... 420
Selected Bath Salt Papers ............................................................................ 426
Prone, Maximal, Weight Force .................................................................... 427
Restraint Chair ............................................................................................ 438
Excited Delirium Guidance ......................................................................... 439
Excited Delirium (ExDS) Features ................................................................. 442
Excited Delirium – Partial History ................................................................. 446
Sickle Cell Exertional Sudden Death ............................................................ 454
Ketamine ....................................................................................................... 455
SPARK CEW (Brazil) .................................................................................... 456
Phazzer Enforcer CEW: ............................................................................... 457
Civil Rights Groups ...................................................................................... 458

FULL TABLE OF CONTENTS

Selected CEW Misconceptions Papers ....................................................... 1
Selected CEW Treatises, Organization Position and Review Papers ............ 2
Selected CEW Treatises/Books: .................................................................... 2
Selected Treatise CEW Chapters: ................................................................. 2
Selected CEW Organization White Papers/Statements: .............................. 4
Selected Primary CEW Review Papers: ...................................................... 6
Selected CEW Survey Papers: ..................................................................... 12
Selected Autopsy/Forensic Pathology CEW-Related Papers: ...................... 12
Selected CEW-Temporal Arrest-Related Death (ARD) Review Papers: ...... 14
Epidemiological (Field) Studies ................................................................. 18
Epidemiological (Field) Studies: Including Chest Probe Hits .................... 18
Cardiac – Selected CEW Medical/Scientific Literature ............................... 22
Cardiac Human Assessment Study ............................................................... 22
CEW Adverse Cardiac Events Inconclusive or Controversial ...................... 23
Ability to Cause Cardiac Capture is not Equivalent to Ability to Induce VF ... 30
CEW Does Not Electrically Induce PEA or Asystole .......................................................................................... 31
Probability of CEW Induced Ventricular Fibrillation: ....................................................................................... 32
Prospective CEW Induced Ventricular Fibrillation: .............................................................................................. 36
QTc Interval: ...................................................................................................................................................... 40
Epidemiological Studies – No CEW Induced Cardiac Arrhythmia: ................................................................. 41
Skin-to-Heart Distances in Humans: .................................................................................................................. 44
CEW VF Safety Margin – Partial Publications List: ............................................................................................. 47
Risk of Cardiac Arrhythmia from CEW: .............................................................................................................. 48
Targeting of Cardiac Arrhythmia from CEW: ....................................................................................................... 60
Cardiac Membrane Time Constant: “there should be almost no additive effect of the [CEW] pulses” ...70
Partial List of Cardiac Safety Dependent Upon Swine/Human Weight/Size: ...................................................... 72
Cardiac Safety Dependent Upon Dart Orientation and Pig Size: ................................................................. 75
Graphic Demonstrative Illustrations – CEW Dart-to-Heart (DTH) Distances: .................................................. 76
Graphic Demonstrative Illustrations – Joule Comparisons: .............................................................................. 77
Swine CEW Cardiac Research ........................................................................................................................... 78
Swine Studies Review Analysis: ....................................................................................................................... 78
Animal Model Differences (including Swine): .................................................................................................... 78
Human Heart Requires 3X More Current to Go Into VF Compared to Swine: .................................................. 79
Epinephrine Increases VFT: ............................................................................................................................. 80
Epinephrine Infusion Alone Causes Ventricular Tachycardia: ........................................................................ 81
Epinephrine – ¼ Life: ........................................................................................................................................... 81
Published Animal Studies with TASER X26 CEW and Probes in the Chest: ..................................................... 83
Swine Studies Review Analysis: ....................................................................................................................... 83
X26/X2 CEWs Comparative Cardiac Capture Safety Study: ............................................................................ 90
DTH Distances in Swine: ................................................................................................................................... 93
Swine CEW Drive Stun and Dart Separation Research: ..................................................................................... 101
Polarity Testing in Swine: ................................................................................................................................. 103
Swine: Changes in Plasma Proteins: .................................................................................................................. 103
Fragility of Swine Model: Experimental Swine Dying Before Test: ............................................................... 104
Human Body’s Resistances to Penetration of Electrical Current ............................................................................ 105
Biomarkers/Respiration/Risks .......................................................................................................................... 112
Meta-Analysis Human Data (Adrenergic, Metabolic, Respiration): ............................................................... 112
Sham CEW Discharge: ....................................................................................................................................... 112
Muscle Contractions: .......................................................................................................................................... 113
Development of Smart Weapons Motor-Nerve Mediated Effectiveness: ......................................................... 113
Muscular Disruption Units (MDUs) [2002–2008]: ............................................................................................... 115
(Maximal Isometric Forces) M26/X26 CEW Simulated Isometric Forces ≈ 46% of Maximal: ....................... 116
No/Mild Clinically Significant Biochemical/Physiologic Changes: ................................................................. 117
(CK/Rhabdomyolysis) No Clinically Significant CK Increase from CEW: ....................................................... 118
(Lactate) No Clinically Relevant Lactate from Short-Duration (≤ 45 s) CEW Discharge: ......................... 119
Breathing – Evidence Suggests CEW Increases Respiratory Parameters: ........................................... 120
(Blood Pressure) CEW Exposure Does Not Raise Blood Pressure: ..................................................... 121
Number of CEW Discharges: Multiple and Prolonged CEW Discharges: ............................................ 121
No Evidence of Negative Effects with CEW Extended Duration Discharge: ...................................... 123
No Increased Mortality with Longer Duration CEW Exposure (swine study): ...................................... 126
Multiple Simultaneous CEW Discharges: .............................................................................................. 126
CEW Induced Stress Comparable or Less Than Some Other Force Options: ...................................... 127
Acidosis/Stress of Five-Second CEW Discharge ≤ 20 Meter Sprint: ..................................................... 127
Serotonin: ........................................................................................................................................... 128
Catecholamines: ................................................................................................................................. 129
Acidosis/Catecholamine Following Simulated Force Encounters: ....................................................... 132
CEW Physiologic Effects After Exercise/Exhausted: ........................................................................... 134
CEW Infection Risk: ............................................................................................................................ 135
CEW – Skin Tissue in Pigs .................................................................................................................... 135
Pneumothorax – CEW Induced .............................................................................................................. 135
CEW Probe Penetration Depths into Human Skull Phantoms ............................................................... 136

Neurocognitive Effects ...................................................................................................................... 137
Memory Studies: ................................................................................................................................. 137
OIS Memory Concerns in Reporting Procedures: ............................................................................... 137
OIS Threat-Induced Errors: ................................................................................................................ 137
Electronic Weapons Neurocognitive Studies: ....................................................................................... 137

CEW Recovery Time ......................................................................................................................... 144

CEW Effective Without Deployment or Application ............................................................................ 146

CEW Effectiveness .............................................................................................................................. 152

Officer Injuries ................................................................................................................................... 158

Reduced Deadly Force/Injuries - Selected CEW Literature ................................................................. 159
CEWs Reduce Use of Deadly Force: .................................................................................................... 159
CEWs Reduce Subject Injuries: ........................................................................................................... 163
CEWs Reduce Officer Injuries: ............................................................................................................ 170
CEWs Are Associated with Less Injury Than “Physical Force”: ....................................................... 176

Selected CEW Use Guidance (Training/Policy) Information ............................................................... 184
TASER CEW Training: ......................................................................................................................... 184
CEW Policy Studies: .......................................................................................................................... 184
Public Acceptance of CEWs: .............................................................................................................. 185
Initial 5-Second CEW Cycle: ............................................................................................................... 186
15-Second CEW Discharge Restrictions (or Advice): ......................................................................... 186

Welfare effects of substituting traditional police ballistic weapons with non-lethal alternatives.. 189
Other – Selected CEW Medical/Scientific Literature ....................................................................... 190
Algorithmic Approach to Assessment of CEW-Associated Fatality: .......................................................... 190
CEW Safety Margin: ..................................................................................................................................... 190
Risk of Injury: ................................................................................................................................................. 192
Risk of Death from CEW: ............................................................................................................................... 193
Back – CEW-Temporal Compression Fractures: ......................................................................................... 195
Risk of Death from CEW-Induced Falls: ........................................................................................................ 195
Risk of Eye (Ocular) Injuries (Dart to Eye) and Related: ............................................................................. 196
Risk of Death from CEW-Ignited Flammable Substances (Explosive Fumes): ........................................... 196
CEW Discharge Duration Temporal to Arrest Related Death (“ARD”): ..................................................... 197
CEW Research Produces Consistent Findings (TASER versus others): ..................................................... 199

CEW Use on Members of Specific Populations ......................................................................................... 200

Force, Risk, CEW Use in Hospital Setting: .................................................................................................... 200
CEW Use Medically Vulnerable or At-Risk Displaying Violent Behaviour: .................................................. 202
CEW Use on Mentally Ill Subjects: ................................................................................................................ 202
CEW Use on Children: ....................................................................................................................................... 205
CEW Use on Pregnant Woman: ....................................................................................................................... 206
CEW Use on Excited Delirium Syndrome (ExDS) Subjects: ........................................................................ 210
CEW Use on Subjects Under Influence of Alcohol/Ethanol: ...................................................................... 217
CEW Use on Subjects Under Influence of Cocaine (VFT) (animal) ............................................................. 217
CEW Use on Subjects Under Influence of Methamphetamine (animal) ....................................................... 218

Wildlife TASER CEWs .................................................................................................................................... 219

TASER CEW Operational Information ........................................................................................................ 220

Graphic – TASER X26 CEW Basic Components: ....................................................................................... 220
Graphic – Necessity of Completed Circuit to Deliver Electrical Charge: .................................................... 220
The New York Conducted Energy Device Course, Student Guide, includes: ................................................. 220
Necessity of Completed Circuit to Deliver Electrical Charge: ....................................................................... 221
X26 CEW Battery of Two Three-Volt (Duracell® CR123 ) Cells: .................................................................... 222
CEW Cartridge/Probe Wires are Very Thin and are Easily Broken: ............................................................... 222
CEW Probes and Darts: .................................................................................................................................... 223
Arcing Research: ............................................................................................................................................... 224
Targeting (lower center mass): ...................................................................................................................... 224
X26 CEW Sound Levels (Open Circuit Arcing versus Delivered Charge): .................................................. 224
CEW Probe Spread and Incapacitation: ........................................................................................................... 225
Graphic - CEW Probe Spread – Distance from CEW to Subject: .................................................................... 226
X26 CEW Log Shows Only Discharges Not Delivered Charge: .................................................................... 226
50,000 Volts Delivered to Body Myth: .......................................................................................................... 227
Cardiac Electrocardiogram (ECG) Monitor in CEW: ..................................................................................... 228

Smart CEWs (X3 (2009), X2 (2011), X26(P) (2013) CEWs) ............................................................................. 231

TASER CEW Handheld Model Development/Life Timeline: ......................................................................... 231
Digital SMART CEWs: ................................................................. 231
Feedback Loop - Charge Metering (digital Smart CEWs): .................................................. 231
TASER Training Version 15 (24 August 2009) ........................................................................ 233
X2 CEW (Smart CEWs) Trilogy Logs: ...................................................................................... 239
Smart CEW Calibration and Function Test .............................................................................. 240
X2 (“Smart”) CEW Concepts, Studies ..................................................................................... 242
  X2 CEW .......................................................................................................................... 242
  X2 CEW Generally .............................................................................................................. 245
  X2 vs X26E CEW Effectiveness .......................................................................................... 247
  X2 CEW Studies/Papers/Abstracts ....................................................................................... 248
  X2 CEW Prospective Human Studies .................................................................................. 249
  X2 CEW Modeling Studies .................................................................................................. 249
Summary Analysis: Electrical Safety Standards ................................................................. 251
X2 CEWs Comparative Cardiac Capture Safety Margin Studies ........................................... 251
X26(P) CEW ....................................................................................................................... 254
M26/X26/X26P CEW Drive-Stun Effects ............................................................................... 255
  CEW Drive Stun Current Distribution ............................................................................... 255
  CEW Drive-Stun Path-of-Current Demonstrations ............................................................. 255
  Drive Stun Discharge vs Probe Deployment ........................................................................ 256
  Drive Stun Discharge Wounds ............................................................................................ 256
  Drive-Stun: Medical Studies ............................................................................................... 256
  Drive-Stun: Legal Cases ..................................................................................................... 258
  Drive Stun: Movement, Multiple Locations ......................................................................... 263
CEW Three-Point Deployment Mode .................................................................................... 265
  Three-Point (and Four-Point) CEW Deployment Mode ....................................................... 265
M26 CEW Operational Information (TASER Training Version 11) ........................................ 269
Selected Cardiac Issues and Concepts ................................................................................. 271
  VFT for Swine, Canine, and Human (Electrode on Heart) ................................................... 271
  Typical Electrical Charges Required for Human Cardiac Effects ..................................... 271
  Human VFT: Electrodes Applied to Epicardial Surface of Ventricle .................................. 271
  Human Heart Requires 3X More Current to Go Into VF Compared to Swine .................. 272
  Drug Effects on Action Potential Repolarisation in Sheep Cardiac Purkinje Fibres .......... 273
  Accuracy of Subject’s Pulse Detection by Responder ......................................................... 273
  Medical Device Litigation ................................................................................................... 274
  The Stability of Electrically Induced Ventricular Fibrillation ........................................... 274
  Defibrillation Success Rates for Electrically-Induced Fibrillation .................................... 275
  Essentials of Low-Power Electrocution: Established and Speculated Mechanisms .......... 276
  Cardiac Arrest Survival: In-Hospital ................................................................................... 277
  Sudden Cardiac Arrest – AEDs – Sports Centres ............................................................... 277
CEW Latency Signs and Symptoms Checklists ............................................................... 280

Autopsy/Forensic Pathology Papers ........................................................................ 280
NAME Presentation 2014 ...................................................................................... 281
Latency for Signs and Symptoms of Electrocution .................................................. 282
Necessary, but not Sufficient, CEW Electrocution Diagnostic Criteria ................. 283

Transcutaneous Cardiac Pacing Thresholds and VF Safety Margins ....................... 284

Transcutaneous Cardiac Pacing Thresholds Modeling .............................................. 284
(CEWs Pacing Theory) Mortality and Timing Death: Runaway Pacemakers .......... 284
Adult Transcutaneous Cardiac Pacing Thresholds ..................................................... 285
Pediatric Transcutaneous Pacing Thresholds ......................................................... 287
Transcutaneous Pacing Threshold to VF Safety Margins ......................................... 288
(Swine) TASER CEW Capture, no VF Safety Margins ............................................ 288
Cao: Human Pacemaker Patient Experiencing Capture with CEW Discharge ......... 289
Stability of Pacing Threshold, Impedance, and R Wave Amplitude at Rest and During Exercise ................................................................. 289

Modeling and Other Studies .................................................................................. 291

CEW Drive Stun Current Distribution .................................................................... 291
Other CEW Modeling Studies .................................................................................. 291

ANSI, UL, IEC, Au/NZ, BS, EN, Webster Proposed CEW Safety Tests .................... 296

Summary Analysis: Electrical Safety Standards ....................................................... 296
Electrical Standards Safety Summary ..................................................................... 297
(02/2017 Adler) CEW Electrical Safety ................................................................... 298
(02/2013) Hughes, et. al. Ventricular Fibrillation Safety Margins ......................... 299
X26 CEW Meets Dr. Webster’s 2009 Proposed Safety Test ..................................... 299
X26 CEW Meets Australian/New Zealand Standards .......................................... 301
X26 CEW Meets British Safety Standards ............................................................. 303
X26 CEW Meets International Electrotechnical Safety Standards ......................... 304
X26 CEW Meets Underwriters Laboratories Safety Standards ............................. 307
Additional Papers that Discuss or Reference Electrical Safety Standards .......... 308

CEW Testing Procedures ....................................................................................... 311

ANSI/AAMI NS4:2013 Transcutaneous electrical nerve (TENS) stimulators .......... 312

Pain – Electrically Induced ...................................................................................... 317

Electroconvulsive Therapy (ECT), Seizure Threshold (ST) ....................................... 318

Zipes’ 2012 and 2014 “Case Series” and Selected Related Documents .................... 328
(Zipes’ CEW Pacing → VF Theory) Mortality and Timing Death: Runaway Pacemakers .......... 328
January 2014 Kroll and Zipes Controversies in Cardiovascular Medicine .......... 328
October 15, 2013 Canada Study Quote ................................................................. 329
October 2013 (Canada) Hall RESTRAINT Quote: .................................................. 330

Sudden Cardiac Deaths: Athletes ............................................................................ 278
Sudden Cardiac Arrest: Brugada ............................................................................. 278
Zipes’ (2012) Paper is a “Case Series” ................................................................. 331
AHA did not endorse or warrant accuracy or reliability of Zipes’ case series. .......... 331
Zipes’ “Case Series” Related Documents .............................................................. 331
Zipes: (1975) Epinephrine Initially ↓ Then ↑ VFT .................................................. 334
Zipes: (1988) Transcutaneous Cardiac Pacing Thresholds (1800-4000 µC) ............... 334
Zipes: (1977) VFT in Dogs (mean: 43.2 ± 25 µC) ................................................... 335

Selected Scientific Literature Criteria .................................................................. 336
Case Series Not Reliable for Determining Causation ........................................... 336
Case Reports Not Reliable for Determining Causation ......................................... 336
Selected Scientific Logical Fallacies .................................................................... 336

Quantum of Force ............................................................................................... 338

Legal: Selected Court Cases Regarding CEWs as a Level of Force ....................... 339
Inappropriate CEW Use on Pre-Trial Detainees ............................................... 339
Selected General Force Statements .................................................................. 339
Attempt to Use Physical Skill, Negotiation, or Commands ................................. 339
Manufacturer recommendations, while relevant, do not equal constitutional requirements ........................................ 340
Failure to Train: Constitutional Limitations of Excessive Force ....................... 340
Failure to Train: Dealing With Mentally Ill ..................................................... 342
Failure to Train: Use of Force on Injured Suspects ........................................... 343
Targeting ............................................................................................................. 344
TASER Ventricular Fibrillation (VF) Research .................................................. 345
OC (Pepper Spray)/Batons – Significant Level of Force .................................... 345
(Alleged) Many (37, 11) CEW Discharges Found to be Reasonable .................. 346
What is “Deadly Force” – Generally ................................................................. 348
Everything has the “Potential” to be “Lethal” ..................................................... 349
Deadly vs. Non-Deadly Under Fourth Amendment ......................................... 349
TASER CEW “drive stun” “is non-deadly force” .............................................. 349
TASER CEW is not “deadly” force ................................................................. 350
TASER CEW is a “non-deadly weapon” .......................................................... 350
TASER CEW is “non-deadly force” ................................................................. 350
TASER CEW is “less-than-lethal” force ............................................................ 350
TASER CEW is “less than deadly force” .......................................................... 351
TASER CEW is “non-lethal” ................................................................. 351
TASER CEW is not “lethal” force ................................................................. 355
TASER CEW is “less-lethal” weapon .............................................................. 356
Cases Citing the May 24, 2011 NIJ CEW Study ............................................. 357
PERF Guidelines/Policies Admissibility for Constitutional Violation ............. 358

Lay/Expert Testimony: CEWs ............................................................................. 360
Warnings .......................................................................................................... 361
Basic Selected Mortality Summary Numbers: ................................................................. 403
Abbreviated summary of selected approximate mortality numbers: .......................... 403
Sudden Cardiac Death (SCD): ...................................................................................... 403
Out of Hospital [Sudden] Cardiac Arrest (SCA) In Those <35 Years of Age: ............... 403
Sudden Cardiac Death (SCD) Minnesota (MN) High School CSP: ............................... 404
Sudden Cardiac Death (SCD) Children: ..................................................................... 404
Sudden Cardiac Death (SCD) NCAA Participants: ....................................................... 404
Probability, see, Hirsch v. CSX Transp., Inc., 656 F.3d 359 (6th Cir. (Ohio) 2011): .......... 405
Death Rate in Jails (no listing of ECD): ...................................................................... 408
US ARDs, BJS, Deaths in Custody Reporting Act ("DICRA"): .................................... 410
Additional Mortality Numbers: .................................................................................. 411
Hospital Emergency Department Mortality Rates: .................................................... 411
Sudden Death in Young Adults .................................................................................... 412
Sudden Cardiac Death (SCD) NCAA. Athletes: ............................................................ 413
SCD During Competitive Sports Activities in Minnesota High School Athletes: ........ 415
Out-of-Hospital Non-traumatic Cardiac Arrest (OHCA): Children: ............................ 416
Sudden Non-Traumatic Sudden Death in Military Recruits: ....................................... 416
Routine Cardiac Ablation Procedures Rates of Major Complications/Deaths: .......... 417
Severe Mental Illness Mortality Rates: ....................................................................... 417
Antipsychotics and the Risk of Sudden Cardiac Death ................................................ 417
SUDEP – Sudden Unexpected Death in Epilepsy Mortality: ...................................... 418
Law Enforcement Officer (LEO) Mortality, Assaults, and Injuries: ............................ 418
Other Numbers: ....................................................................................................... 419

Chemical Aerosol Weapons (OC, CN, CS, Pava): ...................................................... 420
Chemical Aerosol Weapons – Sampling of Legal Statements: .................................... 420
Chemical Aerosol Weapons – Standards: .................................................................. 420
Chemical Aerosol Weapons – Sampling of Literature: ............................................... 420
Personal Defense Aerosols Sprays – A Sampling of Basics ......................................... 422

Selected Bath Salt Papers ......................................................................................... 426

Prone, Maximal, Weight Force .................................................................................. 427
Book Chapters: ......................................................................................................... 427
Restraint – Miscellaneous Papers: ............................................................................ 427
Restraint-related Asphyxia: ....................................................................................... 427
Fatal Compression Asphyxia: .................................................................................... 427
Prone Position Affect on Respiration: ........................................................................ 428
Prone Restraint: ................................................................. 429
Prone Maximal Restraint (PMR) ........................................... 433
Physical Restraint: ............................................................. 435

Restraint Chair ................................................................ 438

Excited Delirium Guidance .................................................. 439

ExDS Books: ..................................................................... 439
2017 Related Book Chapters: ................................................ 439
(1996–2017 IACP) International Association of Chiefs of Police ......................................................... 439
(12/2011 NIJ/Penn State) NIJ Weapons and Protective Systems Technologies Center ...................... 440
(05/2016 UK) Royal College of Emergency Medicine ........................................................................... 440
(02/2012 Ontario, Canada) ExDS Training Bulletin .............................................................................. 441
(2010 IPICD) Institute for the Prevention of In-Custody Deaths .............................................................. 441
(06/2009 Nova Scotia) Minister of Justice and Health ........................................................................... 441
Other .................................................................................. 441

Excited Delirium (ExDS) Features ....................................... 442

Excited Delirium – Partial History ....................................... 446
Partial History of Excited Delirium Papers/Documents ........ 447
Sampling of Legal Cases that Include the Term “Excited Delirium” ..................................................... 452

Sickle Cell Exertional Sudden Death .................................. 454

Ketamine ............................................................................ 455

SPARK CEW (Brazil) .......................................................... 456

Phazzer Enforcer CEW: ....................................................... 457

Civil Rights Groups ............................................................ 458
European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT) .................................................... 458

TABLES

Table 1 Selected CEW Treatises/Books ................................ 2
Table 2 Selected Treatise CEW Chapters .............................. 2
Table 3 Selected CEW Organization White Papers/Statements ... 4
Table 4 Selected Primary CEW Review Papers .................... 6
Table 5 Selected CEW-Temporal Arrest-Related Death (ARD) Review Papers .................................. 14
Table 6 Epidemiological (Field) Studies: Chest Probe Hits ... 18
Table 7 CEW Adverse Cardiac Events Inconclusive or Controversial ...................................................... 23
Table 8 Probability of CEW Induced Ventricular Fibrillation .. 32
Table 9 Prospective CEW Human Cardiac Studies ............... 36
Table 10 Epidemiological Studies – No Documented CEW Induced Cardiac Arrhythmias .................... 41
Table 11 Skin-to-Heart Distances in Humans ....................... 44
Table 12 CEW VF Safety Margin – Partial Publications List ... 47
Table 13 Risk of Cardiac Arrhythmia from CEW ............... 48
Table 14 Not Stated to Avoid CEW Targeting Center Mass/Chest Table .......................................................... 60
Table 15 Partial List of Cardiac Safety Dependent Upon Swine or Human Weight/Size ................................. 72
Table 16 Zipes, 1975 Epinephrine increased VFT. (pg 111-123) ................................................................. 81
Table 17 Six (6) instances of small pigs that experienced CEW induced VF ........................................ 83
Table 18 Detailed Table of Animal Studies: Induced VF Results at 1X X26 CEW Discharge Levels .... 85
Table 19 DTH distances in swine cardiac effects. .............................................................................. 93
Table 20 Dawes 2014 Swine X2/KA MPID Swine Study DTH (-3.4–18.0 mm), Fig. 1 (a–c). .......... 95
Table 21 2013 Dawes 2013 Swine Study – Fig. 2a–d. STH / (calculated) DTH Distances. .............. 96
Table 22 2013 Dawes Swine Study – Fig. 5a–c. STH / (calculated) DTH Distances. .............. 96
Table 23 Wu: Experimental parameters and results of five animal tests ................................................ 99
Table 24 DTH distances for Lakkireddy studies from raw data. ...................................................... 99
Table 25 DTH distances for Lakkireddy studies from raw data. ...................................................... 100
Table 26 Swine CEW Drive Stun and Dart Separation Research ..................................................... 101
Table 27 Human Body Resistances to Penetration of Electrical Current ........................................ 105
Table 28 CEW exposure blood pressure ............................................................................................ 121
Table 29 UK Police Use of CEWs Statistics, England and Wales 2010-1015 ..................................... 147
Table 30 Grove, Table 3 CEW use of street police compared to special trained forces ........ 148
Table 31 CEWs Reduce Use of Deadly Force ................................................................................... 159
Table 32 CEWs Reduce Subject Injuries ............................................................................................ 163
Table 33 CEWs Reduce Officer Injuries ............................................................................................. 170
Table 34 CEWs Are Associated with Less Injury Than “Physical Force” ........................................... 176
Table 35 CEW Use on Children ........................................................................................................... 205
Table 36 CEW Use on Pregnant Woman ............................................................................................ 206
Table 37 CEW Use on Excited Delirium Syndrome (ExDS) Subjects ............................................... 210
Table 38 CEW dart length and dime and five pence comparisons ....................................................... 223
Table 39 Sampling of sound levels from various sources ............................................................... 224
Table 40 Static electricity and Van de Graaff generators ........................................................................ 229
Table 41 TASER Handheld CEW Model Development Timeline (Smart CEWs highlighted) .......... 231
Table 42 X2 CEW Images, Nomenclature, V20 X2 Training .............................................................. 242
Table 43 X26(P) CEW (from Training V20 (1 Jan. 2017), Instructor PowerPoint) ......................... 254
Table 44 X26(E) CEW Drive Stun Graphics ....................................................................................... 255
Table 45 X26 CEW Illustration, arcing with expended cartridge ....................................................... 267
Table 46 VFT for Swine, Canine, and Human (Electrode on Heart) ..................................................... 271
Table 47 Typical Electrical Charges Required for Human Cardiac Effects ..................................... 271
Table 48 1979 Horowitz VF thresholds .............................................................................................. 272
Table 49 Latency for Signs and Symptoms of Electrocution ............................................................. 282
Table 50 Necessary, not Sufficient, CEW Electrocution Diagnostic Criteria (all must be satisfied) .... 283
Table 51 Human Adult Transcutaneous Cardiac Pacing Threshold Literature ................................ 285
Table 52 Pediatric Transcutaneous Pacing Thresholds ................................................................. 287
Table 53 Transcutaneous Pacing Threshold to VF Safety Margins ............................................... 288
Table 54 CEW-Related Electrical Safety Standards Primary References ......................................... 297
Table 55 Electrical Standards Safety Summary Table ................................................................. 298
Table 56 2009 Nimunkar/Webster paper electrical device outputs ................................................... 301
Table 57 Electrical Characteristics ECT Compared with CEW ...................................................... 319
Table 58 ECT device dosage for induction of seizure. .................................................................... 321
Table 60 ECT Bui (temporal), Reilly (2011), and Goudge (2013) Excerpts ........................................ 324
Table 61 Zipes, 1975 Epinephrine increased VFT. (pg III-123) ......................................................... 334
Table 62 Possible Quantum of Force Table: Probe versus Drive Stun .............................................. 338
Table 63 Dziekanski / Braidwood / Williams Timeline ................................................................. 363
Figure 25 Digital Smart CEW Charge Metering and Pulse Calibration .............................................. 233
Figure 26 Labelled drawing of X2 CEW.......................................................................................... 242
Figure 27 Smart Cartridge Cut Away ......................................................................................... 244
Figure 28 CEW Smart Cartridges ......................................................................................... 244
Figure 29 Smart cartridge probes ......................................................................................... 245
Figure 30 Drawing of example of X2 deployment ................................................................ 245
Figure 31 Arrows Pointing to Electrodes on Front of CEW with No Expended Cartridge in Place .... 255
Figure 32 Illustrating CEW Drive-Stun Discharge Across Front Electrodes and LASER .............. 255
Figure 33 X26 CEW Front Electrodes – No Cartridge in Place on CEW .................................... 256
Figure 34 X26 CEW Cartridge Showing Front Electrodes Recessed on Cartridge ..................... 256
Figure 35 Epidermal Distance ................................................................................................. 260
Figure 36 Three-Point ECD Deployment TASER Training Version 19 User PowerPoint Slide 197 .......... 265
Figure 37 M26 CEW. TASER Training Version 11, M26 User Program, Slide 36 .................... 269
Figure 38 CEW Field Success by Level of Use: TASER Training Version 11, M26 User, Slide 79 ...... 269
Figure 39 M26 CEW Drive-Stun Mode, TASER Training Version 11, M26 User, Slide 104 .......... 270
Figure 40 September 23, 2014 NAME Presentation Conclusion ............................................... 281
Figure 41 (02/2013) Hughes, E.L., et. al. Karbon Arms IEC 479-1 Graphic Illustration ......... 299
Figure 42 The X26E pulse width is 42.6 µs ................................................................................. 315
Figure 43. The X26E CEW net charge is 46.4 µC ..................................................................... 316
Figure 44 Bones of Human Skull and Occipital Bone .............................................................. 320
Figure 45 Spread plot of ECT thresholds. Green line marks the 5 s total output charge of X26(E) CEW, which is specified at approx. 9.4 mC .............................................................................. 322
Figure 46 Lee WH, Lisanby SH, Laine AF, Peterchev AV. Stimulation strength and focality of electroconvulsive therapy and magnetic seizure therapy in a realistic head model. Conf Proc IEEE Eng Med Biol Soc 2014;2014:410-3 ................................................................. 323
Figure 47 TASER Training Version 12 (11/04), X26 CEW User Certification PowerPoint Slide ...... 352
Figure 48 Krexi/Varvarigou Stress-Induced Sudden Cardiac Death. ........................................ 365
Figure 49, Tester: Prevalence of Autopsy Negative SUD in the Young ....................................... 375
Figure 50 X26(E) and TF-76 CEWs output waveforms .......................................................... 389
Figure 51 US Deaths 2000–2010 Drugs, Suicide, Firearms, and Alcohol .................................. 406
Figure 52 US Drug Deaths 2000–2010 .................................................................................... 407
Figure 53 Jail inmate deaths in custody, 2000–2009 ................................................................. 409
Figure 54 US ARDs, BJS, Deaths in Custody Reporting Act ("DICRA") ......................................... 410
Selected CEW Misconceptions Papers


   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/Books:

#### Table 1 Selected CEW Treatises/Books

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Mar. 2009</td>
<td>TASER® Electronic Control Devices: Physiology, Pathology, and Law</td>
</tr>
<tr>
<td>3</td>
<td>Apr. 2008</td>
<td>TASER ELECTRONIC CONTROL DEVICES AND SUDDEN IN-CUSTODY DEATH: Separating Evidence from Conjecture</td>
</tr>
</tbody>
</table>


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


### Selected Treatise CEW Chapters:

#### Table 2 Selected Treatise CEW Chapters

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Date</td>
<td>Title</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>----------------------------------------------------------------------</td>
</tr>
</tbody>
</table>


Conclusions

The operational employment of CEDs by law enforcement officers has highlighted a broad range of injuries associated with their use. The risk of some types of injury, such as ocular probe penetration and head injury from falls, can be mitigated by training, while the risk of other injuries, such as skin burns and musculoskeletal injury from the intense muscle contraction, is less amenable to mitigation.

Whether CEDs can adversely affect heart rhythm by a direct effect of the discharge remains a hotly debated topic. Ho and colleagues’ paper (2011) remains the only published human study in which discharge (from a device that was not commercialized) was applied to the frontal chest directly over the heart while cardiac rhythm was monitored. In order to understand more fully the putative cardiac risk from CEDs there is clearly a need for similar studies to be undertaken with existing commercial devices such as the TASER® X26, as well
as with the newly introduced TASER® X26P and TASER® X2. If there is a risk with these commercial devices, then this can only be mitigated by lowering the point of aim away from the frontal chest over the heart, as recommended by TASER International in 2009.

Despite the possible risk to the heart from CED discharge current, the high level of take-up and use of these less-lethal law enforcement options provides circumstantial evidence that any direct cardiac risk must be extremely low.

TASER International asserts that its devices have been discharged on more than 2 million occasions (see www.taser.com). Against this large number of claimed uses, and notwithstanding the likely under-reporting of CED injury cases in the medical literature and elsewhere, the incidence of serious injuries associated with use of these devices appears to be relatively low.

Much of the accumulating evidence for the various types of injury induced by CEDs comes from the peer-reviewed clinical literature; inevitably, these injuries have been associated with use of TASER® brand devices due to their almost ubiquitous penetration of the law enforcement market. However, irrespective of the brand of CED, and in order that the breadth of potential injuries attributable to CED use is brought to the widest possible audience, it is vital that clinicians endeavour to publish case reports when encountering patients in whom there is a suspicion that morbidity may be linked to these increasingly popular devices (Payne-James, Sheridan and Smith, 2010).


Selected CEW Organization White Papers/Statements:

Table 3 Selected CEW Organization White Papers/Statements

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Date</td>
<td>Title</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>May 2011</td>
<td>AAEM: Emergency Department Evaluation after Conducted Energy Weapon Use: Review of the Literature for the Clinician</td>
</tr>
<tr>
<td>5</td>
<td>May 2011</td>
<td>NIJ: Study of Deaths Following Electro Muscular Disruption</td>
</tr>
<tr>
<td>3</td>
<td>Apr. 2010</td>
<td>IACP: Electronic Control Weapons, Concepts and Issues Paper</td>
</tr>
<tr>
<td>2</td>
<td>Jun. 2009</td>
<td>AMA: Report 6 of the Council on Science and Public Health (A-09), Use of Tasers® [Conducted Electrical Devices (CEDs)] by Law Enforcement Agencies (Reference Committee D)</td>
</tr>
</tbody>
</table>


---

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

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


**Selected Primary CEW Review Papers:**

**Table 4 Selected Primary CEW Review Papers**

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Date</td>
<td>Title</td>
</tr>
<tr>
<td>-----</td>
<td>-----------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>


   a. The body of data that have been reviewed provides reasonable support for the safety of CEW.


    **Abstract:**

    The objective of the present study was the analysis of publications in the foreign medical literature concerning the problems of safety, clinical diagnostics, pathological morphology, and treatment of the patients subjected to the impact by various models of the TASER electroshock devices. The materials for this article were borrowed from the available Internet resources and libraries. The methods of scientific analysis were employed to follow up the dynamics of publication and to determine the number of publications on the issues of interest. The main attention was given to the overview of the subject matter of scientific research and experiments. The review covers 74 foreign articles presenting the discussion of various conditions and circumstances of the action of various types of the TASER electroshock devices (ESD) on the man with special reference to their effectiveness and safety as confirmed by numerous experimental impacts on the volunteers and animals. It is shown that the dynamics of relevant publications in the foreign scientific periodicals gives evidence of the strong interest shown by the specialists in various scientific disciplines to the problem of safety of various models of the TASER electroshock devices. The largest number of the articles (60 or 81.1%) published during the period covered by the present study were submitted by the American authors describing their experiments involving the volunteers, anthropometric dummies, and human corpses (n=38 or
51%). The subject matter of these publications included the forensic medical evaluation of the lethal outcomes of the application of the TASER electroshock devices with the related technical problems and characteristic of various ESD models. Despite the extensive studies on the volunteers and the experimental animals, the authors of the publications failed to present direct and conclusive evidence of the lethal consequences of the application of the TASER electroshock devices (ESD) on the man. Some of them recommend to prohibit (or restrict whenever possible) the targeted application of the electric shock weapons to the thoracic region. Experiments on the animals have demonstrated the possibility of development of cardiovascular and respiratory complications following the application of the TASER X2[6] electroshock devices operating at a frequency of 40 Hz during 30 minutes. The clinical and laboratory studies with the participation of the volunteers in an alcoholic intoxication condition have confirmed the long-term increase in the blood lactate levels under the influence of the electric shocking weapons. The analogous data suggesting the development of pronounced acidosis under effect of the TASER X2[6] electroshock devices due to the elevation of the lactate concentration in the venous blood have been obtained in the animal experiments. The studies of humans in a narcotic intoxication condition failed to provide direct evidence of induction of psychic disorders in the form of an acute confusional state (delirium) under the influence of the TASER electroshock devices. The evaluation of changes in the skin cover in the form of the punctured or contused wounds in the victims of the application of the electroshock gun projectiles did not revealed any specific signs of the local electrical action. [highlighting emphasis added]


a. [Google translate to English] Electroshock ranged weapons (Conducted Electrical Weapons - CEW) result in a Bodyshot for delivering high-frequency current pulses with high voltage and current low amperage. One caused thereby, voluntarily cannot be influenced, general muscle contraction caused a momentary incapacity of the measures Person. Using human and animal research and the Creating complex computer simulation models could the physical effect on the human body are analyzed from different angles. Of the
However, precise electrophysiological mechanism of action of CEW could thereby are not yet fully understood. Also, it was not possible so far, to identify specific risk threshold for the effects of CEW pulses. This is certainly one of the reasons why the pathophysiological effects of these in the scientific literature. In the majority of publications to date, no direct causal link between clinically relevant pathophysiological changes and the shelling a healthy person with CEW be occupied. can for the executive officers thereof be concluded that subject to mentally and / or physically impaired People in the professional use of CEW can be classified as harmless.


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.”


Selected CEW Survey Papers:


Selected Autopsy/Forensic Pathology CEW-Related Papers:


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

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


   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.”

[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.


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


a. **Conclusions:** In sudden deaths proximate to CEW discharge, immediate collapse is unusual, and VF is an uncommon VF presenting rhythm. Within study limitations, including selection bias and the possibility that VF terminated before the presenting rhythm was recorded, these data do not support electrically induced VF as a common mechanism of these sudden deaths.”

b. “… For subject 1 [(GA) Gresmond Gray], who collapsed immediately (subject 6 in Table 4), neither drugs nor cardiac disease can be implicated; both the time course and the electrode location are consistent with electrically induced VF.”


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

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

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

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

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

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


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

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

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

Epidemiological (Field) Studies: Including Chest Probe Hits

Table 6 Epidemiological (Field) Studies: Chest Probe Hits

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


- A conclusion: **CEW use was the force modality least likely to result in significant injury.**
- **No significant injuries occurred among 504 CEW uses** (0%; 95% CI 0.0–0.9%).
  - There were no significant injuries after 504 CEW uses (0%; CI 0.0–0.9%) and 88 chemical weapon uses (0%; CI 0.0 – 5.0%).
- **Unarmed physical force resulted in over one third (6/16) of the significant injuries seen in this series. These were evenly distributed among "soft" and "hard" unarmed physical force and included major head injuries and bony fractures.**
- **Unarmed physical force and CEW use were the two most common force modalities used, representing 50.8% and 36.0% respectively and 86.8% combined. Traditional intermediate force options such as pepper spray and impact weapons were not commonly used, representing 6.3% and 0.6% of...**
force utilizations. Firearms were used in 0.4% of force utilizations (n=6 cases).

- The large majority of UOF cases in this series use lower levels of force such as unarmed physical force and CEWs. This reflects modern police practice in the United States as many agencies now equip some or all of their officers with CEW’s. These tools have been associated with lower rates of use of other force options such as OC spray, impact weapons, and firearms, and in lower injury rates among both suspects and officers. 6,17,18
  
  
  

- While serious injuries and fatalities have occurred after CEW use, this is rare.17 With over 500 uses resulting in no significant injuries, these data suggest that CEW use is the force option least likely to result in significant suspect injury. This finding is consistent with prior epidemiology studies of CEW use.8,20
  
  


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.”


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

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


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


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

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

Cardiac – Selected CEW Medical/Scientific Literature

Cardiac Human Assessment Study


Abstract:

**Background:** Case reports of cardiac arrest in temporal proximity to Conducted Electrical Weapon (CEW) exposure raise legitimate concerns about this as a rare possibility. In this pilot study, we respectfully navigate the oversight and regulatory hurdles and demonstrate the intra-shock electrocardiographic effects of an intentional transcardiac CEW discharge using subcutaneous probes placed directly across the precordium of patients with a previously implanted intracardiac EKG sensing lead.

Methods: Adults scheduled to undergo diagnostic EP studies or replacement of an implanted cardiac device were enrolled. Sterile subcutaneous electrodes were placed at the right sternoclavicular junction and the left lower costal margin at the midclavicular line. A standard police issue TASER Model X26 CEW was attached to the subcutaneous electrodes and a 5 s discharge was delivered. Continuous surface and intracardiac EKG monitoring was performed.

**Results:** A total of 157 subjects were reviewed for possible inclusion and 21 were interviewed. Among these, 4 subjects agreed and completed the study protocol. All subjects tolerated the 5 s CEW discharge without clinical complications. There were no significant changes in mean heart rate or blood pressure. Interrogation of the devices after CEW discharge revealed no ventricular pacing, dysrhythmias, damage or interference with the implanted devices.

**Conclusions:** In this pilot study, we have successfully navigated the regulatory hurdles and demonstrated the feasibility of performing intracardiac EKG recording during intentional precordial CEW discharges in humans. While no CEW-associated dysrhythmias were noted, the size of this preliminary dataset precludes making conclusions about the risk of such events. Larger studies are warranted and should consider exploring variations of the CEW electrode position in relation to the cardiac silhouette.
### Table 7 CEW Adverse Cardiac Events Inconclusive or Controversial

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Lead Author</th>
<th>CEW VF Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>June 2018</td>
<td>Kunz</td>
<td>&quot;Conclusions. Electrical weapons are weapons and as such there are risks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>associated with their usage. These weapons satisfy all relevant electrical</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>safety standards and there are, to date, no proven electrocution incidents</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>in spite of millions of exposures. …&quot;</td>
</tr>
<tr>
<td>18</td>
<td>Dec. 2017</td>
<td>Payne-James</td>
<td>&quot;A continuing source of controversy concerns whether the electrical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UK FFLM</td>
<td>discharge from TASER® devices, when applied to the anterior chest through</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a dart that has embedded in the skin or clothing overlying the heart, can</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>directly affect heart rhythm …&quot;</td>
</tr>
<tr>
<td>17</td>
<td>Nov. 2017</td>
<td>Stopyra</td>
<td>Background: Case reports of cardiac arrest in temporal proximity to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conducted Electrical Weapon (CEW) exposure raise legitimate concerns about</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>this as a rare possibility.</td>
</tr>
<tr>
<td>16</td>
<td>Apr. 2017</td>
<td>Kondratova</td>
<td>Despite the extensive studies on the volunteers and the experimental</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>animals, the authors of the publications failed to present direct and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>conclusive evidence of the lethal consequences of the application of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TASER electroshock devices (ESD) on the man.</td>
</tr>
<tr>
<td>15</td>
<td>Feb. 2017</td>
<td>Kunz</td>
<td>According to up-to-date scientific information, it can be assumed that</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with the proper application of CEWs, no clinically significant pathophysio-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>logical effects on the heart are to be expected. Using CEWs following the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>requirements of necessity and proportionality should therefore be classified</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>as safe.</td>
</tr>
<tr>
<td>14</td>
<td>Sep. 2016</td>
<td>Sheridan</td>
<td>&quot;Whether CEDs can adversely affect heart rhythm by a direct effect of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>discharge remains a hotly debated topic. … If there is a risk with these</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>commercial devices, then this can only be mitigated by lowering the point</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>of aim away from the frontal chest over the heart, as recommended by</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TASER International in 2009. Despite the possible risk to the heart from</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CED discharge current, … the high level of take-up and use of these less-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>lethal law enforcement options provides circumstantial evidence that any</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>direct cardiac risk must be extremely low.</td>
</tr>
<tr>
<td>14</td>
<td>Feb. 2015</td>
<td>Havranek</td>
<td>&quot;Existing data concerning adverse cardiac events of EMD including incidental</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>deaths are still inconclusive. …”</td>
</tr>
<tr>
<td>13</td>
<td>Nov. 2014</td>
<td>Graham</td>
<td>&quot;Whether or not an ECD has in fact actually caused the death of a human via</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the direct effect of electricity - electrocution - is controversial”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;If an ECD can induce VF in a human adult, it must be a very rare event.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Although the issue as to whether an ECD under normal use conditions has</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>caused the death of a human has not been definitively settled, there does</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>seem to be general agreement that such an event, if it happens, is rare.”</td>
</tr>
<tr>
<td>12</td>
<td>Jun. 2014</td>
<td>Dawes</td>
<td>In this swine study setting, the probability of VF is no more than 0.69 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(95 % CI 0.018–3.8 %). Among exposures with capture, the probability of VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>in this study setting is no more than 1.6% (95 % CI 0.040–8.5 %).</td>
</tr>
<tr>
<td>11</td>
<td>Apr. 2014</td>
<td>Kunz</td>
<td>&quot;… no medical research has yet demonstrated pathophysiological cardiac</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>effects arising from ECD application …”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;The resulting current level indicated at the heart muscle was 1/5 the level</td>
</tr>
</tbody>
</table>
|     |            |                      | considered the threshold for triggering ventricular fibrillation."
<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Lead Author</th>
<th>CEW VF Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Jan. 2014</td>
<td>Kroll</td>
<td>&quot;Applying this charge density threshold to the ECD simulation results, we obtained safety margins for ECD as up to 5-fold for a male and up to 2.5-fold for a female for a front ECD application.&quot;</td>
</tr>
<tr>
<td>9</td>
<td>Oct. 2013</td>
<td>Canada</td>
<td>No &quot;confirmation or exclusion of a clear causal link&quot;</td>
</tr>
<tr>
<td>8</td>
<td>Mar. 2013</td>
<td>Dawes</td>
<td>No more than 0.59% (even with cardiac capture)</td>
</tr>
<tr>
<td>7</td>
<td>Aug. 2012</td>
<td>White</td>
<td>Disproving the hypothesis that a CEW application anywhere on the chest presents a risk of VF</td>
</tr>
<tr>
<td>6</td>
<td>May 2012</td>
<td>Bozeman</td>
<td>0.0–0.6</td>
</tr>
<tr>
<td>5</td>
<td>Nov. 2011</td>
<td>Kroll</td>
<td>1:2,500,000 (theoretical VF risk estimate)</td>
</tr>
<tr>
<td>4</td>
<td>Sep. 2010</td>
<td>Biria</td>
<td>&quot;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.&quot;</td>
</tr>
<tr>
<td>3</td>
<td>May 2010</td>
<td>Michaud</td>
<td>&quot;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.&quot;</td>
</tr>
<tr>
<td>2</td>
<td>Jan 2009</td>
<td>Bozeman</td>
<td>No evidence of VF</td>
</tr>
<tr>
<td>1</td>
<td>2007</td>
<td>Levine</td>
<td>&quot;... 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....&quot;</td>
</tr>
</tbody>
</table>


   a. “Conclusions. Electrical weapons are weapons and as such there are risks associated with their usage. These weapons satisfy all relevant electrical safety standards and there are, to date, no proven electrocution incidents in spite of millions of exposures...."


   a. "A continuing source of controversy concerns whether the electrical discharge from TASER® devices, when applied to the anterior chest through a dart that has embedded in the skin or clothing overlying the heart, can directly affect heart rhythm (Zipes, 2012). ..."


a. **Background:** Case reports of cardiac arrest in temporal proximity to Conducted Electrical Weapon (CEW) exposure raise legitimate concerns about this as a rare possibility. (emphasis added)


Abstract:

The objective of the present study was the analysis of publications in the foreign medical literature concerning the problems of safety, clinical diagnostics, pathological morphology, and treatment of the patients subjected to the impact by various models of the TASER electroshock devices. The materials for this article were borrowed from the available Internet resources and libraries. The methods of scientific analysis were employed to follow up the dynamics of publication and to determine the number of publications on the issues of interest. The main attention was given to the overview of the subject matter of scientific research and experiments. The review covers 74 foreign articles presenting the discussion of various conditions and circumstances of the action of various types of the TASER electroshock devices (ESD) on the man with special reference to their effectiveness and safety as confirmed by numerous experimental impacts on the volunteers and animals. It is shown that the dynamics of relevant publications in the foreign scientific periodicals gives evidence of the strong interest shown by the specialists in various scientific disciplines to the problem of safety of various models of the TASER electroshock devices. The largest number of the articles (60 or 81.1%) published during the period covered by the present study were submitted by the American authors describing their experiments involving the volunteers, anthropometric dummies, and human corpses (n=38 or 51%). The subject matter of these publications included the forensic medical evaluation of the lethal outcomes of the application of the TASER electroshock devices with the related technical problems and characteristic of various ESD models. Despite the extensive studies on the volunteers and the experimental animals, the authors of the publications failed to present direct and conclusive evidence of the lethal consequences of the application of the TASER electroshock devices (ESD) on the man. Some of them recommend to prohibit (or restrict whenever possible) the targeted application of the electric shock weapons to the thoracic region. Experiments on the animals have demonstrated the possibility of development of cardiovascular and respiratory complications...
following the application of the TASER X2[6] electroshock devices operating at a frequency of 40 Hz during 30 minutes. The clinical and laboratory studies with the participation of the volunteers in an alcoholic intoxication condition have confirmed the long-term increase in the blood lactate levels under the influence of the electric shocking weapons. The analogous data suggesting the development of pronounced acidosis under effect of the TASER X2[6] electroshock devices due to the elevation of the lactate concentration in the venous blood have been obtained in the animal experiments. The studies of humans in a narcotic intoxication condition failed to provide direct evidence of induction of psychic disorders in the form of an acute confusional state (delirium) under the influence of the TASER electroshock devices. The evaluation of changes in the skin cover in the form of the punctured or contused wounds in the victims of the application of the electroshock gun projectiles did not revealed any specific signs of the local electrical action. [highlighting emphasis added]


a. Abstract

Conducted electrical weapons (CEWs), such as Taser devices, have been used by special police forces in Germany, Austria and Switzerland for several years. Due to current political changes and the increasing complexity of requirements for police officers in the field, a large-scale introduction of Taser devices is currently being discussed. In this context, the medical risk assessment of this new technology plays an important role. Although there have been several hundred articles on the pathophysiological risks of CEWs published over the last years, the literature comparison of medical publications on this subject reveals a partially inconsistent picture.

The present work deals with the cardiac aspects of CEWs. Using the medical database PubMed, articles published on this topic are critically evaluated and compared. According to up-to-date scientific information, it can be assumed that with the proper application of CEWs, no clinically significant pathophysiological effects on the heart are to be expected. Using CEWs following the requirements of necessity and proportionality should therefore be classified as safe.

Conclusions

The operational employment of CEDs by law enforcement officers has highlighted a broad range of injuries associated with their use. The risk of some types of injury, such as ocular probe penetration and head injury from falls, can be mitigated by training, while the risk of other injuries, such as skin burns and musculoskeletal injury from the intense muscle contraction, is less amenable to mitigation.

Whether CEDs can adversely affect heart rhythm by a direct effect of the discharge remains a hotly debated topic. Ho and colleagues’ paper (2011) remains the only published human study in which discharge (from a device that was not commercialized) was applied to the frontal chest directly over the heart while cardiac rhythm was monitored. In order to understand more fully the putative cardiac risk from CEDs there is clearly a need for similar studies to be undertaken with existing commercial devices such as the TASER® X26, as well as with the newly introduced TASER® X26P and TASER® X2. If there is a risk with these commercial devices, then this can only be mitigated by lowering the point of aim away from the frontal chest over the heart, as recommended by TASER International in 2009.

Despite the possible risk to the heart from CED discharge current, the high level of take-up and use of these less-lethal law enforcement options provides circumstantial evidence that any direct cardiac risk must be extremely low.

TASER International asserts that its devices have been discharged on more than 2 million occasions (see www.taser.com). Against this large number of claimed uses, and notwithstanding the likely under-reporting of CED injury cases in the medical literature and elsewhere, the incidence of serious injuries associated with use of these devices appears to be relatively low.

Much of the accumulating evidence for the various types of injury induced by CEDs comes from the peer-reviewed clinical literature; inevitably, these injuries have been associated with use of TASER® brand devices due to their almost ubiquitous penetration of the law enforcement market. However, irrespective of the brand of CED, and in order that the breadth of potential injuries attributable to CED use is brought to the widest possible audience, it is vital that clinicians endeavour to publish case
reports when encountering patients in whom there is a suspicion that morbidity may be linked to these increasingly popular devices (Payne-James, Sheridan and Smith, 2010).


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


   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).


   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 %).


   a. “The resulting current level indicated at the heart muscle was 1/5 the level considered the threshold for triggering ventricular fibrillation.”

   b. “…no medical research has yet demonstrated pathophysiological cardiac effects arising from ECD application …”
c. “Applying this charge density threshold to the ECD simulation results, we obtained safety margins for ECD as up to 5-fold for a male and up to 2.5-fold for a female for a front ECD application.”


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

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

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

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


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


a. “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.”

b. IV Summary. “… The effect on cardiovascular system has been the main stem of investigations with no conclusive results. Decrease in overall mortality
and morbidity is the main benefit of these devices in comparison to firearms, batons, pepper spray and wrestling.


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.


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. …”

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


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>
<thead>
<tr>
<th>Table 5: Mechanisms of Electrically-Induced Ventricular Fibrillation (107)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanism</strong></td>
</tr>
<tr>
<td>Shock on T</td>
</tr>
<tr>
<td>Direct induction</td>
</tr>
<tr>
<td>High rate capture-induced ischemia</td>
</tr>
</tbody>
</table>
(1) Note, the term “weak” with regard to the high-rate capture-induced ischemia is 40–50% less strong than the strong current for direct VF induction.⁹

CEW Does Not Electrically Induce PEA or Asystole


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

Probability of CEW Induced Ventricular Fibrillation:

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Lead Author</th>
<th>CEW VF Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Aug. 2015</td>
<td>Panescu</td>
<td>“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.”</td>
</tr>
<tr>
<td>7</td>
<td>Nov. 2014</td>
<td>Graham</td>
<td>“Whether or not an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial”</td>
</tr>
<tr>
<td>6</td>
<td>Jan. 2014</td>
<td>Kroll</td>
<td>The demonstrated incidence of ECD-induced cardiac arrest is extremely low, if not zero. Conclusions of a connection between ECD use and cardiac arrest are speculative at best.</td>
</tr>
<tr>
<td>5</td>
<td>Oct. 2013</td>
<td>Canada</td>
<td>no “confirmation or exclusion of a clear causal link”</td>
</tr>
<tr>
<td>4</td>
<td>Mar. 2013</td>
<td>Dawes</td>
<td>no more than 0.59% (even with cardiac capture)</td>
</tr>
<tr>
<td>3</td>
<td>Aug. 2012</td>
<td>White</td>
<td>disproving the hypothesis that a CEW application anywhere on the chest presents a risk of VF</td>
</tr>
<tr>
<td>2</td>
<td>May 2012</td>
<td>Bozeman</td>
<td>0.0–0.6</td>
</tr>
<tr>
<td>1</td>
<td>Nov. 2011</td>
<td>Kroll</td>
<td>1:2,500,000 (theoretical VF risk estimate)</td>
</tr>
</tbody>
</table>


   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.”

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).


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

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

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

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


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

Swine comparative cardiac safety model. Forensic Sci Med Pathol. DOI 10.1007/s12024-013-9422-x. Published online March 30, 2013.\(^\text{10}\)

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 %.”\(^\text{11}\)

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

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


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


a. Bozeman reported that 49% (424/874) of probe-mode cases involved a probe in the chest.

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

c. “An estimated 609 of these (15%) may have had a transcardiac discharge; with no sudden deaths suggestive of cardiac dysrhythmia observed, the


97.5% confidence interval for an observed proportion of zero deaths in 609 criminal suspects with potential transcardiac CEW discharge is 0.0–0.6.”


a. “CONCLUSIONS: Sophisticated published computer models have estimated the risk of ventricular fibrillation for conducted electrical weapons. A growing body of epidemiological data has now shown that these models produced over-estimates. With the use of male body habitus data, and correcting for the differences between swine and humans the models now give a theoretical VF risk estimate of about 0.4 PPM or 1 per 2.5 million. This is consistent with the epidemiological findings to date.”
### Table 9 Prospective CEW Human Cardiac Studies

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

   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.”


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


   a. “Conclusions: Prolonged continuous CEW exposure in the setting of acute alcohol intoxication has no clinically significant effect on subjects in terms of markers of metabolic acidosis. The acidosis seen is consistent with what occurs with ethanol intoxication or moderate exertion.”
   a. “Conclusions: An apparent brief myocardial capture event occurred with the NGCEWv1. This device was not released and was redesigned. The NGCEWv2 appears to exhibit a reasonable degree of cardiac safety with frontal torso exposures and multiple probe combination configurations.”

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

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

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

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. “Conclusions: Prolonged CEW application in an exhausted human sample did not cause a detectable change in their 12-lead ECGs. Theories of CEW induced dysrhythmia in non-rested humans are not supported by our findings.”


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


a. “CONCLUSIONS: There were no cardiac dysrhythmia and interval or morphology changes in subjects who received a Taser discharge based on a 12-lead ECG performed immediately before and within 1 minute after a Taser activation.”


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

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

   a. “Human subjects exposed to a brief shock from the Taser developed significant increases in heart rate, but there were no cardiac dysrhythmias or morphologic changes. Alterations in the QT interval were observed in some subjects but their true incidence and clinical significance are unknown.”

   a. “Conclusions: In this resting adult population, the TASER X26 CEW did not affect the recordable cardiac electrical activity within a 24-hour period following a standard five-second application. The authors were unable to detect any induced electrical dysrhythmias or significant direct cardiac cellular damage that may be related to sudden and unexpected death proximal to CEW exposure. Additionally, no evidence of dangerous hyperkalemia or induced acidosis was found. Further study in the area of the in-custody death phenomenon to better understand its causes is recommended.”

**QTc Interval:**


**Epidemiological Studies – No CEW Induced Cardiac Arrhythmia:**

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


**Abstract**

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

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

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

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


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

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

   a. “Conclusions: Significant injuries related to 6 years of law enforcement CEW use [1,001 individuals] in one city were rare. A large percentage of those subjected to CEW use had diagnoses of substance abuse and/or psychiatric conditions. Most admissions after CEW use were unrelated to law enforcement restraint.”
   b. “Physiologic studies initially focused on cardiac effects. Although some researchers have found no evidence of changes in electrocardiogram tracings, echocardiographic changes, or elevations in troponin, others have reported QT prolongation, potential to induce ventricular fibrillation, case reports of direct cardiac effects, and theories of acute stress cardiomyopathy have led some experts to suggest that no conclusive results can be drawn as yet.”

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

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


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


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

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


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

Skin-to-Heart Distances in Humans:

Table 11 Skin-to-Heart Distances in Humans

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Date</td>
<td>Title</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>


   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.

Figure 1: mSHD vs. BMI

$r^2 = 0.77$

$mSHD = [ (0.12) * BMI ] - 0.19$
## Table 12 CEW VF Safety Margin – Partial Publications List

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>VF Cardiac Safety Factor</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Apr. 2014</td>
<td>“The resulting current level indicated at the heart muscle was 1/5 the level considered the threshold for triggering ventricular fibrillation.”</td>
<td>Kunz(^{12}), Journal of Forensic Sciences</td>
</tr>
<tr>
<td>19</td>
<td>Jan. 2013</td>
<td>X26 in “no VF” safety of IEC 60479 Part 2</td>
<td>Adler(^{13}), Modern Instrumentation</td>
</tr>
<tr>
<td>18</td>
<td>Mar. 2012</td>
<td>0.0–0.6[%] sudden death probability with transcardiac CEW discharge</td>
<td>Bozeman(^{14}), Journal of Emergency Medicine</td>
</tr>
<tr>
<td>17</td>
<td>Nov. 2009</td>
<td>“very large” safety margin</td>
<td>Jauchem(^{15}), Forensic Science Medical Pathol.</td>
</tr>
<tr>
<td>16</td>
<td>Sep. 2009</td>
<td>“low likelihood;” 50% probability of X26-like pulses ranged from 4 to 5 times higher</td>
<td>Beason(^{16}), Journal of Forensic Science</td>
</tr>
<tr>
<td>15</td>
<td>Sep. 2007</td>
<td>29X safety factor, “large safety factors”</td>
<td>Ideker(^{17}), Am J Forensic Med Pathol</td>
</tr>
<tr>
<td>14</td>
<td>Sep. 2007</td>
<td>30X</td>
<td>Panescu(^{18}), EMB Mag, IEEE</td>
</tr>
<tr>
<td>13</td>
<td>Feb. 2007</td>
<td>M26 &gt; 70X; X26 &gt; 240X</td>
<td>Holden(^{19}), Physics in Medicine &amp; Biology</td>
</tr>
<tr>
<td>12</td>
<td>Sep. 2006</td>
<td>No VF</td>
<td>Stratbucker(^{20}), EMBS, IEEE</td>
</tr>
<tr>
<td>10</td>
<td>Aug. 2006</td>
<td>Significant safety margin</td>
<td>Lakkireddy (cocaine)(^{22}), J Am Coll Cardiol.</td>
</tr>
<tr>
<td>9</td>
<td>Mar. 2005</td>
<td>240:1</td>
<td>U.K., Police Scientific Development Branch(^{23})</td>
</tr>
</tbody>
</table>


\(^{17}\) 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.


Risk of Cardiac Arrhythmia from CEW:

Table 13 Risk of Cardiac Arrhythmia from CEW

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


26 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.


<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Date</td>
<td>Title</td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>

   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).

   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."

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

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

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

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


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


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

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


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


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

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


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

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

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


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

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

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

d. “[E]xperiments using healthy human volunteers have found no cardiac 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.


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


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

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

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

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


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


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

a. “In the current study, the 50% probability of fibrillation level of X26-like pulses ranged from 4 to 5 times higher than the X26 itself. Relatively large variations about the X26 operating level were found not to result in fibrillation or systole. Therefore, it should be possible to design and build an X26-type device that operates efficiently at levels higher than the X26.”


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


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


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


a. “When applied to the ventricles in trains designed to mimic the discharge
patterns of the TASER devices, neither waveform induced ventricular fibrillation at peak currents >70-fold (for the M26 waveform) and >240-fold (for the X26) higher than the modelled current densities. This study provides evidence for a lack of arrhythmogenic action of the M26 and X26 TASER devices.”


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


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


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

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


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

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


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

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

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

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

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


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


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

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

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


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

Targeting of CEW to Center Mass/Chest:

Table 14 Not Stated to Avoid CEW Targeting Center Mass/Chest Table

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Jul. 2012</td>
<td>Consent Decree Regarding the New Orleans Police Department, United States of America v. City of New Orleans, United States District Court for the Eastern District of Louisiana, Case Number 12-1924, Sect. E. Mag. 2.</td>
</tr>
<tr>
<td>5</td>
<td>Jun. 2008</td>
<td>Letter from the National Association of Medical Examiners (NAME) President, Jeffrey Jentzen, M.D.</td>
</tr>
</tbody>
</table>

   a. “… About 13 percent of CEW applications impacted the chest/abdomen area in the Probe mode. Regardless of the target location of the CEW, and weight applied by an officer on the subject’s back, an adverse outcome did not result. Officer applications of the CEW correspond with the behaviors of the arrestee and the instructions and officer training for deploying the CEW. When a subject continued to resist in the prone position, the application of the Probe mode was activated more frequently than the Drive Stun mode (17% v. 3%).…” (page 6/10). (highlighting emphasis added)


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


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

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

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

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

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).


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

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


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

8. (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.


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


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


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

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


a. “Law enforcement personnel are trained to target center body mass when using CEDs. TASER® International, Inc., (a major CED manufacturer) has recently recommended a change in target zone to below the chest. TASER® Bulletin 15 states, “By simply lowering the preferred target zone by a few inches to lower center mass, the goal of achieving Neuro Muscular Incapacitation (NMI) can be achieved more effectively while also improving risk management.” The panel does recognize that CED use involving the area of the chest in front of the heart area is not totally risk-free; current research does not support a substantially increased risk of cardiac dysrhythmia in field situations from anterior chest CED dart penetrations.” Page 12.


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

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


a. PERF/DOJ do not recognize the chest/breast as a “sensitive area.”
"28. Personnel should not intentionally target sensitive areas (e.g., head, neck, genitalia)." Pg. 20.


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

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

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

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


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

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


a. “Ninety-four ECW research papers were reviewed during the preparation of this document. Seven of these received financial support from a manufacturer.”

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

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


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


a. “The primary finding that 99.75% of subjects experienced mild or no injuries represents the first assessment of the safety of this class of weapons when used by law enforcement officers in field conditions.”
b. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges. Other studies of conducted electrical weapon exposure in combination with exercise designed to simulate the physiologic effects of fleeing from or struggling with police demonstrate changes in pH, lactate, and other markers comparable to that induced by exercise of the same duration. No study has demonstrated a pathophysiologic mechanism or effect that would account for delayed deaths minutes to hours after conducted electrical weapon exposure. Findings from independent investigations have been concordant with those performed with industry support. Collectively, these data are broadly reassuring and constitute the current best understanding of the human physiologic effects of conducted electrical weapons.”

c. “The possibility of direct cardiac effects is a common concern with conducted electrical weapons. Experimental studies in human volunteers have found no cardiac dysrhythmias, ischemia, or necrosis after standard (5-second) or prolonged (15-second) conducted electrical weapon exposure. However, animal studies of conducted electrical weapon discharges in anesthetized swine have produced contradictory results. Some have shown no cardiac dysrhythmias with standard conducted electrical weapon outputs and large safety margins before dysrhythmia induction. Other studies have observed myocardial capture or ventricular dysrhythmias with standard conducted electrical weapon discharges. Extrapolation of these contradictory results to humans is problematic, and conclusive human evidence is currently lacking. Additional investigations of the dysrhythmogenic potential of conducted electrical weapons are needed in human subjects and animal models.”

20. (06/2008 Jentzen) Letter from the National Association of Medical Examiners (NAME) President, Jeffrey Jentzen, M.D.

a. “Many of you have read the recent release from the National Institute of Justice (NIJ): “Study of Deaths Following Electro Muscular Disruption: Interim Report.” As you may know over twenty-five NAME members were directly involved in this project; as members of the NIJ’s National Medical Review Panel and as literature reviewers to support the panel. Both John Hunsaker; who co-chaired the Steering Group and Steve Clark; who organized the literature review deserve special thanks for their dedication and tenacity in delivering this project which has potential impact on our forensic practice.”
b. “The report concludes that “although exposure to Conducted Energy Devices (CED) is not risk free, there is no conclusive medical evidence within the state of current research that indicates a high risk of serious injury or death from the direct effects of CED exposure.” In addition, the report suggests that “CED technology may be a contributor to ‘stress’ when stress is an issue related to cause of death.” Studies of the effects of CED’s are very limited and addition research needs to be done. Moreover, as the certifier of death, the medical examiner has a responsibility for investigation deaths associated with the deployment of CEDs by law enforcement personal.”


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

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


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


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

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

b. “Aiming point. Whenever possible, the weapon should be aimed at center body mass—that is, with the sights or laser dot between the shoulder blades—to ensure that darts make solid body contact. …” Page 4.

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

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


a. “If a series of pulses is delivered quickly in succession, it is possible that their effects could summate to change the transmembrane potential more than that caused by a single pulse (Fig. 6A). The TASER X26 delivers 19 pulses per second, which means that the onsets of successive pulses are approximately 53 ms apart. If the time constant of the cardiac membrane is 3.6 ms, 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.” Page 198.
Figure 2 Effects of multiple electrical stimuli on trans-membrane potential (Ideker 2007, pg 199)
### Partial List of Cardiac Safety Dependent Upon Swine/Human Weight/Size:

#### Table 15 Partial List of Cardiac Safety Dependent Upon Swine or Human Weight/Size

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


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

a. “Conclusions: Consistent with the literature, the susceptibility to the external induction of VF is strongly and negatively correlated with body mass. For human weights < 20 kg VF induction is possible for CEW chest exposures which include the heart between the barbs.”


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


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

b. Significant X26 CEW discharge safety factor


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

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

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

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


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

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


Cardiac Safety Dependent Upon Dart Orientation and Pig Size:


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

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

   a. No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance
   
   b. “This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”


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

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

Figure 5 Joule Comparisons 1

What Is a “joule”?

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

Automated External Defibrillator (AED): Delivers 360 joules

Infants & Children: 2–10 joules/kilogram

TASER X26: Delivers up to about 0.1 joule

Figure 6 Joule Comparisons 2

Pediatric Advanced Life Support Guidelines

Infants & Children
2–10 joules/kilogram

Example
5 kg (11 lb) Infant
10–45 joules have been found effective “with negligible adverse effects”


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

Swine Studies Review Analysis:


   a. **Conclusion** — Studies of small swine exaggerate the risks of CEWs to humans. This conclusion may be extrapolated to suggest that the use of small swine for electrical safety studies should be questioned in general.

Animal Model Differences (including Swine):


   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 ..."


   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."


   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.


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


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


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


   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.”


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

b. “swine are 3 times more sensitive — for the induction of VF” (pg 6)


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


a. “Because they have a heart-body weight ratio and general cardiac anatomy similar to that of humans, swine have been used in the testing and development of pacemakers and implantable cardiac defibrillators. However, swine have a relatively low threshold for ventricular fibrillation, in part, because their Purkinje fibers cross the entire ventricular wall, in contrast to human hearts in which these fibers are largely confined to a thin layer in the endocardium. Additionally, the cardiac impulse proceeds from the epicardium to the endocardium in swine, potentially increasing their sensitivity to externally applied electrical currents compared with humans. These differences diminish the relevance of this model for evaluating the safety of CED exposure in humans.20” Pg. 4.


Epinephrine Increases VFT:

Table 16 Zipes, 1975 Epinephrine increased VFT. (pg 111-123)

**Table 1**

<table>
<thead>
<tr>
<th>Increased RPD or decreased VFT</th>
<th>Decreased RPD or increased VFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial ischemia¹⁰-¹²</td>
<td>Epinephrine (initial ↓ VFT)¹²-¹³</td>
</tr>
<tr>
<td>Slower heart rates without ischemia¹⁰</td>
<td>Slower heart rates with ischemia¹⁰</td>
</tr>
<tr>
<td>Faster heart rates with ischemia¹⁰</td>
<td>Faster heart rates without ischemia¹⁰</td>
</tr>
<tr>
<td>Sympathetic nerve stimulation¹⁰</td>
<td>Vagal stimulation¹⁰-¹¹</td>
</tr>
<tr>
<td>Ventricular premature systoles¹⁰</td>
<td>Drugs: lidocaine,¹⁷ bretyllium,¹⁷ procainamide,¹⁷ diphenhydantoin,¹⁷ propranolol,¹⁷ quinidine,¹⁷ nitroglycerin,¹⁷ edrophonium¹⁷</td>
</tr>
<tr>
<td>Acidosis¹⁰-¹⁷</td>
<td>Amisulphurine¹⁷</td>
</tr>
<tr>
<td>Onabasin toxicity¹⁰</td>
<td>(after first 30 min following i.v. administration)</td>
</tr>
<tr>
<td>(for first 30 min after i.v. administration)</td>
<td>Digitoxis in intact dog or after stellate stimulation¹⁸-¹⁹</td>
</tr>
<tr>
<td>Digitalis with autonomic denervation or propranolol¹⁰</td>
<td>Respiratory acidosis with hypoxia¹⁰</td>
</tr>
<tr>
<td>Hypothermia¹⁰</td>
<td></td>
</tr>
<tr>
<td>Quinidine (high doses)¹⁰</td>
<td></td>
</tr>
<tr>
<td>Chloroform¹⁰</td>
<td></td>
</tr>
</tbody>
</table>

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

**Epinephrine Infusion Alone Causes Ventricular Tachycardia:**


   a. Initial VFT was 15.9 ± 1.5 mA.
   b. For 0–4 minutes after start of norepi infusion VFT went down to 11.4 ± 1.1 mA.
   c. For 4–10 minutes after start of norepi infusion VFT was 20.2 ± 1.8 mA (or an increase of 27% over baseline).

**Epinephrine – ½ Life:**

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

a. Figure 1.

*FIGURE 1* 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: 34

Swine Studies Review Analysis:


   a. Conclusion — Studies of small swine exaggerate the risks of CEWs to humans. This conclusion may be extrapolated to suggest that the use of small swine for electrical safety studies should be questioned in general.

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 35)
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 17 Six (6) instances of small pigs that experienced CEW 36 induced VF

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 2006</td>
<td>Nanthakumar</td>
<td>No VF in any instance that did not have simultaneous epinephrine infusion</td>
<td>50 kg (110 lb) [All animals weighed: 45–55 kg or 99–121 lb]</td>
<td>5, 15 s</td>
<td>6 pigs, 150 CEW discharges, 16 with simultaneous infused epinephrine (See Zipes, 1975, after initial decrease epinephrine increased VFT) 38</td>
</tr>
</tbody>
</table>


36 In this table “CEW” refers to a TASER X26 CEW at standard discharge levels.


<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep. 2007</td>
<td>Dennis³⁹</td>
<td>3–6 mo</td>
<td>29 kg (64 lb) 31 kg (68 lb)</td>
<td>80 s total 2 x 40 s</td>
<td>Ventilator off during exposures. 31 kg pig had a thoracotomy</td>
</tr>
<tr>
<td>Jan. 2008</td>
<td>Walter⁴⁰</td>
<td>3–6 mo</td>
<td>28 kg (62 lb)</td>
<td>80 s total 2 x 40 s</td>
<td>VF after first 40 s; ventilator off during exposures.</td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>Valentino⁴¹</td>
<td>3–4 mo</td>
<td>25 kg (55 lb) 36 kg (79 lb)</td>
<td>10 s</td>
<td>XP probes fully embedded</td>
</tr>
</tbody>
</table>

---


Table 18 Detailed Table of Animal Studies: Induced VF Results at 1X X26 CEW Discharge Levels

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Sep. 2003 | Stratbucker42 | 37F        | 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 | McDaniel43  | 38F        | No VF                 |                       | Significant safety factor |
| Aug. 2006 | Jauchem44   | 39F        | No VF                 | 5, 15 s               | Cocaine VF threshold study Significant X26 CEW discharge safety factor |
| Aug. 2006 | Lakkireddy45| 40F        | No VF                 | 5, 15 s               | 6 pigs, 150 CEW discharges, 16 with simultaneous infused epinephrine only one instance had VF in 16 attempts with infused epinephrine |
| Aug. 2006 | Nanthakumar46| 41F       | No VF in any instance that did not have simultaneous epinephrine infusion | 5, 15 s | 50 kg (110 lb) [All animals weighed: - 45–55 kg or - 99–121 lb]

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 2007</td>
<td>Jauchem⁴⁷</td>
<td>42F</td>
<td>No VF</td>
<td>15 s</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>47F</td>
<td>Weight: 50.8 ± 1.6 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>46–61 kg (101–134 lbs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2007</td>
<td>Valentino⁴⁸</td>
<td>No VF</td>
<td>(MK63)</td>
<td>2 x 40 s</td>
<td>10 Yucatan minipigs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lengthy EMI exposures did not cause extreme acidosis or cardiac arrhythmias</td>
</tr>
<tr>
<td>Sep. 2007</td>
<td>Dennis⁴⁹</td>
<td>3–6 mo</td>
<td>29 kg (64 lb)</td>
<td>2 x 40 s</td>
<td>31 kg pig had a thoracotomy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>31 kg (68 lb)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan. 2008</td>
<td>Walter⁵⁰</td>
<td>3–6 mo</td>
<td>28 kg (62 lb)</td>
<td>2 x 40 s</td>
<td></td>
</tr>
<tr>
<td>Feb. 2008</td>
<td>Valentino⁵¹</td>
<td>3–4 mo</td>
<td>No VF</td>
<td>5–15 s</td>
<td>Barb placement study</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weight: 15–33 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(33–73 lbs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>Valentino⁵²</td>
<td>3–4 mo</td>
<td>25 kg (55 lb)</td>
<td>10 s</td>
<td>XP probes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>36 kg (79 lb)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun. 2009</td>
<td>Kroll⁵⁴</td>
<td>3–4 mo</td>
<td>19.5 &amp; 20 kg</td>
<td>5 s</td>
<td>3.4 mm and 7.9 mm DTH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>43 &amp; 44 lbs</td>
<td></td>
<td>no induction of VF at pulse charges up to 300 μC</td>
</tr>
<tr>
<td>Apr. 2010</td>
<td>Dawes⁵⁵</td>
<td>3–4 mo</td>
<td>No VF</td>
<td>5, 15, 30, and 40 seconds</td>
<td>16 Dorset Sheep with methamphetamine</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weight: 26–78 kg (57–)</td>
<td></td>
<td>NO VF with X26 CEW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Sep. 2011 | Walcott⁵⁶   |            | No VF                 | 172 lbs)              | No VF at standard X26 CEW discharge levels at 10 millimeter dart-to-heart (DTH) distance
|           |             |            | Weight: 20–25 kg (44–55 lbs) |                       | "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 | Flaker⁵⁷    |            | No VF                 |                       | No cardiac stimulation with TASER X3 CEW |
| Mar. 2013 | Dawes (SAEM poster presentation)⁵⁹ | 56 | 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 |


### Table 1: CEW Exposure and VF Capture

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 2013</td>
<td>Dawes⁶⁰</td>
<td>55F</td>
<td>60 lbs</td>
<td>5 &amp; 10 seconds</td>
<td>a total of 354 included exposures with no recorded cases of VF. X26 and X2 CEW swine cardiac capture study model. X2 CEW had a smaller “window” of capture.</td>
</tr>
<tr>
<td>May 2013</td>
<td>Masse⁶¹</td>
<td>unk</td>
<td>No VF</td>
<td>5 &amp; 15 seconds</td>
<td>94 transcardiac discharges, 74 stimulated heart, average time for cardiac capture was 3.6 seconds; no reported 2:1 capture, VF, cardiac arrest, or lethal cardiac consequences.</td>
</tr>
<tr>
<td>May 2013</td>
<td>Hado⁶²</td>
<td>unk</td>
<td>No VF</td>
<td></td>
<td>4 anesthetized pigs. Total of 46 CEW discharges were applied. Ventricular capture was seen in 39 discharges of the total 43 discharges that captured the ventricle. “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.</td>
</tr>
</tbody>
</table>

---


⁶¹ (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.

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Age</th>
<th>Animal Weight with VF</th>
<th>CEW Exposure Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun. 2014</td>
<td>Dawes⁶³</td>
<td>unk</td>
<td>No VF 81–85 pounds</td>
<td>5 seconds</td>
<td>144 CEW exposures 63 exposures with cardiac capture no cases of VF.</td>
</tr>
<tr>
<td>Aug. 2014</td>
<td>Koerber⁶⁴</td>
<td>unk</td>
<td>No VF 25, 25, 68, &amp; 71 kg</td>
<td>160 CEW exposures</td>
<td>Highest capture rate: 239 BPM The TASER X3 CEW did not result in cardiac stimulation in small or large pigs. [Also, note, the X3 CEW’s waveform and output are similar to those of the TASER X2 and X26P CEWs.]</td>
</tr>
<tr>
<td>Mar. 2018</td>
<td>Werner⁶⁵</td>
<td>3-5 mo.</td>
<td></td>
<td></td>
<td>60-86 kg No myocardial dysfunction (“cardiac stunning”)</td>
</tr>
</tbody>
</table>


X26/X2 CEWs Comparative Cardiac Capture Safety Study:


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

   b. 160 CEW exposures

      (1) Highest capture rate: 239 BPM

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

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


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

      (1) TASER X2 CEW:

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

         (b) 2 resulted in partial capture

      (2) Karbon Arms MPID CEW:

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

         (b) 10 resulted in partial capture

   b. Probabilities:

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

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

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


a. “… In our estimates, the risk of VF based on this data is no more than 0.29 %. The consensus panel estimated the risk of death in a TASER-related incident to be no more than 0.25 %, in close agreement. Even with cardiac capture, the risk of VF from our data was no more than 0.59 %.”67

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

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

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

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

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


model. (John Webster, Ph.D. has had similar experiences with the swine model.\textsuperscript{68})

\textsuperscript{68} Russell v. Wright, Case No. 3:11-cv-00075-GEC, U.S. District Court, Western Division of Virginia, Charlottesville 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 19 DTH distances in swine cardiac effects.

<table>
<thead>
<tr>
<th>Pub. Date</th>
<th>Lead Author</th>
<th>Animal Weight</th>
<th>DTH Distances</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun. 2014</td>
<td>Dawes(^{69})</td>
<td>81–85 lbs</td>
<td>-3.4–18.0 mm</td>
<td>No VF. No capture &gt; 257 bpm.</td>
</tr>
<tr>
<td>Mar. 2013</td>
<td>Dawes(^{70})</td>
<td>84–85 lbs</td>
<td>2.7–25.2 mm</td>
<td>No VF. No capture &gt;313 bpm.</td>
</tr>
<tr>
<td>Sep. 2011</td>
<td>Walcott(^{71})</td>
<td>44–45 lbs</td>
<td>10 mm</td>
<td>No VF</td>
</tr>
<tr>
<td>Jun. 2009</td>
<td>Kroll(^{72})</td>
<td>43–44 lbs</td>
<td>3.4 &amp; 7.9 mm</td>
<td>No VF at pulse charges up to 300 μC</td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>Wu(^{73})</td>
<td>121–149 lbs</td>
<td>2–8 mm</td>
<td>VF through pre-bored hole to heart</td>
</tr>
<tr>
<td>Apr. 2008</td>
<td>Lakkireddy(^{74})</td>
<td>61–91 lbs</td>
<td>12–23 mm(^{75})</td>
<td>No VF. Significant VF safety margin.</td>
</tr>
<tr>
<td>Jul. 2006</td>
<td>Lakkireddy(^{76})</td>
<td>59.1–81.6 lbs</td>
<td>12.3–16.5 mm(^{77})</td>
<td>No VF. Significant VF safety margin.</td>
</tr>
<tr>
<td>Jun. 2003</td>
<td>Stratbucker(^{78})</td>
<td>92–158 lbs</td>
<td></td>
<td>No VF. Probes on sensitive areas of thorax. &gt;20X VF safety factor.</td>
</tr>
</tbody>
</table>


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

   (1) -3.4 to 18.0 mm DTH distances.

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

   (1) TASER X2 CEW:

---


\(^{75}\) Personal communication. Review of Lakkireddy’s study’s raw data.


\(^{77}\) Personal communication. Review of Lakkireddy’s study’s raw data.

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

<table>
<thead>
<tr>
<th>Subject 1 (a)</th>
<th>Subject 2 (b)</th>
<th>Subject 3 (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>STH (cm)</td>
<td>DTH (mm)</td>
</tr>
<tr>
<td>-1</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>-2</td>
<td>2.38</td>
<td>10.8</td>
</tr>
<tr>
<td>1</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>2</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>3</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>4</td>
<td>2.48</td>
<td>11.8</td>
</tr>
<tr>
<td>5</td>
<td>1.91</td>
<td>6.1</td>
</tr>
<tr>
<td>6</td>
<td>1.95</td>
<td>6.5</td>
</tr>
<tr>
<td>7</td>
<td>1.63</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>1.62</td>
<td>3.2</td>
</tr>
<tr>
<td>10</td>
<td>nv</td>
<td>nv</td>
</tr>
<tr>
<td>11</td>
<td>2.05</td>
<td>7.5</td>
</tr>
<tr>
<td>12</td>
<td>2.13</td>
<td>8.3</td>
</tr>
<tr>
<td>13</td>
<td>2.79</td>
<td>14.9</td>
</tr>
<tr>
<td>17</td>
<td>2.47</td>
<td>11.7</td>
</tr>
<tr>
<td>18</td>
<td>3.05</td>
<td>17.5</td>
</tr>
<tr>
<td>23</td>
<td>5.93</td>
<td>N/A</td>
</tr>
</tbody>
</table>


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

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

c. For the 13 mm XP steel dart:

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

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

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

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

d. Cardiac capture ratio:

(1) Mean 232 BPM 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 21 2013 Dawes 2013 Swine Study – Fig. 2a–d. STH / (calculated) DTH Distances.

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

Table 22 2013 Dawes Swine Study – Fig. 5a–c. STH / (calculated) DTH Distances.

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


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

Figure 7 Walcott 15 cm probe.

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


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

b. 3.4 mm and 7.9 mm DTH.

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


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

b. Probes:

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

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


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

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

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

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


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

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

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


a. Swine weighed 92–158 pounds.

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

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

Swine CEW Drive Stun and Dart Separation Research:

Table 26 Swine CEW Drive Stun and Dart Separation Research

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


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

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

c. “Interestingly, there were two transcardiac discharge vectors which did not result in capture of ventricular rhythm. For one of these, both darts were taped to the skin surface, not penetrating the epidermis, and the current emitting dart was on the abdomen (vector 10 left abdomen). Some cardiac
d. “Ventricular Capture did not Require Skin Penetration of Darts
Interestingly, for two of the vectors studied (vectors 10 and 11), the darts did not penetrate the skin but a 75% capture rate was nonetheless observed. For vector 10, the darts were both laid flat on and taped to the skin with one dart on the right chest and the other over the left upper abdomen (see Fig. 1) in an arrangement previously shown to result in 100% capture. 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 tasering or the drivestun mode, where the discharge is delivered by laying the TASER gun directly in contact with the skin? In these situations, no barbs are deployed into the human subject and thus, it would be much harder to create that trans-cardiac vector of electrical current.” Page 1486.


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

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


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

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

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

**Polarity Testing in Swine:**


   a. “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-

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. According to Dr. Webster, the “experience [is] one time in 100.”


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

---

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

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

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

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

Table 27 Human Body Resistances to Penetration of Electrical Current

<table>
<thead>
<tr>
<th>No.</th>
<th>Graphic Illustration</th>
<th>Illustration Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image" alt="External Anatomy" /></td>
<td>External View of Torso</td>
</tr>
</tbody>
</table>

---

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


<table>
<thead>
<tr>
<th>No.</th>
<th><strong>GRAPHIC ILLUSTRATION</strong></th>
<th><strong>ILLUSTRATION DESCRIPTION</strong></th>
</tr>
</thead>
</table>
| 2   | ![Subcutaneous Fat Layer](image1.png) | **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](image2.png) | **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](image3.png) | **Muscle Group 1 Removed**  
Platysma—neck  
Pectoralis major—chest  
Deltoids—shoulders  
Trapezius—shoulders |
No. | GRAPHIC ILLUSTRATION | ILLUSTRATION DESCRIPTION
--- | --- | ---
5 | ![Muscle Group 2 Removed](image) | **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](image) | **Muscle Group 3 Removed**
Internal Oblique–upper abdomen  
Omohyoid–neck region  
Teres major–shoulder region  
Serratus Anterior–along ribs

7 | ![Muscle Group 4 Removed](image) | **Muscle Group 4 Removed**
Intercostal Externus–along ribs  
Coracobrachialis–upper arm  
Scalenes–along neck  
Rectus Abdominis–middle abdomen
No. | **GRAPHIC ILLUSTRATION** | **ILLUSTRATION DESCRIPTION**
--- | --- | ---
8 | ![Muscle Group 5 Removed](image1) | **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
--- | ![Muscle Group 6 Removed](image2) | **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.
--- | ![Muscle Group 5 Removed](image3) | **Muscle Group 5 Removed**
   Transversus Thoracis—sternum area
   Subcostalis—ribs area
   Visible ribs, lung outer pleura, heart behind sternum
<table>
<thead>
<tr>
<th>No.</th>
<th>GRAPHIC ILLUSTRATION</th>
<th>ILLUSTRATION DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td><img src="image1" alt="Ribs 1-10 Removed from Left Side" /></td>
<td>Ribs 1-10 Removed from Left Side</td>
</tr>
<tr>
<td>12</td>
<td><img src="image2" alt="Ribs 11-12 Removed from Left Side" /></td>
<td>Ribs 11-12 Removed from Left Side</td>
</tr>
<tr>
<td>13</td>
<td><img src="image3" alt="Removal of the Parietal Pleura Surrounding the Left Lung" /></td>
<td>Removal of the Parietal Pleura Surrounding the Left Lung</td>
</tr>
<tr>
<td>No.</td>
<td>Graphic Illustration</td>
<td>Illustration Description</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>14</td>
<td><img src="image1" alt="Removal of Visceral Pleura Surrounding the Left Lung" /></td>
<td>Removal of the Visceral Pleura Surrounding the Left Lung</td>
</tr>
</tbody>
</table>
| 15  | ![Lung Showing as Transparency Revealing the Pulmonary Vessels](image2) | Lung Showing as Transparency Revealing the Pulmonary Vessels  
Note: The heart is in the pericardial sac [or pericardium] consisting of two layers.  
The pericardial sac [or pericardium] is a conical sac of fibrous tissue which surrounds the heart and the roots of the great blood vessels. |
<p>| 16  | <img src="image3" alt="Removal of Transparent Lung Revealing Pulmonary Vessels" /> | Removal of Transparent Lung Revealing Pulmonary Vessels |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>GRAPHIC ILLUSTRATION</th>
<th>ILLUSTRATION DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td><img src="image1" alt="Removal of Remaining Ribs, Sternum, and Lung Exposing Heart and Pulmonary Vessels" /></td>
<td>Removal of Remaining Ribs, Sternum, and Lung Exposing Heart and Pulmonary Vessels</td>
</tr>
<tr>
<td>18</td>
<td><img src="image2" alt="Fading of Pulmonary Vessels to Show Heart" /></td>
<td>Fading of Pulmonary Vessels to Show Heart</td>
</tr>
<tr>
<td>19</td>
<td><img src="image3" alt="Removal of Pulmonary Vessels to Completely Show Heart" /></td>
<td>Removal of Pulmonary Vessels to Completely Show Heart</td>
</tr>
</tbody>
</table>
Biomarkers/Respiration/Risks

Meta-Analysis Human Data (Adrenergic, Metabolic, Respiration):


   a. **Conclusions** Thorough review and meta-analyses show that electrical weapon exposures have mixed and mild adrenergic effects. Ventilation is increased and there are metabolic changes similar to mild exercise.

Sham CEW Discharge:


   **Study Objectives:** Law enforcement and out-of-hospital care personnel often confront violent and dangerous individuals who must be restrained for safety purposes as well as to allow for assessment and treatment. Many are under the influence of drugs and law enforcement officers may need to use an electronic control device like a TASER to gain control. However, these techniques have been reported to increase stress on an individual, potentially worsening their physiologic condition. The purpose of this study was to investigate the specific psychological effects of anticipating vs not anticipating a TASER activation on stress biomarkers in exercised and restrained human subjects.

   **Methods:** We performed a randomized, crossover controlled trial to study stress associated with exercise, physical exhaustion, and restraint with and without an induced psychological stress simulating the field use of a TASER event in human volunteer subjects. Subjects were consented that they would be receiving a TASER activation. Each subject performed two trials each consisting of a brief period of intense exercise on a treadmill to physical exhaustion followed by placement into the hogtie restraint position with and without induced psychological stress. The psychological stress consisted of a TASER brandished and sparked in front of them, followed by shouting the words “Taser, Taser,” followed by a pulling of the trigger to activate the TASER without actual application of the electrical shock to the subject. We collected blood samples for analysis pre and post exercise, as well as 10 minutes after completion of the exercise and sham TASER. Hormones and stress markers measured included cortisol, copeptin, orexin A, dynorphin,
oxytocin, neuropeptide Y, dopamine, norepinephrine, and cortisol-ACTH ratio. Means and standard deviations (SD) are presented compared between and within groups.

**Results:** In the table. Numbers are mean values with standard deviations in parenthesis. We identified differences within and between study groups for the biomarkers measured.

**Conclusions:** In this limited study, during a brief period of intense exercise and restraint followed by the psychological stress of a sham TASER application, there were some differences in the markers measured. These differences need to be studied further.

<table>
<thead>
<tr>
<th>Compound measured</th>
<th>Pre-EX</th>
<th>Post-Ex</th>
<th>Post-Res</th>
<th>Pre-EX Taser</th>
<th>Post-Ex Taser</th>
<th>Post-Res Taser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortisol (ng/ml)</td>
<td>70.47</td>
<td>73.97</td>
<td>75.64</td>
<td>109.41</td>
<td>104</td>
<td>88.21</td>
</tr>
<tr>
<td>(38-102.7)</td>
<td>(36-111.9)</td>
<td>(52-99)</td>
<td>(78.7-140)</td>
<td>(70.8-137)</td>
<td>(49.5-127)</td>
<td></td>
</tr>
<tr>
<td>Coppeptin (ng/ml)</td>
<td>1.77</td>
<td>1.68</td>
<td>1.32</td>
<td>0.91</td>
<td>1.36</td>
<td>1.74</td>
</tr>
<tr>
<td>(1.40-2.15)</td>
<td>(1.21-2.16)</td>
<td>(0.99-1.64)</td>
<td>(0.69-1.14)</td>
<td>(0.73-1.99)</td>
<td>(1.30-2.18)</td>
<td></td>
</tr>
<tr>
<td>Orexin A (pg/ml)</td>
<td>20.95</td>
<td>22.06</td>
<td>20.34</td>
<td>24.63</td>
<td>24.42</td>
<td>16.23</td>
</tr>
<tr>
<td>(10-31.9)</td>
<td>(11.6-32.6)</td>
<td>(8.1-32.6)</td>
<td>(10.7-38.5)</td>
<td>(12.2-36.6)</td>
<td>(7.1-25.4)</td>
<td></td>
</tr>
<tr>
<td>Dynorphin (pg/ml)</td>
<td>3.20</td>
<td>2.82</td>
<td>2.55</td>
<td>4.86</td>
<td>3.61</td>
<td>3.62</td>
</tr>
<tr>
<td>(0.7-7.7)</td>
<td>(0.6-5.1)</td>
<td>(0.9-4.2)</td>
<td>(0.3-9.4)</td>
<td>(1.2-6.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxytocin (pg/ml)</td>
<td>49.7</td>
<td>46.47</td>
<td>49</td>
<td>52.86</td>
<td>51.08</td>
<td>51.59</td>
</tr>
<tr>
<td>Neuropeptide Y (pg/ml)</td>
<td>102.32</td>
<td>83.75</td>
<td>65.70</td>
<td>68.65</td>
<td>68.19</td>
<td>79.23</td>
</tr>
<tr>
<td>(66-139)</td>
<td>(60-107)</td>
<td>(48-83)</td>
<td>(36-101)</td>
<td>(46-90)</td>
<td>(59-100)</td>
<td></td>
</tr>
<tr>
<td>Dopamine (ng/L)</td>
<td>15.55</td>
<td>17.58</td>
<td>17.67</td>
<td>19.58</td>
<td>19.42</td>
<td>15.61</td>
</tr>
<tr>
<td>(3.4-27.7)</td>
<td>(6.9-28.3)</td>
<td>(9.26-3)</td>
<td>(5.5-33.7)</td>
<td>(5.8-33.1)</td>
<td>(8.6-22.6)</td>
<td></td>
</tr>
<tr>
<td>Norepinephrine (ng/ml)</td>
<td>24.39</td>
<td>20.64</td>
<td>17.71</td>
<td>24.06</td>
<td>21.03</td>
<td>16.93</td>
</tr>
<tr>
<td>(11.1-37.7)</td>
<td>(7.9-33.4)</td>
<td>(8.2-27.2)</td>
<td>(14.1-34.0)</td>
<td>(9.7-32.3)</td>
<td>(9.6-24.3)</td>
<td></td>
</tr>
<tr>
<td>Cortisol/ACTH ratio</td>
<td>1.76</td>
<td>1.89</td>
<td>1.12</td>
<td>1.8</td>
<td>1.47</td>
<td>1.51</td>
</tr>
<tr>
<td>(0.35-4)</td>
<td>(0.2-3.58)</td>
<td>(0.2-1.96)</td>
<td>(0.58-3.02)</td>
<td>(0.55-2.39)</td>
<td>(0.3-0.3)</td>
<td></td>
</tr>
</tbody>
</table>

**Muscle Contractions:**


**Development of Smart Weapons Motor-Nerve Mediated Effectiveness:**

1. TASER human testing to validate the effectiveness of the X26(E) CEW was performed with electrodes taped on the outside of clothing, delivering ≈ 50
microcoulombs (µC) of charge. This level of charge was determined to be effective against highly motivated subjects including TASER’s former Chief Instructor Hans Marrero, retired chief instructor of hand-to-hand combat for the United States Marine Corps. The next generation TASER Smart Weapons (X3, X2, and X26P CEWs) were designed to have a slightly higher output, at 63 ± 9 µC. This level was chosen such that there was a small additional buffer above the minimum output of the X26(E) CEW to ensure the CEWs remained above the 50 µC threshold for effective incapacitation. In extensive human testing, TASER has validated that this charge level causes incapacitation and has similar take down power to the X26(E) CEW.

2. Subjects cannot walk through the Smart weapons' charge. To appropriately measure comparables, the AIR TASER 34000 effectively delivered ≈ 25 microcoulombs (µC), and not 70 µC. For the AIR TASER 34000, the charge in the primary phase is ≈ 25 µC. It is the charge in the primary phase that is most relevant to causing peripheral motor-nerve stimulation. The charge in the entire pulse (including both positive and negative phases) is ≈ 70 µC, but the positive and negative oscillations tend to cancel each other out, hence they are not relevant for the purpose of stimulating motor nerves. Although the average person cannot “walk through the AIR TASER” effects, some focused, motivated and/or pain-resistant subjects (under hard narcotics) could overcome the effects and conduct coordinated action causing slight impairment instead of incapacitation. This led to the development of a new pulse waveform for the TASER M26 CEW, which was the first electronic weapon to deliver more than 50 µC in the primary phase of the pulse, causing motor-nerve stimulation and resulting in incapacitation. Similarly, the Smart Weapons deliver 63 ± 9µC, also above this 50 µC threshold.
Muscular Disruption Units (MDUs) [2002–2008]:

1. The Muscular-Disruption Unit (MDU) test used in 2002 during development of the X26(E) CEW was based on the 4-limb muscle-strain measurement in swine. This was used as an approximation for the ability to incapacitate human beings. In developing the Smart Weapons, circa 2010, TASER had progressed to human-subject motivation testing using human volunteers so that TASER could test the actual incapacitation, under medical supervision, of human subjects trying to attain a goal. These human tests are a significantly more realistic test protocol - testing actual incapacitation of human subjects. Hence, TASER did not rely upon swine 4-limb muscle strain measurements as we had transitioned to a more realistic testing methodology.

a. MDU information was included in TASER Training Versions 10.1 (November 2003) through 14.2 (August 2008).
Figure 11 MDUs, TASER Training Version 14.2 (Aug. 2008)

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

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

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

**No/Mild Clinically Significant Biochemical/Physiologic Changes:**


   a. **Conclusions** Thorough review and meta-analyses show that electrical weapon exposures have mixed and mild adrenergic effects. Ventilation is increased and there are metabolic changes similar to mild exercise.


   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].


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


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


   a. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.”

   b. “Other studies of conducted electrical weapon exposure in combination with exercise designed to simulate the physiologic effects of fleeing from or struggling with police demonstrate changes in pH, lactate, and other markers comparable to that induced by exercise of the same duration.”

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


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


   a. “Although we cannot draw conclusions about the individual devices included in this analysis, our findings indicated that multiple contact points or exposures may result in a larger increase in CK, but the duration of the exposure does not appear to have a significant effect on CK. There is a correlation between the distance between the probes and the change in CK.”
(Lactate) No Clinically Relevant Lactate from Short-Duration (≤ 45 s) CEW Discharge:


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


   a. **Conclusions** Thorough review and meta-analyses show that electrical weapon exposures have mixed and mild adrenergic effects. Ventilation is increased and there are metabolic changes similar to mild exercise.


   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 following exposures less than 45 seconds.” Page 27.


   a. “A rapidly evolving body of literature has examined a range of physiologic and cardiovascular effects of conducted electrical weapon exposure in human volunteers (Table 6). These studies, which include articles and published preliminary reports in abstract form, demonstrate no evidence of dangerous respiratory or metabolic effects using standard (5-second), prolonged (15-second), and extended (up to 45-second) conducted electrical weapon discharges.”


   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 28 CEW exposure blood pressure

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

Number of CEW Discharges: Multiple and Prolonged CEW Discharges:


“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.**


   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).


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

c. “Most multiple or prolonged Taser deployments involve people from “medically vulnerable or at-risk” groups who are displaying violent behavior”

No Evidence of Negative Effects with CEW Extended Duration Discharge:


   a. “The medical risks of repeated or continuous CED exposure beyond the [45 second] durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.

   b. “Studies examining the effects of extended exposure in humans to CEDs are limited to humans exposed to less than 45 seconds.” Page 27.

   c. “ … [E]xperiments using healthy human volunteers have found no cardiac 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, from continuous activations of greater than 15 seconds, as few studies have reported on longer time frames.” Page viii.


   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.

   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.”


   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, pCO₂, HCO₃, 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.


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.”


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):

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

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

Multiple Simultaneous CEW Discharges:

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

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

a. “**Methods:** This was a prospective, observational study of human subjects. A master instructor shot subjects with a TASER X3 in the anterior thorax with either one or two cartridges. Each subject received a 10-s exposure from the device. …”

b. “**Conclusions:** In our study, the respiratory, metabolic, and neuroendocrine effects were similar to previous generation devices. There was an increase in CK with more probes deployed.”


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

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


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

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


---

92 [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)
a. Abstract: “Both profound acidosis and catecholamine excess have been proposed as underlying physiologic derangements in subjects at high risk for arrest related death (ARD). In this study, the objective was to determine a level of physical exertion that is “equivalent” in terms of levels of acidosis and catecholamines to a “standard” TASER X26 exposure. Data were collected on subjects who underwent a 5-second TASER X26 exposure or a sprint of variable distances during a law enforcement training exercise. Our results show that levels of acidosis and catecholamines are less among subjects exposed to the TASER X26 than among subjects who sprinted 20 yards or more.

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

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


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


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

Serotonin:

Conclusions A full-trunk 5-s CEW exposure caused no clinically significant increase in serum serotonin. The small increase was far less than that seen with exercise. The hypothesis of CEW induced excited delirium, through increased serotonin release, was not supported by the findings of this study.

Key Points
1. A full-trunk electrical weapon exposure slightly raises serum serotonin levels.
2. The increase is less than that seen with exercise.
3. The resulting serotonin levels are within clinically normal levels.

Abstract

It has been suggested that a CEW (conducted electrical weapon) exposure could elicit a stress response that could cause ExDS (excited delirium syndrome). There are some parallels between the signs of ExDS and serotonin syndrome (SS). Electroconvulsive therapy raises serotonin levels and therefore provides a plausible link between CEW applications and elevated serotonin levels. This study was designed to determine whether a CEW exposure elevates serum serotonin. A total of 31 police academy cadets were exposed to a very broad-spread 5-s CEW stimulus from a TASER brand X26 CEW. Blood was drawn before and after the exposure and at 24 h post exposure to measure serum serotonin levels. Lactic acid and cortisol levels were also compared. Median serum serotonin levels were 30 IQR (21,46), 36 IQR (22,50), and 32 IQR (21,45) ng/mL before exposure, after exposure, and 24 h after exposure (NS by pooled comparisons). The increase from baseline to post-test serotonin (Δ median = +6, Δ mean = +2.7) ng/mL was not significant by a paired T-test (p = .29) but was significant by the Wilcoxon signed-rank test (p = .037). The increase to post-test log serotonin was not significant by a paired T-test (p = .13) but was significant by the Wilcoxon test (p = .049). All serotonin levels remained within the normal reference range of 0–200 ng/mL. Post-hoc analysis demonstrated that the study was powered to detect a ½ SD change, in log serotonin, with a 90% likelihood. With a very-broad electrode spread, CEW exposure did not significantly raise serum serotonin levels.

Catecholamines:

   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.”


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.93

(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.”


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 by 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 by 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.”


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


   a. “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:**


   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 12 Acidosis](image-url)
c. Catecholamines:

![Figure 13 Catecholamines](image)


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


   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.”


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:

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

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

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

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


   a. **ABSTRACT:** Concern has been raised over the infection risk of the TASER electrical weapon since the probes penetrate the skin. The manufacturing process produces unsterilized probes with a 5% rate of Staphylococcus aureus contamination. Voluntary recipients (n = 208) of probe exposures were surveyed and there were no self-observations of infection. With over 3.3 million probe landings, there have been 10 case reports of penetrations of sensitive tissue with no reported infections. The electrical field was modeled and found that the electrical pulses generate a field of over 1200 V/mm on the dart portion. This is sufficient to sterilize the dart via electroporation. Electrical weapon probes appear to have a very low (possibly zero) rate of infection. The factors leading to this low infection rate appear to be a manufacturing process producing a low rate of bacterial contamination and the pulses sterilizing the dart via electroporation.


CEW – Skin Tissue in Pigs


Pneumothorax – CEW Induced


CEW Probe Penetration Depths into Human Skull Phantoms

Neurocognitive Effects

Memory Studies:


OIS Memory Concerns in Reporting Procedures:


OIS Threat-Induced Errors:


Electronic Weapons Neurocognitive Studies:

Statement from TASER:

One: “The Kane and White conclusions rely on an unrealistic comparison scenario, emphasizes a few measures, and ignores others, does not fairly recognize that the punching bag group which, again, is unrealistic, also had decrements in performance and may have had a slower recovery in some measures, over relies on non-objective self-reporting, and uses small statistical differences on
some limited cognitive batteries to generalize to a statement about understanding consequences."

Two: "We feel the Dawes, et al. study better addresses the issue and that all use of force, as well as other stressors (fear of arrest, etc.), can affect some areas of neurocognition as part of a general stress response, but that this does not necessarily extrapolate to an ability to understand consequences and the Miranda warning."

Details:
Drs. Kane and White’s current study compared a 5-second TASER exposure to 30 seconds of punching a heavy bag, and found a statistically (not necessarily important) greater decrement in performance in a few of the tested cognitive measures in the TASER group compared to the punching bag group. In fact, the TASER group showed improvements in some of the measures immediately after the exposure, and, in fact, there were measures in which the TASER had a faster recovery than the punching bag group. The conclusions of the authors over-emphasizes a few measures, does not fairly recognize that the punching bag groups also had decrements in performance and may have had a slower recovery in some measures, and over relies on non-objective self-reporting.

The authors make a giant leap by generalizing these findings to the broader question of a suspect understanding a Miranda warning. In their first figure, they present the average number of words recalled on testing. First, the control group, which had no intervention, had a drop. Second, the range between the groups was 22-26 remembered words. It is very difficult to take a few word score differences and generalize that to the understanding of the Miranda warning.

Furthermore, 30 seconds of punching a heavy bag, which is highly effort dependent, causes no pain or stress over the exertion itself. In a study by Dawes, et al., previously published, several use of force scenarios were compared to a TASER exposure. These scenarios included a fight scenario, sprinting, pepper spray and a K-9 search and bite scenario. In this study, there was no statistical difference between the groups and the authors concluded that the decrement in cognitive testing post scenario represented a generalized stress response. In the Dawes, et al. paper, the fight scenario involved 45 seconds of fighting with an opponent, creating a much more realistic scenario than college students punching a heavy bag. The Kane and White conclusions rely on an unrealistic comparison scenario, emphasizes a few measures, and ignores others, does not fairly recognize that the punching bag group, which, again, is unrealistic, also had decrements in performance and may have had a slower recovery in some measures, over relies on non-objective self-reporting, and uses small statistical differences on some limited cognitive batteries to generalize to a statement about understanding consequences.
We feel the Dawes, et al. study better addresses the issue and that all responses to resistance, as well as other stressors (fear of arrest, etc.), can affect some areas of neurocognition as part of a general stress response, but that this does not necessarily extrapolate to an ability to understand consequences and the Miranda warning.

Reference Papers/Materials:


Abstract:

While the physiologic effects of conducted electrical weapons (CEW) have been the subjects of numerous studies over nearly two decades, their effects on neurocognitive functioning, both short-term and long-term, have only recently been studied. In a 2014 study involving use-of-force scenarios, including a CEW scenario, we found that there was a decline in neurocognitive performance immediately post-scenario in all groups; however this effect was transient, of questionable clinical/legal significance, not statistically different between the groups, and, returned to baseline by one hour post-scenario. Two subsequent studies by other authors have also found transient neurocognitive effects in the immediate post-exposure period; however, in one study, the effect was greater in one measure (of 5) for the CEW compared to exertion, and the authors suggested that this effect could have implications for the Miranda waiver obtained before custodial interrogation as well as consent.

In our current study, we compared the neurocognitive effects of an exposure to a CEW to another exertion regimen, as well as to alcohol intoxication given the latter has significant established case law with regard to the Miranda waiver and consent. Such a comparison may offer more insight into the clinical/legal significance of any measured changes. As with the prior studies, the neurocognitive performance decrements of the CEW and exertion regimens, found only in one measure in this study (of three), were transient, and here, non-significant. Only alcohol intoxication resulted in statistically significant performance declines across all measures and these were persistent over the study period. Given that the neurocognitive changes associated with the CEW were nonsignificant, but were significant for alcohol intoxication, and given that current case law does not use intoxication as a per se or bright line barrier to Miranda and consent, our results do not
suggest that a CEW exposure should preclude waiving of Miranda rights or obtaining consent.


   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.”


a. “Conclusions The questions driving this study involve serious issues including constitutionally protected rights of the accused, use of force by police, and previously unexamined effects of the TASER on the human body. The pilot study represents a critical first step in exploring the effects of the TASER on cognitive functioning. Moreover, the results provided the authors with important information that will guide their larger study, a randomized controlled trial where healthy human volunteers will be randomly assigned to four groups, two of which receive a TASER exposure.”

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


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

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

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

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


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


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

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


a. A few quotes:

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

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

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

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

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

b. “Psychomotor function was evaluated by measuring the time elapsed between the onset of X-26 TASER® exposure and first switchbox trigger event. Response times to execute the button-press task are shown in Figure 2. Figure 2 (a) corresponds to the audio stimulus button-press response times (n=7); a reduced number but sufficient for characterizing the baseline response because of tight grouping of the data, and consultation with a statistician has confirmed that this data has sufficient power to establish confidence. Mean baseline response time of the control set was 0.98 (±0.25) seconds. Figure 2 (b) depicts a distribution of the response times to execute the psychomotor task in the presence of the X-26 TASER® stimulus (n=30). Two subjects were excluded due to data acquisition failures. Mean response time with the X-26 TASER® exposure was 6.06 (±0.91) seconds; two subjects were able to execute the task during the exposure period; response times for these individuals were 2.56 seconds and 4.59 seconds. A comparison of the response times for these two groups is shown in Figure 2 (c). The average time taken to press the button after start of X-26 TASER® stimulus minus the average time taken to press the button after start of audio stimulus is 5.08 seconds which is roughly equal to the duration of TASER stimulus (5 sec).”
c. “Mean response time to execute the test once exposure ended was 1.14 (±0.85) seconds and is shown in Figure 3 (b) (n=30). The negative time delays correspond to the two subjects able to trigger the switchbox before the five-second application ended. Figure 3 (c) compares the data with baseline. The average difference in response time from baseline is 0.16 seconds. The ability to press the button after the X-26 TASER® stimulus ended is roughly the same as the ability to press the button after an audio stimulus.”

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

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

CEW Recovery Time


Abstract

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

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

**Results** The response time after the audio trigger was $1.05 \pm 0.25$ s; the median was $1.04$ s (range $0.69$–$1.34$ s). For the paired CEW triggered group the mean response time was $1.41 \pm 0.61$ 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 $1.27 \pm 0.58$ s with a median of $1.19$ s (range $0.31$–$2.99$ s) (NS vs. the audio trigger).

CEW Effective Without Deployment or Application

1. United Kingdom and Australia Presence-Compliance Effectiveness:

2. Presence-Compliance Effectiveness

Figure 17: Number of times CEDs were used, by use type, England and Wales, year ending March 2018

85,100 Total CEW Uses
- Up to 85% Non-Discharges

Figure 2: Breakdown of Taser uses (22 July 2010 to 30 June 2012)

**Results:** There were 752,138 calls for service over the 9-year period and 182 events [1:4,133] where a CEW was presented/displayed to a violent person (0.0002%). Of these, 36 results in the CEW probe deployment (19.8%) and 146 (80.2%) did not because the person de-escalated their behavior upon presentation and display of the CEW (p<0.0001). The circumstances for CEW presentation situations of imminent threat of harm to someone.

**Conclusions:** CEW use within this healthcare setting was done only when there was no other option to stop the immediate threat of harm to a person that was present. The visible presentation and display of a CEW appears to have a statistically significant effect on de-escalating violent behavior of persons within a healthcare facility overall.


**Table 29 UK Police Use of CEWs Statistics, England and Wales 2010-1015**

<table>
<thead>
<tr>
<th>Type</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Numeric change between 2014 to 2015</th>
<th>% change between 2014 to 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawn</td>
<td>1,325</td>
<td>1,568</td>
<td>1,684</td>
<td>2,497</td>
<td>2,212</td>
<td>2,445</td>
<td>233</td>
<td>11%</td>
</tr>
<tr>
<td>Aimed</td>
<td>341</td>
<td>388</td>
<td>345</td>
<td>481</td>
<td>549</td>
<td>819</td>
<td>70</td>
<td>13%</td>
</tr>
<tr>
<td>Arced</td>
<td>228</td>
<td>314</td>
<td>292</td>
<td>297</td>
<td>122</td>
<td>108</td>
<td>-16</td>
<td>-13%</td>
</tr>
<tr>
<td>Red-dot</td>
<td>3.284</td>
<td>3.795</td>
<td>3.831</td>
<td>5.105</td>
<td>5.222</td>
<td>5.238</td>
<td>16</td>
<td>0%</td>
</tr>
<tr>
<td>Total non-discharge</td>
<td>5,178</td>
<td>6,045</td>
<td>6,216</td>
<td>8,350</td>
<td>8,105</td>
<td>8,408</td>
<td>303</td>
<td>4%</td>
</tr>
<tr>
<td>Drive stun</td>
<td>229</td>
<td>308</td>
<td>313</td>
<td>247</td>
<td>145</td>
<td>104</td>
<td>-41</td>
<td>-28%</td>
</tr>
<tr>
<td>Angled drive stun</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>111</td>
<td>87</td>
<td>-24</td>
<td>-22%</td>
<td>-22%</td>
</tr>
<tr>
<td>Wired</td>
<td>1,239</td>
<td>1,506</td>
<td>1,620</td>
<td>1,733</td>
<td>1,733</td>
<td>1,730</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total discharge</td>
<td>1,468</td>
<td>1,818</td>
<td>1,940</td>
<td>2,020</td>
<td>1,899</td>
<td>1,921</td>
<td>-58</td>
<td>-3%</td>
</tr>
<tr>
<td>Not stated</td>
<td>3</td>
<td>14</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>100%</td>
<td>-100%</td>
</tr>
<tr>
<td>Total</td>
<td>6,649</td>
<td>7,877</td>
<td>8,161</td>
<td>10,380</td>
<td>10,095</td>
<td>10,329</td>
<td>234</td>
<td>2%</td>
</tr>
</tbody>
</table>

Notes:
Caution should be taken when comparing Taser use prior to 2014 as not all forces were able to provide a full breakdown.
2013 was the first year in which all 43 Home Office police forces in England and Wales completed the rollout of Taser to Specially Trained Units – see appendix.


a. “In summary, training seems to be a major impact factor for the use of the Taser and hence serves as a prerequisite for the awareness of the Taser as a weapon. A continuously ongoing training and professional education is
necessary in order to keep the number of situations requiring force and thus the use of Taser devices stable \((n^1 = n)\)."

b. “…It can be stated that specially trained forces fired 4–6% less shots than the average police force. This leads to a difference of 5–10% of the cases where the Taser was not discharged by trained forces. We also see a clear trend towards handling situations where no shots were required by trained forces from 76% in Q2 in 2009 up to 81% in Q1 in 2010. In contrast, the average police officer remained on a level at about 71%. Furthermore, the use of drive stun mode (contact mode without firing the electrodes into the body) was slightly less for the specially trained forces.”

c. “We also see a clear trend towards handling situations where no shots were required by trained forces from 76% in Q2 in 2009 up to 81% in Q1 in 2010. In contrast, the average police officer remained on a level at about 71%.” (highlighting emphasis added)

Table 30 Grove, Table 3 CEW use of street police compared to special trained forces

<table>
<thead>
<tr>
<th>Taser usage</th>
<th>Time</th>
<th>Uses, street police ((n = 1884))</th>
<th>Uses, special trained forces ((n = 1689))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fired</td>
<td>Q2 2009</td>
<td>101</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>Q3 2009</td>
<td>117</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>Q4 2009</td>
<td>116</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>Q1 2010</td>
<td>112</td>
<td>23%</td>
</tr>
<tr>
<td>Drive stun</td>
<td>Q2 2009</td>
<td>20</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Q3 2009</td>
<td>22</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Q4 2009</td>
<td>33</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Q1 2010</td>
<td>28</td>
<td>6%</td>
</tr>
<tr>
<td>Non-discharge</td>
<td>Q2 2009</td>
<td>296</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td>Q3 2009</td>
<td>326</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>Q4 2009</td>
<td>375</td>
<td>72%</td>
</tr>
<tr>
<td></td>
<td>Q1 2010</td>
<td>338</td>
<td>71%</td>
</tr>
</tbody>
</table>


---

a. In 2015 there were 10,329 uses of electrical weapons by police representing a 2% (234) increase on the previous year.

(1) Discharge

(a) Of the 10,329 CEW uses, 19% (1,921) were discharges; a decrease of 3% (-68) from the previous year.

(b) Of the 1,921 discharges, 90% (1,730) were fired and 10% (191) were drive-stun and angled drive-stun.

(c) The proportion of discharges decreased by one percentage point to 19% when compared with the previous year.

(2) Non-discharge

(a) Of the 10,329 uses of CEWs, 81% (8,408) were non-discharges; an increase of 4% (303) on the previous year.

(b) Red-dot (LASER sight) was the most common use and accounted for 51% (5,238) of the total use in 2015.

(c) The proportion of non-discharges (81%) increased by one percentage point when compared with the previous year.


a. Drawn – 648 out of 1944

b. Aimed – 177 out of 1944

c. Red-dotted – 872 out of 1944

d. Arced – 11 out of 1944


a. “… The most recent UK statistics available at the time of writing (Home Office, 2013) … show that, in 2011, … red-dotting accounted for nearly half (47%) of all recorded ‘uses’. …”

96 http://www.met.police.uk/taser-statistics/
b. “The most recent [UK] Home Office statistics available at the time of writing (January – July 2014) thus show that [CEWs were] used over 5,000 times in this period. According to the Home Office press release accompanying the data (Home Office 2014), the most common use of Taser in this period was ‘red dot’ (52% of overall use), …”

a. “…for every deployment made against a resistive subject there are 5 to 7 times when the mere presence or presentation of the TASER is enough to deter the suspect from starting or continuing his or her resistant behavior.” (highlighting added)

b. Suspects: “94.6% efficacy rate with no officer or suspect injuries recorded”

c. Vicious animals: “94.8% efficacy rate and no recorded officer injuries”

d. “The TASER X26' is an effective and reliable force option that is used by more than 12,500 law enforcement agencies throughout the United States. There are currently over 340,000 TASER devices deployed by law enforcement officers and private citizens throughout the country. The Oakland Police Department has deployed TASER devices since 2000. OPD has deployed 270 TASER devices to officers throughout the department. Since August 2006, OPD officers have deployed the TASER on suspects 230 times with a 94.6% efficacy rate with no officer or suspect injuries recorded. In the same time period, officers used TASER devices in 96 vicious animal deployments with a 94.8% efficacy rate and no recorded officer injuries. Anecdotally, officers verbally report that for every deployment made against a resistive subject there are 5 to 7 times when the mere presence or presentation of the TASER is enough to deter the suspect from starting or continuing his or her resistant behavior.” (page 3)
CEW Effectiveness


   a. TASER CEWs - 90.2% effectiveness rate.

   b. Of the 245 incidents where a TASER was used, in 85 of them, only a TASER was used. In the other 160 incidents, a TASER and some other force were used. In 136 of the 160 incidents, a TASER was the last type of force used. In the other 24 incidents, a TASER was deployed first but some other force ended the encounter. To calculate an effectiveness rate of TASERs, the 85 incidents that only involved a TASER and the 136 incidents where a TASER was used last are combined (85 + 136) and divided by the total number of incidents in which a TASER was used (245). This calculation results in a 90.2% effectiveness rate. Using the same parameters for calculating the it is clear that TASERs demonstrate a substantially higher effectiveness rate than OC spray.

   c. Effectiveness of OC Spray and TASERs: The only significant predictor of OC spray (in)effectiveness was subject resistance. The more a subject resisted the police, the less likely OC spray was to be effective. In particular, when OC spray was used in situations where the subject resisted, it was likely that OC spray was not the last type of force used. Either the OC spray caused additional resistance that had to be overcome with other force, or OC spray was not effective in subduing a subject who was already resisting. The model predicting TASER effectiveness was neither significant nor did any variables predict TASER effectiveness. The observed high level of TASER effectiveness may be a function of the circumstances in which TASERs are used, the amount and quality of training officers received with the TASER, as well as their limited deployment in the study department, variables that we were not able to account for in this study.

   d. With regard to the effectiveness rates of OC spray and the TASER, and congruent with previous studies, we found that the TASER was substantially more effective than OC spray. Given the research that has been conducted, it is safe to say that TASERs have inherent advantages over OC spray in their ability to incapacitate subjects.

a. Officers rated the performance of the TASER as satisfactory in 79% of cases.


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


   a. “TASERs play an important role in law enforcement. This research and this report show that electric weapons are deployed more frequently than other less-lethal weapons and tactics, but they also appear to enjoy higher success rates in conflict resolution. This success in bringing officer/suspect confrontations to an end is invaluable as it has the effect of reducing injuries to all persons in the conflict. ... The fact that TASERs offer society the best ‘set phasers on stun’ solution currently available makes them extremely appealing to police in use-of-force situations. Added to this are the many safeguards implemented by TASER International to identify when and where a TASER has been discharged. These electronic and physical tracking safeguards highly discourage improper use. In a police use of force confrontation, the most humane weapon or tactic would be one in which the resultant injury would be the least severe. While TASERs are not injury free (puncture wounds from dart probes, or skin burns from drive stuns), the alternative (broken bones from batons, burning pain from pepper spray, and potential death from firearm) makes them a preferential choice. Clearly this research has shown that electric weapons are very effective at ending conflict situations quickly, this in turn leads to less injuries to both suspects and officers.”
b. “…Early studies indicated this weapon’s effectiveness ranged from 50% - 85% (Donnelly, 2001) when deployed. In a pilot study examining a random selection of four hundred deployments, the TASER was immediately successful in 68% of the cases (Mesloh, Henych, Hougland, & Thompson, 2005). On the other end of the spectrum, this rate has been validated in a second study by White and Ready (2007) who found that 68.6% of suspects continued to resist after a TASER deployment. Some literature shows that since the TASERs deployment in 2000, the use of deadly force by officers and the number of officers injured during arrest confrontations has been dramatically reduced (Hopkins & Beary, 2003).” (page 25)

c. “In examining their relative effectiveness rates in stopping confrontations in the first iteration, canines were effective 69.8% of the time, TASERs were 69% effective, chemical agents were 64% effective, and takedowns were effective 41.4% of the time. This rate of effectiveness needs to be considered also in light of the number of cases they represent. TASER deployments represented 2,113 total cases and by far exceeded the other techniques in the number of cases. While canine deployments were statistically more successful, the total number of cases (n = 301) should to be considered.” (page 54)

d. “TASER Effectiveness in Third Iteration: The TASER, as shown in Table 24, was effective in 81.51% (n = 221) of the cases in the third iteration. Missed probes, baggy clothes, loose probes, broken wires, malfunctions, and the suspect grabbing the TASER only accounted for 5.1% (n = 14) of the TASER deployments at the third iteration. Despite these issues, TASER was still responsible for the apprehension of 271 suspects.” (page 63)

e. “In the first iteration, the TASER was 59.8% effective, in the second, the device was 68.1% effective, and in the third iteration the device was 81.5% effective. Again, these effectiveness percentages reflect the direct effectiveness based upon a deployment of electrical charge into the suspect and not surrenders based upon a “startle reflex”. In viewing the TASER as a means of ending confrontation, these percentages are significantly higher. When comparing the use of the TASER in the drive stun tactic to the deployment of probes through firing of the weapon, the drive stun was more effective in the initial iteration, although barely so in the second. Both the drive stun tactic and the probe deployment tactic gained (became more effective) in effectiveness in multiple iterations.” (page 65)
f. “When examining conflicts at the event level, this research focused on TASER’s ability to end officer and suspect confrontations. This ability is inherently a measure for their effectiveness. A total of 2395 use of force reports reported conflict ending at the first iteration. In the first iteration, TASERs were deployed 2113 times. Out of these deployments, 1459 ended the conflict at this level representing a 69% success rate at conflict resolution. In comparison, other less lethal weapon such as impact weapons represented 45% success rate, and compliance holds were successful 16% of the time, takedowns were successful in 41% of the cases, and chemical agents were 65% effective in stopping conflicts before they escalated to a higher level, or an alternative was used. While the success rates for the other less lethal may appear high, they represent fewer than does TASER.” (pages 88-89)

g. “Conclusion: 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....” (pages 92-93)

h. “Conclusion: … 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.” (page 93)
7. (05/2008 Oakland (CA) PD/Leonesio) Agenda Report, To: Office of the City Administrator, City of Oakland, California, 15 May 2008:

a. “…for every deployment made against a resistive subject there are 5 to 7 times when the mere presence or presentation of the TASER is enough to deter the suspect from starting or continuing his or her resistant behavior.” (highlighting added)

b. Suspects: “94.6% efficacy rate with no officer or suspect injuries recorded”

c. Vicious animals: “94.8% efficacy rate and no recorded officer injuries”

d. “The TASER X26' is an effective and reliable force option that is used by more than 12,500 law enforcement agencies throughout the United States. There are currently over 340,000 TASER devices deployed by law enforcement officers and private citizens throughout the country. The Oakland Police Department has deployed TASER devices since 2000. OPD has deployed 270 TASER devices to officers throughout the department. Since August 2006, OPD officers have deployed the TASER on suspects 230 times with a 94.6% efficacy rate with no officer or suspect injuries recorded. In the same time period, officers used TASER devices in 96 vicious animal deployments with a 94.8% efficacy rate and no recorded officer injuries. Anecdotally, officers verbally report that for every deployment made against a resistive subject there are 5 to 7 times when the mere presence or presentation of the TASER is enough to deter the suspect from starting or continuing his or her resistant behavior.” (page 3)


a. considered the TASER effective if it led to the “successful incapacitation” of the subject. They found that after deploying a TASER, “85% of subjects were subdued by the TASER and taken into custody” (p. 183).


a. “The probability of inducing a complete EMD ranges from 74% to 52% depending on distance to the target.”

a. “…TASERs have been demonstrated to be useful in subduing criminals by law enforcement agencies for approximately 20 years. Kornblum and Reddy (1991) reported that the TASER was effective; that is, it provided some level of control of the subject's behavior about 80% of the time when it was used by the Los Angeles Police Department. There are other anecdotal reports, mostly on the Internet, suggesting that the effectiveness is as low as 60%. …”
Officer Injuries


   a. Results:

      (1) Between 2003 and 2014, an estimated 669,100 law enforcement officers were treated in U.S. emergency departments for nonfatal injuries.

      (2) The overall rate of 635 per 10,000 full-time equivalents was three times higher than all other U.S. workers rate (213 per 10,000 full-time equivalents).

      (3) The three leading injury events were assaults and violent acts (35%), bodily reactions and exertion (15%), and transportation incidents (14%).

      (4) Injury rates were highest for the youngest officers, aged 21–24 years.

      (5) Male and female law enforcement officers had similar nonfatal injury rates.

      (6) Rates for most injuries remained stable; however, rates for assault-related injuries grew among law enforcement officers between 2003 and 2011.
Reduced Deadly Force/Injuries - Selected CEW Literature

CEWs Reduce Use of Deadly Force:

Table 31 CEWs Reduce Use of Deadly Force

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th># / % Deadly Force Justified</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Jul. 2005</td>
<td>8.1% [14 of 172]</td>
<td>Sergeant Brian A. Bruce, Six Month T[ASER ECD] Study July 5, 2005, City of Columbus, Ohio Division of Police.</td>
</tr>
</tbody>
</table>

a. 67 (26.7%) of the 249 (of the 580 total) law enforcement officers who used the TASER ECD at least once in the field stated that they have used the ECD in a situation where they would have been legally justified in using deadly force (i.e. firearm).


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


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


a. “… 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.


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


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


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


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

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


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

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 TASER 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 TASER ECD Study July 5, 2005, City of Columbus, Ohio Division of Police.

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

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


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

b. “Also, several of the instances in which TASER ECD use was threatened or the TASER 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 TASER ECD.” Page 6.


(1) 945 total TASER CEW uses

(2) 32 out of 945 where the use of deadly force was justified

(a) 1 out of 29.53125

(b) 3.38624339%


“The Orange County Sheriff’s Office Human Resource Division reported nearly an 80 percent decrease in officer related injuries in arrest situations over a two year period. The agency began utilizing the ECD in 2000. It should also be noted that the ECD has been used by Orange County deputies in 32 situations (2003-2004) where the use of deadly force was justified. Report of the Orange County Sheriff’s Office Taser Task Force, pgs. 29, 31, March 4, 2005.” (highlighting emphasis added)

**CEWs Reduce Subject Injuries:**

Table 32 CEWs Reduce Subject Injuries

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Updated</td>
<td>See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®)</td>
</tr>
</tbody>
</table>
No. | Date     | Document                                                                                                                                                                                                 |
---|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
4  | 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. |

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


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


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

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


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

   a. “ECD adoption did not result in a reduction of citizen injury claims.” Pg. 163.
   b. “[I]t was found that ECD-involved cases had a lower arrestee injury rate than non-ECD involved cases, an effect highly influenced by the ECD display only cases.” Pg. 171.

   a. “ … 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.


a. Overall findings:

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

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

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

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

b. Suspect injuries reduced:

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

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

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


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


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


   a. “The Monitoring Team also noted a significant decline in serious force-related incidents at this time. We attribute much of this decrease to the department-wide deployment of the Taser. Our review of use of force reporting and investigative files showed that the Taser replaced other types of force in the majority of incidents. Moreover, injuries to officers and citizens also declined.” Page 36.

14. (12/2008 Butler) Chris Butler, Staff Sergeant, Calgary Police Service, Christine Hall, MSc MD FRCPC, Principal Investigator, RESTRAINT Study, Department of Emergency Medicine, Vancouver Island Health Authority, Police/Public Interaction: Arrests, Use of Force by Police, and Resulting Injuries to Subjects and Officers-A Description of Risk in One Major Canadian City (Calgary Police Services, Calgary, Alberta, Canada), Law Enforcement Executive Forum, 2008.
a. “The commonly held belief that the conducted energy weapon carries a significant risk of injury or death for the population of interest is not supported by the data. Within the force modality framework most commonly available to police officers, the CEW was less injurious than either the baton or empty hand physical control. Although the study used the intention to treat analysis, when we removed the incidents where the use of the CEW was unsuccessful (n = 14) (thereby requiring subsequent alternative force options typically physical control), the safety profile of the CEW rose to 88.7% (i.e., no injury or minor injury to subjects only).”


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

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

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


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

**CEWs Reduce Officer Injuries:**

**Table 33 CEWs Reduce Officer Injuries**

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Updated</td>
<td>See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®)</td>
</tr>
</tbody>
</table>
1. See generally the current version of TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®).


   a. Abstract

   Police officers continue to sustain injuries during close proximity encounters with noncompliant and combative suspects. The purpose of this quasi-experimental study was to examine whether the use of less-lethal instruments, such as conducted energy devices, oleoresin capsicum, impact batons, and hands/feet defensive tactic reduced police officer injury during confrontations with uncooperative suspects at a medium-sized police department in a southern state. Fichtelberg’s democratic policing was used as the theoretical framework for this study. Data were acquired from Suspect Resistant Reports (n = 409) written by police officers over a 10-year period (1/05 – 12/14). The dependent variable was police officer injury and the categorically ranked independent variable was the less-lethal instrument. A significant association was found between officer injuries and less-lethal instruments using chi-square analysis (p <.0001). Cramer’s V test for strength of association was moderately strong (.371). Odds ratios revealed that the risk of injury increased by 6.5 times when hands/feet defensive tactics or impact baton were used. However, the risk of injury decreased by 10 times if conducted energy devices were used. The positive social change implications of this study include recommendations to law enforcement executives to
consider policies and procedures that reinforce the use of CEDs over other less-lethal options, especially the impact baton, which was found to be rarely deployed and risky in terms of officer injury when used. Addressing these policies may result in reductions in officer injuries and improved public safety for the community overall. (highlighting emphasis added)


   a. Abstract: “… The present study used officer injury panel data from the City of Dallas (Texas) Human Resources Department to assess the impact of a 2005 modification to the Dallas Police Department’s TASER policy. The goal of the study was to assess change in the rate of officer injury after the implementation of a more restrictive policy. We observed a modest increase in the monthly rate of police officer injuries following the policy restricting [CEW] use. …” (highlighting emphasis added)


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


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

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


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


a. “[W]e may conclude that the adoption of ECD did indeed reduce the rate of officer injury to a noteworthy extent.” Pg. 163.

b. “[T]he evidence is rather convincing that the adoption of electronic control devices by the agency has led to fewer injuries to officers resulting from officer-arrestee confrontation.” Pg. 171.

a. “… 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.”


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.”


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

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

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

b. Officer injuries reduced:

(1) “For agencies that deploy CEDs, our data suggest that the odds of an officer being injured are reduced by over 70%.” Pg. 4.

(2) “Also, for our CED-only site analyses, when officers actually use CEDs our data suggest that there is a 76% reduction in officer injuries.” Pg. 4.

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

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

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


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


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

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

Table 34 CEWs Are Associated with Less Injury Than “Physical Force”

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Aug. 2012</td>
<td>Hagans v. Franklin County Sheriff’s Office, 695 F.3d 505, 510 (6th Cir. (Ohio) Aug 23, 2012); quoting the May 24, 2011 NJ/Laub study</td>
</tr>
</tbody>
</table>

- A conclusion: CEW use was the force modality least likely to result in significant injury.
- No significant injuries occurred among 504 CEW uses (0%; 95% CI 0.0–0.9%).
  - There were no significant injuries after 504 CEW uses (0%; CI 0.0–0.9%) and 88 chemical weapon uses (0%; CI 0.0 – 5.0%).
- Unarmed physical force resulted in over one third (6/16) of the significant injuries seen in this series. These were evenly distributed among "soft" and "hard" unarmed physical force and included major head injuries and bony fractures.
- Unarmed physical force and CEW use were the two most common force modalities used, representing 50.8% and 36.0% respectively and 86.8% combined. Traditional intermediate force options such as pepper spray and impact weapons were not commonly used, representing 6.3% and 0.6% of force utilizations. Firearms were used in 0.4% of force utilizations (n=6 cases).
- The large majority of UOF cases in this series use lower levels of force such as unarmed physical force and CEWs. This reflects modern police practice in the United States as many agencies now equip some or all of their officers with CEW’s. These tools have been associated with lower rates of use of other force options such as OC spray, impact weapons, and firearms, and in lower injury rates among both suspects and officers. 6,17,18
While serious injuries and fatalities have occurred after CEW use, this is rare. With over 500 uses resulting in no significant injuries, these data suggest that CEW use is the force option least likely to result in significant suspect injury. This finding is consistent with prior epidemiology studies of CEW use.


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

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


   a. “[T]he relative risk of CED deployments appears to be lower than other use-of-force options.” Page 3.
   
   b. “The risks of cardiac arrhythmias or death remain low and make CEDs more favorable than other weapons.” Page 10.
   
   c. “All evidence suggests that the use of CEDs carries with it a risk as low as or lower than most alternatives.” Page 24.
   
   d. “CED use is associated with a significantly lower risk of injury than physical force, so it should be considered as an alternative in situations that would otherwise result in the application of physical force.” Page 31.

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


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

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

c. Rates of injury (ROI) per 100,000 population included:
   – CED ROI 2.8 per 100,000 (95% CI was “1.4 to 4.2”)
   – Physical contact w/officer ROI 17.6 per 100,000 (95% CI or 13.6 to 21.6)

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


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

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

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.


(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.


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


a. Overall findings:

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

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

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

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

b. Officer injuries reduced:

(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.


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.”


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

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

TASER CEW Training:


   a. “In summary, training seems to be a major impact factor for the use of the Taser and hence serves as a prerequisite for the awareness of the Taser as a weapon. A continuously ongoing training and professional education is necessary in order to keep the number of situations requiring force and thus the use of Taser devices stable ($n^i = n$).”

   b. “…It can be stated that specially trained forces fired 4–6% less shots than the average police force. This leads to a difference of 5–10% of the cases where the Taser was not discharged by trained forces. We also see a clear trend towards handling situations where no shots were required by trained forces from 76% in Q2 in 2009 up to 81% in Q1 in 2010. In contrast, the average police officer remained on a level at about 71%. Furthermore, the use of drive stun mode (contact mode without firing the electrodes into the body) was slightly less for the specially trained forces.”

CEW Policy Studies:


   a. Abstract: “… The present study used officer injury panel data from the City of Dallas (Texas) Human Resources Department to assess the impact of a 2005 modification to the Dallas Police Department’s TASER policy. The goal of the study was to assess change in the rate of officer injury after the implementation of a more restrictive policy. We observed a modest increase in the monthly rate of police officer injuries following the policy restricting [CEW] use. …” (highlighting emphasis added)


   a. Ferdik found that agencies with less-restrictive CEW force policies experienced a two-thirds reduction (66%) in fatal suspect shootings, stating: “[A] policy or practice that allowed the use of a CED in probe, drive, or either
mode on passive resistors is substantially and significantly associated with decreases in the number of fatal police shootings.” Policies that limited CEW usage to “active” resistance were “significantly associated with increases in the number of fatal police shootings.” Ferdik at 21.

b. 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)

Public Acceptance of CEWs:


   **Abstract:** Crime is a menace to our society and pose a huge challenge to our law enforcers and society at large. It had taken a toll on valuable resources, slowed down productivity, and destroyed lives, threatened prosperity, created uncertainty and fear in every level of society. Incorrectly or mistakenly weapons often spelt trouble for the law enforcers as enshrine in Penal Code (ACT 574). The purpose of this research is to find out the public acceptance on saving lives using TASER for Royal Malaysian Police. With well-trained users, there should be no death or permanent injury to anyone shot with the TASER. As such it is a win-win situation for both law enforcers and suspects. Findings shown that there are relationship between public and police, TASER
and police, public and TASER and found to be significant. Furthermore, TASER is user friendly. Quantitative research with convenience sampling techniques was adopted and sample size of 380 responded. 93% of the public accepted the TASER to be used by police. This will make police-works more successful and give relief to law enforcers who will now be able to execute their role in upholding the law without fear of killing a wrong person or innocent bystanders and having to face the law that may works against them.”

Initial 5-Second CEW Cycle:


   a. “1. Electronic Control Weapons. [Para.] 68. ... e. After one standard ECW cycle (5 seconds), the officer shall reevaluate the situation to determine if subsequent cycles are necessary, including waiting for a reasonable amount of time to allow the subject to comply with the warning. Officers shall describe and explain the reasonableness of each ECW cycle in their use of force reports;” Page 19.


   a. “21. Personnel should use an ECW for one standard cycle (five seconds) and then evaluate the situation to determine if subsequent cycles are necessary. Personnel should consider that exposure to the ECW for longer than 15 seconds (whether due to multiple applications or continuous cycling) may increase the risk of death or serious injury. Any subsequent applications should be independently justifiable, and the risks should be weighed against other force options.” Page 20.

15-Second CEW Discharge Restrictions (or Advice):

a. “1. Electronic Control Weapons. [Para.] 68. ... f. Officers shall make every reasonable effort to attempt handcuffing during and between each ECW cycle. Officers should avoid deployments of more than three ECW cycles unless exigent circumstances warrant use;” Page 19.

i. “II. Definitions. ... [Para.] 29. “Exigent circumstances” means circumstances in which a reasonable person would believe that imminent and serious bodily harm to a person or persons is about to occur.” Page 10.

ii. “II. Definitions. ... [Para.] 58. “Serious Use of Force” means: ... (7) more than two applications of an ECW on an individual during a single interaction, regardless of the mode or duration of the application, regardless of whether the applications are by the same or different officers, and regardless of whether the ECW application is longer than 15 seconds, whether continuous or consecutive; (8) any ... ECW application ... against a handcuffed, otherwise restrained, under control, or in custody subject with or without injury; and (9) any use of force referred by an officer’s supervisor to IA that IA deems serious.” Page 14.


a. “Because the physiologic effects of prolonged or repeated CED exposure are not fully understood, law enforcement officers should refrain, when possible, from continuous activations of greater than 15 seconds, as few studies have reported on longer time frames.” Page viii.

b. “The medical risks of repeated or continuous CED exposure beyond the [45 second] durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.

c. “Studies examining the effects of extended exposure in humans to CEDs are limited to humans exposed to less than 45 seconds.” Page 27.

d. “ ... [E]xperiments using healthy human volunteers have found no cardiac dysrhythmias9,10 or respiratory dysfunction11 following exposures less than 45 seconds.” Page 27.

a. Reviewed studies did not report any evidence of dangerous laboratory abnormalities, physiologic changes, or immediate or delayed cardiac ischemia or dysrhythmias after exposure to CEW electrical discharges of up to 15 seconds.


   a. “21. Personnel should use an ECW for one standard cycle (five seconds) and then evaluate the situation to determine if subsequent cycles are necessary. Personnel should consider that exposure to the ECW for longer than 15 seconds (whether due to multiple applications or continuous cycling) may increase the risk of death or serious injury. Any subsequent applications should be independently justifiable, and the risks should be weighed against other force options.” Page 20.


   “IV. PROCEDURES …
   D. Post-Deployment Considerations …
       2. Personnel shall request EMT response, or the person shall be transported to a medical facility for examination if any of the following occur: …
          f. he or she has been exposed to more than three ECW cycles,
          g. he or she has been exposed to the effects of more than one ECW device, …”
Welfare effects of substituting traditional police ballistic weapons with non-lethal alternatives


a. Empirical results

“The introduction of the Taser reduces the total cost for situations requiring force on an overall welfare basis according to the previous results. A relevant precondition is that the Taser does not change the behavior of police forces in evaluating situations requiring force as such. A proxy for a change in behavior is hence the probability of using the Taser PT, depending on the level of training with the respective weapons or accessories. It is assumed that a better trained staff will have a greater control over selecting equipment within enforcement behavior. In order to prove this hypothesis, we looked at differences in Taser use between the average police officer and officers that are members of specially trained forces. The dataset is taken from the Home Office of the UK Government, representing Taser use in the UK from 2009–2010 [15]. A detailed dataset is available for distinguishing between total Taser use and its application by specially trained forces from the second quarter (Q2) of 2009 to the first quarter (Q1) of 2010. The results are presented in Table 3. It can be stated that specially trained forces fired 4–6% less shots than the average police force. This leads to a difference of 5–10% of the cases where the Taser was not discharged by trained forces. We also see a clear trend towards handling situations where no shots were required by trained forces from 76% in Q2 in 2009 up to 81% in Q1 in 2010. In contrast, the average police officer remained on a level at about 71%. Furthermore, the use of drive stun mode (contact mode without firing the electrodes into the body) was slightly less for the specially trained forces.

In summary, training seems to be a major impact factor for the use of the Taser and hence serves as a prerequisite for the awareness of the Taser as a weapon. A continuously ongoing training and professional education is necessary in order to keep the number of situations requiring force and thus the use of Taser devices stable (n| = n)."
Other – Selected CEW Medical/Scientific Literature

Algorithmic Approach to Assessment of CEW-Associated Fatality:


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

CEW Safety Margin:


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


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

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


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


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

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.”


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


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

Risk of Injury:

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


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

Risk of Death from CEW:


   a. “[T]he risk of human death due directly or primarily to the electrical effects of CED application has not been conclusively demonstrated.” Page viii.

   b. “The risks of ... death remain low and make CEDs more favorable than other weapons.” Page viii.

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

   d. “Unlike the risk of secondary injury due to falling or puncture, the risk of human death due directly or primarily to the electrical effects of CED application has not been conclusively demonstrated.” Page 23.
e. “The medical risks of repeated or continuous CED exposure beyond the durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.

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

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

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

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

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


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

Back – CEW-Temporal Compression Fractures:


a. Excerpt: A 23-year-old male presented to a rural emergency department (ED) for evaluation of mid-back pain following electrocution via a CED. This occurred while the patient, an employee of the Department of Corrections, was volunteering as a model to experience deployment of the device. During the demonstration, Taser® leads were placed on the patient’s right shoulder and ankle and were followed by a five-second electrical discharge from the device.


Risk of Death from CEW-Induced Falls:


a. Results: We found 16 probable cases of fatal brain injuries induced by electronic control from electrical weapons. Out of 3 million field uses, this gives a risk of 5.3 ± 2.6 PPM which is higher than the theoretical risk of
electrocution. The mean age was 46 ± 14 years which is significantly greater that the age of the typical ARD (36 ± 10). Probe shots to the subject’s back may present a higher risk of a fatal fall.

b. Conclusions: The use of electronic control presents a small but real risk of death from fatal traumatic brain injury. Increased age represents an independent risk factor for such fatalities.


Risk of Eye (Ocular) Injuries (Dart to Eye) and Related:


Risk of Death from CEW-Ignited Flammable Substances (Explosive Fumes):

a. We estimated a risk of 3.2 per million of major burns (CI [1.7–5.8] by the Wilson score interval). For fatalities, the estimated risk was 1.9 per million CI [0.9–4.1] and for non-fatal major burns the risk was 1.3 per million CI [0.5–3.2]. The mean age was 35.5 ± 9.7 years which is consistent with the typical arrest-related death. These estimates must be read in the context of the major limitation of the study being the way in which we were forced to find the data—through online and database searches. We focus on the rarity of the event, without claiming precision in its measurement.

b. Abstract:

Introduction: While generally reducing morbidity and mortality, electrical weapons have risks associated with their usage, including eye injuries and falls. With the presence of explosive fumes or fuels there also exists the possibility of burn injury.

Methods: We searched for cases of fatal and non-fatal major burns with TASER® electrical weapon usage where there was a possibility that the weapon ignited the explosion.

Results: We confirmed 6 cases of fatal burn injury and 4 cases of major non-fatal burns out of 3.17 million field uses. The mean age was 35.5 ± 9.7 years which is consistent with the typical arrest-related death. Moderate, minor, and noninjurious fires typically due to a cigarette lighters in a pocket, petrol, recreational inhalants, or body spray were also noted.

Conclusions: The use of electrical weapons presents a small but real risk of death from fatal burn injury. It also presents a small risk of major non-fatal burn injury. The ignition of petrol fumes dominates these cases of major fatal and nonfatal burns.


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


   a. “The medical risks of repeated or continuous CED exposure beyond the [45 second] durations studied in humans are currently unknown, and the role of CEDs in causing death is unclear in these cases.” Page 27.
b. “Studies examining the effects of extended exposure in humans to CEDs are limited to humans exposed to less than 45 seconds.” Page 27.

c. “… [E]xperiments using healthy human volunteers have found no cardiac dysrhythmias\textsuperscript{9,10} or respiratory dysfunction\textsuperscript{11} following exposures less than 45 seconds.”


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


a. 292 CEW temporal ARD incidents analyzed:

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

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

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

**CEW Research Produces Consistent Findings (TASER versus others):**


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


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

CEW Use on Members of Specific Populations

Force, Risk, CEW Use in Hospital Setting:


**Results:** There were 752,138 calls for service over the 9-year period and 182 events [1:4,133] where a CEW was presented/displayed to a violent person (0.0002%). Of these, 36 results in the CEW probe deployment (19.8%) and 146 (80.2%) did not because the person de-escalated their behavior upon presentation and display of the CEW (p<0.0001). The circumstances for CEW presentation situations of imminent threat of harm to someone.

**Conclusions:** CEW use within this healthcare setting was done only when there was no other option to stop the immediate threat of harm to a person that was present. The visible presentation and display of a CEW appears to have a statistically significant effect on de-escalating violent behavior of persons within a healthcare facility overall.


   **Abstract:** In this article, the authors maintain that if properly used by trained security officers Taser CEWs result in significant reductions in injuries and reduction in costs by type of injury. HSS's security officers have carried Taser CEW's in hospitals for more than 10 years in 40 facilities across the country producing no negative CMS finding or excessive use of force claims, they report.


   **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.


   **Conclusion:** CEW introduction into a health care setting demonstrated the ability to avert and control situations that could result in further injury to subjects, patients, and personnel. This correlates with a decrease in injury for hospital personnel. Further study is recommended for validation.
CEW Use Medically Vulnerable or At-Risk Displaying Violent Behaviour:


   a. The majority of multiple or prolonged Taser incidents involved people from one or more “medically vulnerable or at-risk” groups:

      (1) More than 80 per cent of the people were reportedly affected by drugs and/or alcohol.

      (2) Indigenous people comprised 16 per cent of all people who were the subject of a multiple or prolonged deployment.

      (3) Over 40 per cent of the people were believed to have an underlying mental health condition.

CEW Use on Mentally Ill Subjects:

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 bandaid 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.

   http://www.jaapl.org/cgi/content/abstract/44/2/213?ct=ct


   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)

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


a. "... Further, extended CED exposure may not be effective in the subduing 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.


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):

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


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


   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)."


CEW Use on Children:

Table 35 CEW Use on Children

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2018</td>
<td>Generally see United Kingdom stats on use of CEWs on children (ages 13-17)</td>
</tr>
</tbody>
</table>


Abstract

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

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

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


CEW Use on Pregnant Woman:

Table 36 CEW Use on Pregnant Woman

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

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

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

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


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

b. “Spontaneous abortion and other implications for fetal well-being

29. The risks to the pregnant woman and fetus from Taser discharge are poorly understood.

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

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

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

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

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

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


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).


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


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

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


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

CEW Use on Excited Delirium Syndrome (ExDS) Subjects:

Table 37 CEW Use on Excited Delirium Syndrome (ExDS) Subjects

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
</table>
“In addition, although the deputies did not follow every OPTC [Ohio Peace Officer Training Commission] protocol, we note that the training materials acknowledge that the use of a taser might be effective in controlling an individual suffering from excited delirium, that a physical struggle might ensue, and that force might be appropriate or necessary in order to restrain the individual.”  |
<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
</table>


   a. In these incidents, officers should consider intervention options that provide greater time and distance from the subject (e.g., probe deployment of conducted energy weapon [CEW]), and also have lower injury rates when compared to the use of physical control (Baldwin et al., 2017; Bozeman et al., 2018). Given the nature of ExDS symptomology (e.g., pain tolerance, constant/near constant activity, superhuman strength), typical UoF interventions (e.g., physical control, pepper spray) that rely on pain compliance or manual force may be rendered ineffective, which should also be taken into account by responding officers (Blaskovits et al., 2017). In the past, ExDS deaths have been suggested to be a consequence of OC spray,
the CEW, or the use of neck restraints on subjects (DiMaio & DiMaio, 2006). However, no study to date has established a causal relationship between these less lethal intervention options and fatal subject outcomes (e.g., Goudge et al., 2013; Michalewicz et al., 2007; Mitchell, Roach, Tyberg, Belenkie, & Sheldon, 2012; Petty, 2004).


2a. Abstract

Incidents where the police and corrections officers confront a person exhibiting the symptoms of the excited delirium syndrome (ExDS) has become an important concern, although rare in occurrence. To date there has been two prospective, epidemiologic studies which have examined the frequency of the symptoms of ExDS during a police use of force confrontation. Using a prospective research design, we analyzed a cohort of 635 arrestees who exhibited symptoms of ExDS as reported by 17 police agencies from six states in the U.S. over twelve months in 2013 during a use of force incident. We sought to determine if police officers could recognize the associated symptoms of ExDS, determine their prevalence during a use of force confrontation, and to assess if the symptoms were observable across multiple agencies. We also assessed the types of resistance displayed by the arrestees and the outcomes of the use of a conducted energy weapon (CEW) in response to the resistance. Officers reported observing thirteen symptoms associated with ExDS. Using descriptive statistics and regression analysis (p=0.05) showed that 58 percent of the arrestees presented 3 to 4 symptoms, 30 percent presented 5 to 6 symptoms, and 12 percent presented 7 or more symptoms. A CEW was applied in 38 percent (n=240) of the incidents and all arrestees were controlled and restrained in the prone position. None of the arrestees died and in 79 percent of the incidents, an arrestee did not sustain an injury. Officers from multiple agencies were able to recognize the varying symptoms associated with ExDS and their prevalence. The outcome of the incidents showed that applying a CEW with an arrestee exhibiting signs of ExDS is a safe and viable use of force device reducing the likelihood of an arrestee death and minimizing arrestee injuries. Based on the results policy, training, and the focus of future research is discussed.

a. “In addition, although the deputies did not follow every OPTC [Ohio Peace Officer Training Commission] protocol, we note that the training materials acknowledge that the use of a taser might be effective in controlling an individual suffering from excited delirium, that a physical struggle might ensue, and that force might be appropriate or necessary in order to restrain the individual.”


a. **Key Point:** TASERs are used commonly in the prehospital setting to ensure safety of personnel and the altered, aggressive, and agitated patient.

b. **Key Point:** TASERs are increasingly used to control violent and aggressive individuals while maintaining a margin of safety, as well as to reduce the need for impact weapons and injuries associated with their use. They are reported to have prevented many law enforcement personnel injuries as well as subject injuries.

c. “Quickly controlling an ExDS subject in the prehospital setting to minimize the subject's exertional activity is a priority, while maintaining both the safety of providers and the subject. ExDS subjects typically have altered mental status, are often paranoid, and are essentially impossible to effectively communicate with, making verbal de-escalation of little value. The use of an ECD such as TASER to rapidly gain physical control and restrain a subject is preferable to the approach of going hands-on, as heavy physical exertion may exacerbate acidosis in the subject and contribute to a greater risk of sudden death. Data have shown that exertion and struggle increase acidosis more than use of a TASER (Ho et al. 2010). The goal is rapid control allowing as little struggle as possible by the subject. Once the subject is restrained and scene safety is
secured, the medical evaluation and treatment can begin for the patient.” (page 179, highlighting emphasis added).


   a. Tactics used by law enforcement to gain control of a subject exhibiting signs and symptoms of ExDS should focus on rapid control and minimization of the patient’s exertional activity, while maintaining the safety of officers and the subject. The use of a TASER® (electronic control device, ECD) to gain control and restrain someone exhibiting signs of ExDS is felt by many experts to be preferable to the more traditional physical wrestling for control as fighting or heavy physical exertion has been shown to have a more deleterious effect on a patient’s acid-base status (Ho, Dawes and Bultman, 2009; Ho, Dawes, Cole et al., 2009; Ho, Dawes, Nelson et al., 2010). Use of the large muscle groups of the arms and legs in repeated contractions and extensions will cause a significant rise in oxygen consumption and lactic acidosis. Thus, once controlled, restraint becomes protective for the subject (Michalewicz, Chan, Vilke et al., 2007). Patients with ExDS, already severely acidotic from their underlying condition and significant prolonged exertion, could aggravate this and contribute to a greater risk for cardiac arrest compared to a short burst of electrical control from an ECD and subsequent rapid restraint. Additionally, the patient’s airway should be protected during any forceful manoeuvre and the breathing status monitored during and after the manoeuvre. [pg 106]


   a. “There is insufficient research on the effects of TASER on ABD however its use as a rapid takedown method to minimise restraint time and activity and

---

allowing expeditious medical intervention may be a necessary alternative once nonphysical methods have failed.”


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


a. “Tactics used in the prehospital setting to control a patient in ExDS should revolve around patient and provider safety with rapid control and minimisation of the patient’s exertional activity. The use of an electronic control device, such as a TASER® ECD, to gain control of a patient appears preferable to the more traditional and drawn out approach of going ‘hands on’, as fighting or heavy physical exertion has more of a deleterious effect on a patient’s already tenuous acid-base status.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.”


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.


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


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

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

CEW Use on Subjects Under Influence of Alcohol/Ethanol:


   a. “Conclusions: Prolonged continuous CEW exposure in the setting of acute alcohol intoxication has no clinically significant effect on subjects in terms of markers of metabolic acidosis. The acidosis seen is consistent with what occurs with ethanol intoxication or moderate exertion.”

CEW Use on Subjects Under Influence of Cocaine (VFT) (animal)


   a. “CONCLUSIONS Cocaine increased the VFT of NMI discharges at all dart locations tested and reduced cardiac vulnerability to VF. The application of cocaine increased the safety margin by 50% to 100% above the baseline safety margin.”


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

CEW Use on Subjects Under Influence of Methamphetamine (animal)


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

TASER CEW Operational Information

Graphic – TASER X26 CEW Basic Components:

Figure 15 TASER X26 CEW Basic Components

Graphic – Necessity of Completed Circuit to Deliver Electrical Charge:

Figure 16 Necessity of Completed Intact Electrical Circuit to Deliver Charge

The New York Conducted Energy Device Course, Student Guide, includes: ⁹⁷

---

Necessity of Completed Circuit to Deliver Electrical Charge:


   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<sup>96</sup>) Cells:

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.

---

96 See Duracell Ultra Photo, Ultra 123 Lithium/Manganese Dixoide (Li/MnO<sub>2</sub>) cell specifications data sheet.
CEW Probes and Darts:

Figure 20 TASER CEW probes/darts

![Image of TASER CEW probes/darts](image)

Figure 21 TASER CEW probes/darts comparisons with U.S. dime

![Image of TASER CEW probes/darts with U.S. dime and five pence](image)

<table>
<thead>
<tr>
<th>Length/Diameter (mm)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 mm</td>
<td>CEW dart</td>
</tr>
<tr>
<td>13 mm</td>
<td>XP CEW dart</td>
</tr>
<tr>
<td>17.91 mm</td>
<td>U.S. dime</td>
</tr>
<tr>
<td>18.0 mm</td>
<td>U.K. five pence</td>
</tr>
<tr>
<td>18.03 mm</td>
<td>Canadian dime</td>
</tr>
</tbody>
</table>

A U.S. dime is 17.91 millimeters (mm)\(^{99}\) in diameter [United Kingdom five pence is 18.0 mm\(^{100}\), and Canadian dime is 18.03 mm\(^{101}\)]

\(^{99}\) [http://www.usmint.gov/about_the_mint/?action=coin_specifications](http://www.usmint.gov/about_the_mint/?action=coin_specifications) referenced on September 15, 2015.


\(^{101}\) [http://www.mint.ca/store/mint/about-the-mint/10-cents-5300008#10_1](http://www.mint.ca/store/mint/about-the-mint/10-cents-5300008#10_1) referenced on September 5, 2015.
Arcing Research:


Targeting (lower center mass):

Figure 22 CEW Pre-Probe Deployment LASER Aiming (targeting lower center mass).

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


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

Table 39 Sampling of sound levels from various sources.

<table>
<thead>
<tr>
<th>Sound level (dBA at 1 m)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>screaming</td>
</tr>
<tr>
<td>79</td>
<td>X26 ECD open-circuit crackling</td>
</tr>
<tr>
<td>70</td>
<td>vacuum cleaner</td>
</tr>
<tr>
<td>60</td>
<td>polite conversational speech</td>
</tr>
<tr>
<td>51</td>
<td>X26 ECD closed-circuit clicking</td>
</tr>
<tr>
<td>50</td>
<td>average home volume, normal refrigerator</td>
</tr>
<tr>
<td>40</td>
<td>quiet library</td>
</tr>
<tr>
<td>30</td>
<td>quiet bedroom at night</td>
</tr>
</tbody>
</table>
The scientific basis of the crackling sound emitted from an electrical arc has been well studied.

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

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

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

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

**CEW Probe Spread and Incapacitation:**


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


a. “Muscle-contraction force increased as the spacing increased from 5 to 20 cm, with no further change in force above 20 cm of spacing. Therefore, it is suggested that any future developments of new conducted energy weapons should include placement of electrodes a minimum of 20 cm apart so that efficiency of the system is not degraded.”

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

*Figure 23 CEW Probe Spread – Distance from CEW to Subject*
Figure 24 CEW Cartridge Showing Probe Discharge and Eight Degree Discharge Downward Angle.

X26 CEW Log Shows Only Discharges Not Delivered Charge:

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

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

50,000 Volts Delivered to Body Myth:

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

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


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

**Cardiac Electrocardiogram (ECG) Monitor in CEW:**


a. Conclusion: An electrocardiogram (ECG) recording device was successfully incorporated into a standard issue CEW without impeding the functioning of the device. This serves as proof-of-concept that safety measures such as cardiac biomonitoring can be incorporated into CEWs and possibly other law enforcement devices.
### Table 40 Static electricity and Van de Graff generators

<table>
<thead>
<tr>
<th>Static electricity in human body</th>
<th>Static electricity (up to 30,000 V)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Static electricity in human body" /></td>
<td><img src="image2" alt="Static electricity (up to 30,000 V)" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Van de Graff Generator (up to 25 million V)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Van de Graff Generator" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Van de Graff Generator</th>
<th>Mark Twain and Nikola Tesla (1800s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Van de Graff Generator" /></td>
<td><img src="image5" alt="Mark Twain and Nikola Tesla (1800s)" /></td>
</tr>
</tbody>
</table>
Smart CEWs (X3 (2009), X2 (2011), X26(P) (2013) CEWs)

TASER CEW Handheld Model Development/Life Timeline:

Table 41 TASER Handheld CEW Model Development Timeline (Smart CEWs highlighted)

<table>
<thead>
<tr>
<th>No.</th>
<th>Year</th>
<th>Date</th>
<th>CEW Model</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1976</td>
<td>1976</td>
<td>TF-76 electric weapon</td>
<td>Available</td>
</tr>
<tr>
<td>2</td>
<td>1994</td>
<td>1994</td>
<td>AIR TASER Model 34000</td>
<td>Available</td>
</tr>
<tr>
<td>3</td>
<td>1999</td>
<td>Nov. 1999</td>
<td>ADVANCED M26 CEW</td>
<td>Available</td>
</tr>
<tr>
<td>4</td>
<td>2003</td>
<td>May 2003</td>
<td>X26(E) CEW</td>
<td>Available</td>
</tr>
<tr>
<td>5</td>
<td>2007</td>
<td>Jan. 2007</td>
<td>(#) C2 Personal Protector</td>
<td>Available</td>
</tr>
<tr>
<td>6</td>
<td>2009</td>
<td>Jul. 2009</td>
<td>X3 CEW (with charge metering)</td>
<td>Available</td>
</tr>
<tr>
<td>7</td>
<td>2011</td>
<td>Apr. 2011</td>
<td>X2 CEW (with charge metering and APPM)</td>
<td>Available</td>
</tr>
<tr>
<td>8</td>
<td>2011</td>
<td>Q4 2011</td>
<td>X3 CEW</td>
<td>End of life</td>
</tr>
<tr>
<td>9</td>
<td>2013</td>
<td>Jan. 2013</td>
<td>X26(P) CEW (with charge metering and APPM)</td>
<td>Available</td>
</tr>
<tr>
<td>10</td>
<td>2014</td>
<td>Dec. 2014</td>
<td>X26(E) CEW</td>
<td>End of life</td>
</tr>
<tr>
<td>12</td>
<td>2017</td>
<td>Jan. 1 2017</td>
<td>Smart cartridge: “SP” probe replaced the “XP” probe</td>
<td>Available</td>
</tr>
</tbody>
</table>

# designates civilian CEW, not intended for law enforcement or military use.

Digital SMART CEWs:

1. TASER first introduced a digital, SMART CEW, that incorporated design and technical features including a feedback loop (charge metering) to stabilize the output charge and trilogy logs in July 2009 with the TASER X3 CEW. The TASER X2 CEW was introduced in April 2011, and the TASER X26(P) CEW was introduced in January 2013.

2. The TASER X3 CEW, a 3-shot weapon released in July 2009, was the first CEW in the world incorporating charge metering and trilogy log technologies. Because of the size, weight, and complexity of this weapon, it was not popular with law enforcement and TASER ceased production in the 4th quarter of 2011.

Feedback Loop - Charge Metering (digital Smart CEWs):

1. Feedback loop/charge metering basically means that each pulse is measured and then the succeeding pulse is adjusted as necessary based upon measured electrical parameters to maintain a close range of delivered electrical charge to the subject. SMART CEWs discharge ≈ 19 very short duration pulses per second (PPS).

2. The early 2003 technologies of the TASER® X26(E) Conducted Electrical Weapon (CEW) provided a synergistic combination of excellent human physiologic safety coupled with outstanding neuromuscular incapacitation (NMI) capability. The next generation TASER Smart CEWs further improved delivered
charge safety margins while delivering a more precisely calibrated charge within equivalent range of the X26(E) CEW. Also, the overall waveform duration also comes into effect. The shorter waveform of the Smart CEWs gives more motor-nerve mediated muscle lockup at lower charge than the X26(E) CEW.

3. The development of Smart CEW technologies allowed for charge metering and pulse calibration of the delivered charge to decrease the total delivered charge when deployed in probe skin-embedded mode while achieving NMI. Charge metering and pulse calibration are important aspects of continually striving to improve CEW safety margins. These concepts of charge metering and pulse calibration were explained in detail in TASER’s sales and training materials dating back to at least August 2009 (release of the first SMART CEW, the X3 CEW) [for later versions of this information see, as examples: (1) TASER Training Version (V) 17 (May 1, 2010), CEW Instructor Certification Course, Day 1, Part 1, Slides 48-53; (2) Training V 19 (April 1, 2013) Evolution of TASER Technology video; (3) Training V 20 (January 1, 2016) Evolution of TASER Technology video; and (4) TASER Smart CEW technical specifications], as this is one of the primary benefits of the newer generation digitally-controlled Smart CEWs.

4. The X26(E) CEW delivers ≈ 56 microcoulombs (µC) when the probes are in the clothing and the delivered charge must spark through the clothing and skin. The X26(E) CEW will deliver ≈ 107 µC (Adler (2013)) when the probes are embedded in the skin. Smart CEWs are designed to deliver ≈ 63 µC. This discharge level is above the ≈ 56 µC sparking discharge of the X26(E) CEW, and has similar effectiveness while maintaining significantly increased precision. And, because the delivered charge of the Smart CEWs is well below the maximum delivered charge of the X26(E) CEW, it further increases cardiac safety margins. In blinded scientifically-controlled head-to-head human effectiveness motivation testing, no discernible differences were found between the X26(E) and the X2 CEWs at similar probe-spreads and probe-body locations.

5. In technical terms, the X26(E) CEW’s output is dependent on the connection to the subject. When a low resistance connection is established to a subject (both probes into low resistance tissue), the X26(E) CEW delivers ≈ 107 (max specification 135) µC. When a poor connection is made to the subject (arching probes, and/or connecting through highly resistive tissue) the X26(E) CEW delivers as low as 50 µC. The next generation Smart CEWs (X3, X2, and X26P) with charge metering and pulse calibration regulate the delivered charge to 63 ± 9 µC. This allows enhanced cardiac safety margins while performing equivalent or better to the older technology X26(E) CEW in conditions where the X26(E) CEW’s delivered charge is less than optimal.
1. TASER’s Training Program Version 15 was released and effective on 24 August 2009. An explanation of “charge metering” was included in the Version 15 CEW Instructor Program, online Module 2 – Technology and History, PowerPoint® Slides 34–45.

2. Slide 34 (with instructor notes) explained the new “Pulse Calibration System,” which allows for measuring, recording, and adjusting the next subsequent pulse, as follows:
3. Slide 38 (with instructor notes) graphically depicted the X26(E) pulse waveform with penetrated probes:

4. Slide 39 (with instructor notes) showed the X26(E) pulse with penetrated probes during the “Arc Phase,” i.e. the initial spike necessary to jump the air gap.
5. Slide 40 (with instructor notes) showed the X26(E) pulse with penetrated probes during the stimulation or “Stim Phase” where the vast majority of the charge is delivered:
6. Slide 41 (with instructor notes) showed the delivered charge of the X26(E) CEW in microcoulombs ("µC") when probes penetrated the subject’s skin:

![Graph showing delivered charge](image)

If we measure the area under the curve for the slim phase, we get 107.3 microcoulombs of charge for this test case. A microcoulomb is one millionth of a coulomb – however, because "microcoulomb" is not a term most people work with everyday, we just use the term "Units of Charge".

Now, for comparison, if we measure that same X26, but this time we pull the darts out so that it must arc through an air barrier to deliver the charge, we get a slightly diminished waveform...

7. Slide 42 (with instructor notes) showed a comparison of the X26(E) CEW delivered pulse with Penetrated Probes vs. Arcing Current. When the probes penetrate the subject’s skin, the delivered electrical charge is ≈107.3 microcoulombs ("µC"). When the charge instead is arcing to the subject (i.e., when the CEW is being used in drive or touch stun mode), the delivered electrical charge is 56.7 µC:
8. Slide 43 (with instructor notes) demonstrated the difference between the X26(E) CEW pulse with Penetrated vs. Arc delivery, again graphically illustrating the difference in delivered electrical charge in probe mode versus drive-stun mode when the CEW is delivering its' charge by arcing:

9. Slide 44 (with instructor notes) compared the X26(E) CEW constant discharge pulse vs. X3 CEW metered or calibrated pulse:
10. Slide 45 (with instructor notes) also demonstrated the X26(E) CEW constant charge delivered pulse vs. X3 CEW metered or calibrated pulse:

And that's exactly what the X3 does with its new Pulse Calibration System. It measures the charge and voltage for every pulse and adjusts the next pulse to optimize the output at 63 charge units.

If you look at the chart here, we show the X3 with probes penetrated in dark blue and with the probes arcing in light blue. The shape of the pulse changes very slightly (due to increased circuit resistance), but the area under the curve is very consistent. The X3 delivered 63.9 charge units when probes were penetrated, and 62.5 charge units when the probes were arcing — a difference of only 2.2% versus 89% for the standard shaped pulse.

As a result, the X3 delivers a more consistent effect on target. Our tests on aggressive human volunteers shows that 63 charge units is about the optimal level to achieve incapacitation while maximizing safety.

When the darts are in clothing and there is an arc required, the X3 will outperform the X26 by consistently delivering more than 60 charge units to cause incapacitation. When the probes penetrate the skin, the X3 maintains a higher safety margin by adjusting its internal circuits to deliver approximately the same level charge units.
X2 CEW (Smart CEWs) Trilogy Logs:

1. The TASER X2 CEW, a lighter more compact 2-shot weapon released in April 2011. The X2 CEW incorporated charge metering or pulse calibration and trilogy logs technologies.

2. Trilogy Logs (Event Log, Pulse Log, Engineering Log): Trilogy Logs: The X2 CEW records objective data into the Trilogy™ Logs, which consist of (1) the Event Log, (2) the Pulse Logs, and (3) the Engineering Logs.

   a. Event Log: The Event Log is a recording of the date, time, and details of each event that occurs with the X2 CEW, including every time the weapon is armed, the trigger is pulled, the ARC switch is pressed, the menu is accessed, the time is changed, the safety switch is placed in the safe position, USB mode is entered, the firmware is updated, and more. Relevant events also include the cartridge status, internal temperature of the weapon, the duration of the event (in seconds), and the battery percentage remaining at the time of the event. The Event Log will record approximately 16,000 entries before it will “wrap” and begin to overwrite the oldest entries.

   b. Pulse Log: The Pulse Log is a recording of every pulse that is generated by the X2 CEW. There are three measurements recorded for each pulse: (1) the voltage across the stimulation capacitor; (2) the voltage across the arc...
c. **Engineering Log:** The Engineering Logs is a recording of all of the measureable activity in the X2 CEW. The Engineering Log records, along with a timestamp, every button push, microprocessor command, circuit status, reported errors, faults and more. The Engineering Logs are only accessible by Axon Engineering and are used for troubleshooting purposes or acquiring deeper information about a specific activation or incident.

3. **USB:** The X2 CEW is downloaded by connecting the CEW to a proprietary USB pack that inserts into the CEW's battery pack compartment. Once connected to USB, the X2 CEW will enter USB mode and the CEW's Trilogy Logs can be downloaded to a local PC or network or uploaded to Evidence.com using Evidence Sync software. USB mode also allows the synchronization of the X2 CEW clock, firmware updates, and configuration setting.

**Smart CEW Calibration and Function Test**

1. The following addresses how TASER X2 CEWs are calibrated in order to measure and adjust the electrical output.

   a. **SMART CEWs,** including the X2 CEW, are programmed with a predetermined electrical charge target. **SMART CEWs,** including the X2 CEW, are designed to perform its own calibration adjustment, when necessary, after every pulse it generates. The SMART CEWs, including the X2 CEW discharge ≈ 19 pulses per second. It does this by measuring the capacitor voltage and output current of each pulse, then adjusting the output of the next pulse to compensate for any variation in the load. In other words, every time a SMART CEW is used, it measures the charge and adjusts its level to ensure accuracy.

   b. Because the SMART CEWs are manufactured as self-calibrating, there is no need to separately "calibrate" the CEW.
c. The accuracy of the SMART CEWs, including the X2 CEW, can be verified by viewing the Pulse Graphs generated by evidence.com, as the output charge of every pulse is displayed for the user to see.
X2 ("Smart") CEW Concepts, Studies

X2 CEW

Table 42 X2 CEW Images, Nomenclature, V20 X2 Training

![X2 CEW Diagram](image)

Figure 26 Labelled drawing of X2 CEW.
Drawing of front of X2 CEW Smart Cartridge showing arc deflector metalized label that allows for arcing discharge to attempt to gain compliance.

X2 CEW showing warning arcs across fronts of un-deployed Smart cartridges.

Drawing of front of X2 CEW showing deployed cartridges exposing cartridge electrodes.

Drawing of X2 CEW with no cartridges installed showing 4 metal electrodes that provide ability in drive (contact or touch)-stun mode as traditional stun type electroshock weapon.

---

**Probe Spread**

15 & 25-ft Smart Cartridges

- Rule of thumb: ~1 foot (.3 m) spread for every 9 feet (2.7 m) of travel

<table>
<thead>
<tr>
<th>Target Distance (ft)</th>
<th>2.7m</th>
<th>5.4m</th>
<th>7.6m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread (in)</td>
<td>9&quot;</td>
<td>18&quot;</td>
<td>25&quot;</td>
</tr>
<tr>
<td></td>
<td>23cm</td>
<td>46cm</td>
<td>69cm</td>
</tr>
</tbody>
</table>

**Smart Cartridges: 25 ft**

- Serial #
- Shipping Cover (must be removed prior to loading)
- 25 ft
- 7.62 m
- Solid Black Door
- Green Shipping Cover
- Live Cartridge
Figure 27 Smart Cartridge Cut Away.

Figure 28 CEW Smart Cartridges.
X2 CEW Generally

The TASER X2 CEW is a dual cartridge (two shot) CEW in Axon’s Smart CEW line. The X2 CEW was first available for acquisition in April 2011.

**Smart Cartridges:** The X2 CEW uses Axon’s Smart cartridges and is not compatible with Axon standard cartridges. When Smart cartridges are properly loaded into the X2 CEW and when the X2 CEW is armed, it will read the cartridge
type and display it on the Central Information Display (CID). The cartridge types can be displayed as: live 15’, 25’; training 25’; or deployed. The X2 CEW contains 2 cartridge bays. Bay 1 (cartridge 1) is on the left side of the weapon (from the user’s aim perspective). Bay 2 (cartridge 2) is on the right side of the weapon (from the user’s aim perspective).

**Safety Switch:** The X2 CEW has an ambidextrous safety switch designed to be manipulated by the CEW user’s thumb. When the safety switch is placed in the Armed (up) position, the weapon will enter armed mode and is ready to activate. The X2 CEW will arm anytime the safety switch is placed in the armed position, except when in Universal Serial Bus (USB) mode. When the X2 CEW is armed, it will automatically select the first bay that has a loaded and un-deployed cartridge, starting with Bay 1. If no cartridges are present, then Bay 1 will be selected. If 1 bay contains a deployed cartridge and the other bay contains an un-deployed cartridge, the X2 CEW will select the un-deployed cartridge. The X2 CEW enters safe mode when the safety switch is placed in the Safe (down) position.

**Trigger:** When the X2 CEW is armed and the trigger is pulled, if there is an un-deployed cartridge it will deploy the cartridge in the selected bay and activate the high voltage pulses on the selected bay for 5 seconds at 19 ± 1 pulses per second (pps). If the selected bay has no cartridge or a deployed cartridge, the trigger will only activate the high voltage pulses on the selected bay and not attempt to activate the cartridge deployment circuitry. The trigger only activates the high voltage on the selected bay. If the trigger is pulled and then released, after 5 seconds the high voltage activation will stop. With a standard battery pack, if the trigger is held beyond 5 seconds, the high voltage will remain active as long as the trigger is held or until the battery is depleted, whichever occurs first. In the event the trigger is held back beyond the 5 seconds the CEW discharge will cease immediately upon the user’s release of the trigger (the discharge will not continue for the completion of subsequent 5-second cycles). Axon also offers battery packs that limit activations to 5 seconds, regardless of the trigger being held (e.g., Auto Shut-Down Performance Power Magazine (APPM). The APPM also first became available in April 2011. The APPM gives an audible beeping warning tone at the 4th second of the activation until the activation stops or the trigger is released.

**ARC Switch:** The X2 CEW has an ARC switch that has dual functions: (1) 2 bay arc activation, and (2) cartridge selection. The cartridges do not deploy with the ARC switch. Cartridges can only be deployed with a trigger activation. When the ARC switch is held for longer than 0.25 seconds, both cartridge bays will activate the high voltage pulses at 19 ± 1 pps. With a standard battery pack, the high voltage will be active on both cartridge bays as long as the ARC switch is depressed. The high voltage pulses will stop when the ARC switch is released. X2 CEWs equipped with the APPM also limits ARC switch activations to 5 seconds, regardless of the ARC switch being held. The APPM gives an audible beeping warning tone at the 4th second of the activation until the activation stops or the ARC switch is released. When the ARC switch is “tapped”, or pressed for less than 0.25 seconds, the X2
CEW will advance the cartridge selection to the next cartridge bay, providing it is selectable.

**Weapon Mode and Cartridge Selection:** The X2 CEW can operate in two weapon modes: (1) semi-automatic or (2) manual mode. The weapon mode is an agency selectable software setting that is set on the agency’s Evidence.com account. If the agency does not have an Evidence.com account, the X2 CEW will remain in the factory default semi-automatic mode. The weapon mode determines how the X2 CEW will advance to the next available cartridge when a cartridge is deployed.

**Semi-automatic Mode:** When a cartridge is deployed by a trigger pull, the next cartridge will be selected when the trigger is released. If there is no cartridge available (i.e., empty bay or previously deployed cartridge installed), then the cartridge selection will not advance to the next bay.

**Manual Mode:** When a cartridge is deployed by a trigger pull, the cartridge bay selection will remain on the selected bay until the user manually advances to the next available cartridge. The user advances the cartridge selection by tapping the ARC switch. If there is no fresh (un-deployed) cartridge available (i.e., empty cartridge bay), then the cartridge selection will not advance to the next bay.

Regardless of the weapon mode, the cartridge bay can be selected by tapping the ARC switch. There are, however, conditions when a cartridge bay cannot be selected. Bay 2 cannot be selected when it is empty. A deployed cartridge cannot be selected if there is an un-deployed cartridge installed. Once both cartridges are deployed, then deployed cartridges can be selected. A cartridge with a fault detected by the weapon also cannot be selected.

**Menu and Selector Button:** The X2 CEW menu is used to read or change the targeting aid sighting LASER [Light Amplification by Stimulated Emission of Radiation] and flashlight illumination settings and read information, such as the battery pack details, system time, and system firmware version. The menu can be selected by pressing the Selector Button on the top of the weapon while in safe mode. Note that the X2 CEW can be armed with the safety switch and activated at any time, even when the weapon is in the menu settings. When the X2 CEW is armed, the Selector Button will put the weapon in “stealth” mode, which will dim the Central Information Display (CID) and turn off the LASER and flashlight.

**X2 vs X26E CEW Effectiveness**


   a. “Conclusion: The preliminary results from the project presented above demonstrates that there appears to be no discernible, descriptive difference in incapacitation effectiveness between the TASER X26 and X2 CEWs when compared in head-to-head fashion. Based on this, end-users should expect similar performance characteristics during use. Weapon tactics and instruction should also take this new information into account in the interest of user safety. As new generation CEW technology becomes more popular, it may be important to increase the scope of this research for validation. The methodology used in this project represents the only reproducible human model to date that appears to accurately measure incapacitation effectiveness during simulated field use.”


**X2 CEW Studies/Papers/Abstracts**


**X2 CEW Prospective Human Studies**


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

**X2 CEW Modeling Studies**


   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.”


   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.

**Summary Analysis: Electrical Safety Standards**


   b. "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."

   c. “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.”

**X2 CEWs Comparative Cardiac Capture Safety Margin Studies**

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

b. 160 CEW exposures

   (1) Highest capture rate: 239 BPM

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

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


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

      (1) TASER X2 CEW:

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

         (b) 2 resulted in partial capture

      (2) Karbon Arms MPID CEW:

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

         (b) 10 resulted in partial capture

   b. Probabilities:

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

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

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

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


a. “… In our estimates, the risk of VF based on this data is no more than 0.29%. The consensus panel estimated the risk of death in a TASER-related incident to be no more than 0.25%, in close agreement. Even with cardiac capture, the risk of VF from our data was no more than 0.59%.”103

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

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

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

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

f. “One animal inexplicably died shortly after being paralyzed, but before any CEW exposures …” This death illustrates the fragility of the swine study model. (John Webster, Ph.D. has had similar experiences with the swine model.104)

---


104 Russell v. Wright, Case No. 3:11-cv-00075-GEC, U.S. District Court, Western Division of Virgini, Charlottesville Division, Deposition of John G. Webster, Ph.D., taken on September 24, 2012, Page 38, line 10 to page 40, line 6.
X26(P) CEW

Table 43 X26(P) CEW (from Training V20 (1 Jan. 2017), Instructor PowerPoint)

Central Information Display (CID)

- Central Information Display (CID)
- Safety switch
- Performance Power Magazine (PPM) release button
- Trigger
- Performance Power Magazine (PPM)

X26P CEW: Safety Switch

- Safety Switch Down
  - (SAFE)
- Safety Switch Up
  - (ARMED)
  - Activates CID, LASERS and illumination
  - Begins events in the Event Log
M26/X26/X26P CEW Drive-Stun Effects

CEW Drive Stun Current Distribution


   a. Conclusion: The fat layer provided significant attenuation of drive-stun CEW currents. Beyond the skeletal muscle layer, only fractional amounts of the total CEW current were estimated to flow. The regions presenting risk for VF induction or for cardiac capture were well away from the typical heart depth.

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). 105 Similar demonstrations can be shown with CEW in probe mode.

Table 44 X26(E) CEW Drive Stun Graphics

Figure 31 Arrows Pointing to Electrodes on Front of CEW with No Expended Cartridge in Place.

Figure 32 Illustrating CEW Drive-Stun Discharge Across Front Electrodes and LASER.

105 See my full list of electronic weapons demonstrations outline for additional demonstrations and greater depth of how to perform the various visuals and demonstrations.
Drive Stun Discharge vs Probe Deployment


Drive Stun Discharge Wounds


   a. “Drive Stun. 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.” (page 124).


Drive-Stun: Medical Studies

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).


a. “Risk of ventricular dysrhythmias is exceedingly low in the drive-stun mode of CEDs because the density of the current in the tissue is much lower in this mode.” Page 10.

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


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

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.”


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


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


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

**Drive-Stun: Legal Cases**


a. EN 1 In drive-stun mode (used here), the officer “applies the taser so as to make direct contact with the subject’s body.” *De Boise v. Taser Int’l, Inc.*, 760
F.3d 892, 895 n.5 (8th Cir. 2014). When used in drive-stun mode, the taser “causes discomfort” but “does not incapacitate the subject.” Id. In dart mode (not used here), “[t]asers fire metal probes into the skin, penetrating up to half an inch” and “deliver[ing] a 50,000 volt shock that lasts up to five seconds and causes electrical muscular disruption.” McKenney v. Harrison, 635 F.3d 354, 362 (8th Cir. 2011) (Murphy, J., concurring) (internal citations and quotation marks omitted).


a. “Plaintiffs rely heavily on our decisions in Shekleton and Brown that “use of [a] taser on a nonfleeing, nonviolent suspected misdemeanant was unreasonable.” Shekleton, 677 F.3d at 367. But the principle does not apply in this case. Thomas was not nonviolent—he had participated in an armed standoff resulting in deployment of a SWAT team and then his arrest for felony terrorizing. Called to the scene to transport the brothers to a detention center, Braathen observed that a SWAT team member had handcuffed the brothers and was holding them on the ground at gun point. Thomas resisted lawful arrest by refusing to walk to the patrol car and then by refusing to comply with Braathen’s command that he move over so the squad car could transport all three brothers. In response to this dangerous defiance, Braathen deployed his taser in drive stun mode, a use of force that “only causes discomfort and does not incapacitate the subject.” De Boise, 760 F.3d at 895 n.5.6 “[T]he infliction of only de minimis injuries supports the conclusion that the officer did not use excessive force.” Davis, 794 F.3d at 1012 (quotation omitted).” (highlighting emphasis added)

6. In Brooks v. City of Seattle, 599 F.3d 1018, 1027-28 (9th Cir. 2010), the court observed that “use of the Taser in drive-stun mode is painful, certainly, but also temporary and localized, without incapacitating muscle contractions or significant lasting injury”—an amount of force “more on par with pain compliance techniques, which this court has found involve a ‘less significant’ intrusion ... than most claims of force, even when they cause pain and injury,” rev’d on other grounds sub nom. Mattos v. Agaran, 661 F.3d 433 (9th Cir. 2011).


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)

4. 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.”


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


a. “Cooks said that he had stunned Allen once with the probes and two times in dry stun mode, although his T[ASER X26 ECD’s] data download showed that the device had been activated twelve times. Harkleroad said that he had stunned Allen three times in dry stun mode, but his T[ASER X26 ECD’s] data download showed that it had been activated six times. The record shows that an “activation” of the T[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 tasing were in the dry stun mode.” [Hoyt, at 976].

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

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

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


a. “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)

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. Pickett, 717 F.3d 751, 756 (10th Cir. 2013) (in drive stun mode, “the taser delivers an electric shock, but does not cause an override of an individual’s central nervous system as does a taser in dart probe mode”).


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

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

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. at 1026.

(3) “The use of the [CEW] in drive-stun mode is painful, certainly, but also temporary and localized, without incapacitating muscle contractions or significant lasting injury.” Id. at 1027.
10. **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.


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**


a. “The record shows that an ‘activation’ of the T[TASER ECD] does not mean that the T[TASER ECD] actually touched or stunned Allen.” *Hoyt*, 672 F.3d at 976.
   a. “According to [TASER], each ECD trigger pull activates a 5 second cycle, but when in drive stun mode, it delivers an electrical charge only for the time that it is in direct contact with the skin.”

   a. "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.)

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

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

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.”

Figure 36 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

---

the same deployment guidelines and restrictions as any other ECW cartridge deployment.\textsuperscript{107}

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 “numerical 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.”\textsuperscript{108}

\textsuperscript{107} Electronic Control Weapons, Model Policy, April 2010, International Association of Chiefs of Police.

<table>
<thead>
<tr>
<th>X26 CEW with no cartridge attached</th>
<th>X26 with Silver door cartridge attached</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>X26 CEW with expended cartridge</td>
<td>X26 CEW with expended cartridge</td>
</tr>
<tr>
<td>showing rounded, recessed electrodes</td>
<td>showing rounded, recessed electrodes</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>X26/X26(P) CEW Cartridge showing</td>
<td>X26/X26(P) CEW Cartridge showing</td>
</tr>
<tr>
<td>rounded, recessed electrodes</td>
<td>rounded, recessed electrodes</td>
</tr>
</tbody>
</table>
M26 CEW Operational Information (TASER Training Version 11)

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

   Figure 37 M26 CEW. TASER Training Version 11, M26 User Program, Slide 36.

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

   Figure 38 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 39 M26 CEW Drive-Stun Mode, TASER Training Version 11, M26 User, Slide 104.

**Drive Stun Mode**

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

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

Drive stun field use success: 94%

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

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

Table 46 VFT for Swine, Canine, and Human (Electrode on Heart)

<table>
<thead>
<tr>
<th>Species</th>
<th>Year</th>
<th>VFT (µC)</th>
<th>Calculation (time x current)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig109</td>
<td>2013</td>
<td>RV VFT</td>
<td>38.8 ± 8.4 4 ms x 9.7 ± 2.1 mA</td>
</tr>
<tr>
<td>Dog110</td>
<td>1977</td>
<td>LV epicardium</td>
<td>43.2 ± 25 4 ms x 10.8 ± 6.2 mA</td>
</tr>
<tr>
<td>Human111</td>
<td>1979</td>
<td>RV VFT</td>
<td>85 ± 21 4 ms x 24.3 ± 5.2 mA</td>
</tr>
</tbody>
</table>

Typical Electrical Charges Required for Human Cardiac Effects

Table 47 Typical Electrical Charges Required for Human Cardiac Effects

<table>
<thead>
<tr>
<th>Intracardiac Electrode</th>
<th>Transcutaneous Electrodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low rate cardiac pacing</td>
<td>1 µC = 1 mA • 1 ms</td>
</tr>
<tr>
<td>VF from cardiac pacing</td>
<td>85 µC113</td>
</tr>
<tr>
<td>VF from single pulse</td>
<td>25,000 µC114</td>
</tr>
</tbody>
</table>

Human VFT: Electrodes Applied to Epicardial Surface of Ventricle


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

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

---

109 Personal communication.


### Table 48 1979 Horowitz VF thresholds

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

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

   a. “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.”

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

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

   a. “Because they have a heart-body weight ratio and general cardiac anatomy similar to that of humans, swine have been used in the testing and development of pacemakers and implantable cardiac defibrillators. However, swine have a relatively low threshold for ventricular fibrillation, in part,
because their Purkinje fibers cross the entire ventricular wall, in contrast to human hearts in which these fibers are largely confined to a thin layer in the endocardium. Additionally, the cardiac impulse proceeds from the epicardium to the endocardium in swine, potentially increasing their sensitivity to externally applied electrical currents compared with humans. These differences diminish the relevance of this model for evaluating the safety of CED exposure in humans.\textsuperscript{20} Pg. 4.


Drug Effects on Action Potential Repolarisation in Sheep Cardiac Purkinje Fibres


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.\textsuperscript{116}
   
   (1) Given a full minute, responder will find the pulse with 97% accuracy.\textsuperscript{117}

   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.\textsuperscript{118}


Medical Device Litigation

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."


The Stability of Electrically Induced Ventricular Fibrillation


   a. "VF due to electrocution is a benign type of cardiac arrest."


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

   Knowing the time course of this deterioration may allow for improvements in

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

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

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

4. 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


a. Electrically induced VF, wait 8 minutes and defibrillation with 100% success.
However, asphyxia leads to 50% success.


**ABSTRACT**

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

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

**Essentials of Low-Power Electrocutation: Established and Speculated Mechanisms**

1. Abstract – Even though electrocutation 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).

Cardiac Arrest Survival: In-Hospital


a. Among 151,071 participants, 79,091 (52.4%) had an IHCA during off-hours. Risk-adjusted survival improved over time in both groups (on-hours: 16.0% in 2000, 25.2% in 2014; off-hours: 11.9% in 2000, 21.9% in 2014; p for trend <0.001 for both).


Sudden Cardiac Arrest – AEDs – Sports Centres

1. (2017 Aschieri) Aschieri, Daniela, Diego Penela, Valentina Pelizzoni, Federico Guerra, Anna Chiara Vermi, Luca Rossi, Lucia Torretta, Giulia Losi, Giovanni Quinto Villani, and Alessandro Capucci. "Outcomes after sudden cardiac arrest in

a. 26 SCAs (24 (92%) men, 54±17 years old) with 15 (58%) of them in centres with on-site AED. Neurologically intact survival rates were 93% in centres with on-site AED and 9% in centres without (P<0.001).

b. **Conclusions** The presence of on-site AEDs is associated with neurologically intact survival after an exercise-related SCA. Continuous efforts are recommended in order to introduce AEDs in sports and fitness centres, implement educational programmes and increase common awareness about SCA.

**Sudden Cardiac Deaths: Athletes**


**Sudden Cardiac Arrest: Brugada**

CEW Latency Signs and Symptoms Checklists

Autopsy/Forensic Pathology Papers


   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


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 40 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
Latency for Signs and Symptoms of Electrocution

Table 49 Latency for Signs and Symptoms of Electrocution

<table>
<thead>
<tr>
<th>Sign</th>
<th>Time from shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of pulse</td>
<td>Instantaneous. 122 There is no pulse after VF induced.</td>
</tr>
<tr>
<td>Loss of blood pressure</td>
<td>3 seconds. 123</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>1–5 seconds if standing. About 13 ± 4 s if supine. 124</td>
</tr>
<tr>
<td>Cessation of normal breathing</td>
<td>15–60 seconds. 125 Note: agonal breathing can persist for &lt; 6 minutes with a rate around 1–3 BPM (Breaths Per Minute). 126</td>
</tr>
<tr>
<td>Defibrillation success</td>
<td>Electrically-induced VF is defibrillated with a 95% success rate at 10 minutes with any chest compressions with 3 or fewer defibrillating shocks. 127</td>
</tr>
</tbody>
</table>

Necessary, but not Sufficient, CEW Electrocution Diagnostic Criteria


2. Generally:

Table 50 Necessary, not Sufficient, CEW Electrocution Diagnostic Criteria (all must be satisfied)

<table>
<thead>
<tr>
<th>Criteria (all must be satisfied)</th>
<th>Cutoff Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CEW deployed in probe mode</td>
<td>Must be present</td>
</tr>
<tr>
<td>2 Successful delivery of electrical charge to person</td>
<td>Must be present</td>
</tr>
<tr>
<td>3 Conductive electrical path to the heart</td>
<td>Must be present</td>
</tr>
<tr>
<td>4 Lung not between electrode and heart</td>
<td>Must be present</td>
</tr>
<tr>
<td>5 Short DTH (Dart-to-Heart (epicardial) distance)</td>
<td>( \leq 4 \text{ mm (millimeters)} ) DTH\textsuperscript{128}</td>
</tr>
<tr>
<td>6 Cardiac capture ratio [BPM (beats per minute)]</td>
<td>2:1 capture ratio (550 BPM)</td>
</tr>
<tr>
<td>7 Immediate loss of pulse (no pulse after VF)</td>
<td>Any</td>
</tr>
<tr>
<td>8 Loss of blood pressure</td>
<td>3 seconds</td>
</tr>
<tr>
<td>9 Loss of consciousness (LOC)</td>
<td>1-5 seconds (if standing) ( \approx 13 \pm 4 \text{ s (if supine)} )</td>
</tr>
<tr>
<td>10 Cessation of normal breathing</td>
<td>( \leq 60 \text{ seconds} )</td>
</tr>
<tr>
<td>11 Presenting cardiac rhythm</td>
<td>Ventricular Fibrillation</td>
</tr>
<tr>
<td>12 Cessation of agonal breathing</td>
<td>( &lt; 6 \text{ minutes} )</td>
</tr>
<tr>
<td>13 ( \leq 3 ) Defibrillation attempts restoring rhythm</td>
<td>( \leq 10 \text{ minutes} )</td>
</tr>
<tr>
<td>14 Deterioration of VF to asystole</td>
<td>( \leq 21 \text{ minutes} )</td>
</tr>
</tbody>
</table>

Transcutaneous Cardiac Pacing Thresholds and VF Safety Margins

Transthoracic Pacing Thresholds Modeling


   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.”


   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


   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 51 Human Adult Transcutaneous Cardiac Pacing Threshold Literature

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

---

<table>
<thead>
<tr>
<th>Source Information</th>
<th>Minimum (µC)</th>
<th>Minimum Range (in µC)</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1986) Noe&lt;sup&gt;142&lt;/sup&gt;</td>
<td>2000</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>(1987) Barold&lt;sup&gt;143&lt;/sup&gt;</td>
<td>3200</td>
<td>–</td>
<td>1 patient. Termination of all 5 episodes of ventricular tachycardia (VT) was accomplished without rate acceleration or degeneration into VF.</td>
</tr>
<tr>
<td>(1988) Klein, Zipes&lt;sup&gt;144&lt;/sup&gt;</td>
<td>1800</td>
<td>1800–4000</td>
<td>Mean of 2440 µC</td>
</tr>
<tr>
<td>(1989) Heller&lt;sup&gt;145&lt;/sup&gt;</td>
<td>2660 Zoll NTP 1440 PaceAid 53 1600 Redipace 1720 Transpace 2080 LifePak 8</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td>(1990) Luck&lt;sup&gt;146&lt;/sup&gt;</td>
<td>1600</td>
<td>1600–3200</td>
<td>Close “double” captures with max output (5600 µC = 140 mA * 40 ms). Researchers never had VF induced.</td>
</tr>
<tr>
<td>(1993) Vukmir&lt;sup&gt;147&lt;/sup&gt;</td>
<td>25 mA ≥ 500 µC 25–107mA ≥ 500–2140 µC</td>
<td>Pulse widths of 20 to 40 ms were used but were not correlated to specific mA outputs</td>
<td></td>
</tr>
</tbody>
</table>

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


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

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

---


<sup>143</sup> Barold Serge S, Falkoff MD, Ong LS, Heinle RA. Termination of ventricular tachycardia by transcutaneous cardiac pacing. *Brief Communications*. 1987; 114: 180–182.


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

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

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

**Pediatric Transcutaneous Pacing Thresholds**

<table>
<thead>
<tr>
<th>Source Information</th>
<th>Minimum (µC)</th>
<th>Minimum Range (in µC)</th>
<th>Pad Size</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Béland 1987&lt;sup&gt;148&lt;/sup&gt;</td>
<td>1160 µC</td>
<td>1160–3280 µC</td>
<td>Small</td>
<td>53 of 56 patients (ages 0.9–17.9 years) resulted in successful capture</td>
</tr>
<tr>
<td></td>
<td>1440 µC</td>
<td>1440–3680 µC</td>
<td>Med</td>
<td>No complications of NTP were noted.</td>
</tr>
<tr>
<td></td>
<td>1580 µC</td>
<td>1680–3920 µC</td>
<td>Large</td>
<td>No arrhythmias were produced.</td>
</tr>
</tbody>
</table>

Transcutaneous Pacing Threshold to VF Safety Margins

Table 53 Transcutaneous Pacing Threshold to VF Safety Margins

<table>
<thead>
<tr>
<th>Source Information</th>
<th>Safety Factor (mean)</th>
<th>Comments/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984 Voorhees¹⁴⁹</td>
<td>12.6 ± 2.9 (x)</td>
<td>No significant difference between the safety factors for different stimulus durations (1–50 ms) was observed. The threshold pacing strength for rectangular current pulses having durations of 1, 2, 5, 10, 20, and 50 ms, The current for transcutaneous pacing was approximately 70 mA. The current for VF with the same electrode arrangement was approximately 1000 mA.</td>
</tr>
</tbody>
</table>
| 09/2007 Ideker¹⁵⁰  | 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. [Voorhees]
Since the fundamental law of electrostimulation estimates that the average minimum pacing threshold is 2.33 times the size of the TASER X26 pulse, the ventricular fibrillation threshold should be approximately 29 times the magnitude of the TASER pulse.
This estimate is in good agreement with the experimental study of McDaniel et al, who found that the size of the pulses needed to induce ventricular fibrillation in pigs is a mean of 28 times the size of the TASER pulse.
Again, these results are for electrodes located in small regions on the anterior chest; the stimulus strength required to initiate ventricular fibrillation with electrodes at other sites on the body surface should be much higher. |
| 1964 Zoll¹⁵¹       | 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


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. 

   a. (12/2007 Cao) Cao, M., Shinbane, J., Gillberg, J. 

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

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


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

CEW Drive Stun Current Distribution


   a. Conclusion: The fat layer provided significant attenuation of drive-stun CEW currents. Beyond the skeletal muscle layer, only fractional amounts of the total CEW current were estimated to flow. The regions presenting risk for VF induction or for cardiac capture were well away from the typical heart depth.

Other CEW Modeling Studies


   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.”


   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.”


   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.”


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


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


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


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

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

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


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

Summary Analysis: Electrical Safety Standards


   a. 1 Scope. 1.1 This standard is applicable to high voltage Electronic Control Devices (ECD), or Conducted Electrical Weapons, (CEW) used by law-enforcement agencies. This standard specifies the characteristic electrical requirements for effective and safe performance.


   b. “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.”

   c. “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.”
## Electrical Standards Safety Summary

### Table 54 CEW-Related Electrical Safety Standards Primary References

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>In progress</td>
<td>[ANSI] BSR/CPLSO 18-201x, Effects of Charge on Human Beings and Livestock (new standard)(^{152}) [4 May 2018]</td>
</tr>
</tbody>
</table>

\(^{152}\) This standard describes the effects of charge passing through the human body in the form of single and multiple successive discharges. A means of examining random complex irregular charges is given. The charge durations considered are from 1 μs up to and including 100 ms such as may be found in disconnecting auto charging cables. This standard does not consider charge induced within the body caused by its exposure to an external electromagnetic field.

\(^{153}\) 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).
**Conclusion:** The TASER X26, X3, X2, X26(P) CEWs meet relevant sections of the ANSI, 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.

<table>
<thead>
<tr>
<th>X26(E) CEW Meets</th>
<th>Electrical Safety Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Definitions Only</td>
</tr>
<tr>
<td></td>
<td>(IEC) Transitions, pulses and related waveforms - Terms, definitions and algorithms, IEC 60469 (Ed. 1.0), IEC Geneva, Switzerland, 2013 [Published April 23, 2013]</td>
</tr>
<tr>
<td>Yes</td>
<td>ANSI/CPLSO-17-2017, Electrical Characteristics of ECDs and CEWs.</td>
</tr>
<tr>
<td>Yes</td>
<td>(AS/NZS) AS3S59•19131; IEC479-1 &amp; IEC479-2 Australian Standard [IEC title: Effects of current passing through the human body]</td>
</tr>
<tr>
<td>Yes</td>
<td>(BS) EN 60601-1:2006 Medical electrical equipment. General requirements for basic safety and essential performance, 2006 (including corrigenda up to March 2010).</td>
</tr>
<tr>
<td>Yes</td>
<td>Webster's Proposed Safety Test Standard (01/2009).</td>
</tr>
</tbody>
</table>

(02/2017 Adler) CEW Electrical Safety


   a. **Note 8:** There is no specification which applies exactly to the waveforms of complex CEW discharges. In our opinion, the most relevant specification is that of IEC TS 60479 Part 2 (Section 11) which considers the “effects of unidirectional single impulse currents of short durations” (0.1 ms and above). This section of the specification defines curves based on the "probability of fibrillation risk for current flowing through the body from the left hand to both feet". We base our calculation on the "C1 curve" which is defined as "no risk of fibrillation". For a 0.1 ms pulse, this is equivalent to a 710 μC charge. To account for differences in body size and placement of stimulation electrodes, 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.

---

154 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.

we recommend an additional safety factor of four be imposed, so the maximum allowable value for any individual stimulating pulse would be the value listed in the corresponding appendix for specific models of CEW. Since CEW waveforms are not unidirectional, two possible parameters may be compared to the IEC 60479-2 based threshold: 1) Total Charge, or 2) Monophase Charge. Total Charge is a more conservative measure, however, Monophase Charge may be justified based on physiological models such as Reilly et al\textsuperscript{10}. Based on our understanding of the current literature, Monophase Charge is the appropriate measure\textsuperscript{2}. (page 10) (highlighting added)

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


Figure 41 (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:

111
19 Q … “Hence if the X26 Taser were to be assessed according to IEC 2006\textsuperscript{156} and UL 2003\textsuperscript{157} standards for electric fence energizers it would pass the safety test,” is that correct?
20 A That’s correct.
21 Q Was that correct when you wrote it?
22 A Yes.

112
1 Q Was that correct when it was published?
2 A Yes.
3 Q Is that correct today?
4 A Yes.
5 Q And then on that same page on 162 you begin to propose a new standard; is that correct?
6 A Correct.
7 Q And that new standard on page 166, the third paragraph down, it starts, “A similar”? 
8 A Right.
9 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?
10 A Yes.
11 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?
12 A Correct.
13 Q Is that still true today?
14 A Yes.


\textsuperscript{157} Underwriters Laboratories 2003 UL Standard for Electric-Fence Controllers, UL 69 9th edn (Northbrook, IL: UULaboratories).

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

b. In his 2009 paper\textsuperscript{158}, “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.

\textbf{Table 56 2009 Nimunkar/Webster paper electrical device outputs}

<table>
<thead>
<tr>
<th>EUTs Parameters</th>
<th>Units</th>
<th>EFE1</th>
<th>EFE2</th>
<th>EFE3</th>
<th>EFE4</th>
<th>EFE5</th>
<th>Taser</th>
<th>Leak detector</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Without 2 ( \mu )F (IEC)</td>
<td>( A^2 ) ms</td>
<td>7.94</td>
<td>4.04</td>
<td>3.10</td>
<td>0.42</td>
<td>4.69</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total energy</td>
<td>( \mu s )</td>
<td>129</td>
<td>346</td>
<td>91</td>
<td>253</td>
<td>138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>95% energy duration</td>
<td>A</td>
<td>7.65</td>
<td>3.33</td>
<td>5.69</td>
<td>1.25</td>
<td>5.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEC standard</td>
<td>A</td>
<td>13.0</td>
<td>6.21</td>
<td>15.7</td>
<td>7.85</td>
<td>12.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety factor (SF) = IEC standard ( I_{mf} )/I(_{rms})</td>
<td>A/A</td>
<td>1.70</td>
<td>1.86</td>
<td>2.76</td>
<td>6.28</td>
<td>2.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass IEC standard</td>
<td>Yes/No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. With 2 ( \mu )F (UL)</td>
<td>( A^2 ) ms</td>
<td>58.7</td>
<td>21.9</td>
<td>22.6</td>
<td>1.00</td>
<td>18.9</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Total energy</td>
<td>( \mu s )</td>
<td>120</td>
<td>210</td>
<td>140</td>
<td>393</td>
<td>118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>95% energy duration</td>
<td>A</td>
<td>21.6</td>
<td>9.95</td>
<td>12.4</td>
<td>1.55</td>
<td>12.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I(_{rms})</td>
<td>A</td>
<td>8.82</td>
<td>5.96</td>
<td>7.92</td>
<td>3.85</td>
<td>8.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UL standard</td>
<td>A</td>
<td>8.82</td>
<td>5.96</td>
<td>7.92</td>
<td>3.85</td>
<td>8.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pass UL standard</td>
<td>Yes/No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Proposed standard</td>
<td>Voltage</td>
<td>3.88</td>
<td>2.91</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.469</td>
<td>0.0113</td>
</tr>
<tr>
<td>Duration</td>
<td>( \mu s )</td>
<td>233</td>
<td>132</td>
<td>170</td>
<td>1390</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td>A</td>
<td>3.33</td>
<td>4.41</td>
<td>0.55</td>
<td>0.00163</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge</td>
<td>( \mu C )</td>
<td>776</td>
<td>582</td>
<td>93.76</td>
<td>2.26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage ( \times ) SF (1.70)</td>
<td>V</td>
<td>6.60</td>
<td>4.95</td>
<td>NA</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

\textbf{X26 CEW Meets Australian/New Zealand Standards}

1. Australian/New Zealand Standards\textsuperscript{™} (AS/NZS):


c. AS3S59-19131; IEC479-I & IEC479-2 Australian Standard. Effects of current passing through the human body

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


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

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

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

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

g. “The measured X·26 [CEW] results were compared with recognised Australian/New Zealand and the International Electro-technical Commission (IEC) electrical safety standards for the application of electric current to the human body. Both M-26 and X-26 [TASER] outputs were then compared with some typical medical and domestic equipment. As shown in the table (section 3.5), the M-26 Taser output is less than 2% of the normalised current likely to produce ventricular fibrillation. The X-26 improves this figure even more to less than 1% of normalised current likely to cause ventricular fibrillation.” Pg. 24.
h. “The conclusion reached is that the output of the X-26 [TASER] is below the fibrillation threshold set out in the Standard. Our testing showed that the X-26 design is improved over the M-26 providing greater pulse power output with lower total energy outlet. This provides greater electrical safety and better performance than the M-26. From an electrical safety viewpoint the device presents an acceptable risk when used by trained law enforcement officers in accordance with the manufacturers directions for use.” Pg. 25.


**X26 CEW Meets British Safety Standards**

1. BSI British Standards\(^{159}\). BS EN\(^{160}\) 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\(^{161}\). 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\(^3\):

\(^{159}\) 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.

\(^{160}\) European standard are approved by the CENELEC (French: Comité Européen de Normalisation Electrotechnique; English: European Committee for Electrotechnical Standardization). CENELEC members are bound to comply with the CEN(French: Comité Européen de Normalisation; English: European Committee for Standardization )/CENELEC Internal Regulations which stipulate the conditions for giving a European Standard the status of a national standard without any alteration.

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

\(^{161}\) BSI British Standards. BS EN 60601-1:2006 Medical electrical equipment. General requirements for basic safety and essential performance. 2006.
“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 µArms for safety to a lead inserted directly inside the heart. While the 10 µArms limit does not apply to TASER X26 devices, as they are 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\textsuperscript{162}:

   a. Specific IEC Standards:

\textsuperscript{162} International Electrotechnical Commission (IEC) (French: Commission électrotechnique internationale (CEI))

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

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

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

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


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

The IEC 60479 standard deals with effects of electrical current on human beings and livestock\textsuperscript{164,165}. IEC 60479-1 describes the effects of sinusoidal alternating currents with frequencies between 15 hertz (Hz) and 100 Hz and of direct currents passing through the human body, respectively. The effects of non-sinusoidal currents of higher frequencies are covered by IEC 60479-2. Section 11.4 describes the thresholds of VF for impulses of short duration\textsuperscript{2}. It states that “for 50% probability of fibrillation, 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\textsubscript{Cms} as being I\textsubscript{peak}/sqrt(6), for currents approximated as being mostly unidirectional impulses of short durations. The X26 CEW active pulse is mostly unidirectional with a short duration of 126 microseconds (µs), or 0.126 milliseconds (ms). Even if considering I\textsubscript{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\textsubscript{Cms} 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\textsubscript{Cms} 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<sub>rms</sub>, if calculated over the complete duration of one pulse, at the average 19 pulses per second (pps) rate.

Additionally, it is important to note that the X26 CEW peak current stays above 2A for approximately 0.0025 ms, and above 3 A for approximately 0.0012 msec. Consequently, the IEC 60479-2 standard strongly suggests that a single TASER X26 CEW has practically very remote chances, if any, of directly inducing VF in a human. With a sequence of pulses, the VF threshold may decrease (see section 9.2 of IEC 60479-2). However, if its 126 microsecond (µs) pulse duration and corresponding 0.2% duty cycle are taken into account and worked into IEC 60479-2 table 1, section 9.2, page 26, in light of example 1, Fig. 14, the standard strongly suggests that a series of TASER X26 CEW pulses would not significantly decrease the applicable VF threshold (VFT). Consequently, the electrical output of a typical TASER X26 CEW is well within the ‘no fibrillation’ region, as defined by IEC 60479-2, even for an application with a hypothetical duration extending over several seconds.


This International Standard deals with the safety of electric fence energizers. In section 3.118, the standard defines ‘standard load: load consisting of a non-inductive resistor of 500 +/- 2.5 ohm resistor.’ In section 22.108, the standard calls out that an energizer output characteristic shall be such that:

- the impulse repetition rate shall not exceed 1 hertz (Hz);
- the duration of the impulse shall not exceed 10 ms;
- for energy-limited energizers, the energy/impulse in the 500 ohm component of the standard load shall not exceed 5 J/pulse;
- for current-limited energizers the output current in the standard load shall not exceed 15,700 mA<sub>rms</sub> 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


Review of TASER X26 CEW delivered electrical output with respect to requirements of standard UL 69: 2009.

The UL 69 requirements cover electric-fence controllers used only for the control of animals. UL 69 also covers portable and permanently mounted electric-fence controllers with peak-discharge or sinusoidal-discharge output for indoor or outdoor use, including battery-operated controllers intended to operate from battery circuits of 42.4 V or less, line-operated controllers intended to operate from circuits of 125 V or less, combination controllers intended to operate from either a battery or a line circuit, and photovoltaic module battery operated controllers. These requirements do not cover electric-fence controllers for the continuous (uninterrupted) current type or intermediate equipment, such as a converter, a rectifier, or the like, that is sometimes used between the primary source of supply and an electric-fence controller and that is investigated only as part of a complete controller.

UL 69 standard load consists of a non-inductive resistor of 500 ohm resistor with a parallel capacitor of less than 2 microfarads (uFs). Based on such load, the UL 69 standard requires that the energizer output characteristics shall be such that:

- Figure 22.1 of the standard shows the relationship between current (mA) versus time (ms) for the safe levels of current. The equation indicating this relationship is:

  \[ \text{current (mA)} = 2000 \times (\text{pulse duration (ms)})^{-0.7}. \]

  \( \text{For a single impulse with a duration of 0.1 ms, the equation yields:} \)

  \[ I_{\text{single_pulse_UL_limit}} = 10023 \text{ mA}_\text{rms} \]
Abnormal operation restrictions are specified as:

- \( \text{current (mA)} = 2000 \times (\text{pulse duration (ms)})^{-0.7} \times (\text{pps})^{-0.5} \)
- For an impulse with a duration of 0.1 ms and a repetition rate of 19 pps, \( I_{\text{repetitive UL limit}} = 2300 \text{ mA}_{\text{rms}} \)

A typical TASER X26 CEW impulse duration is 0.126 ms. UL 69 defines the pulse duration as the interval of time which contains 95% of the overall energy. Based on this definition, the TASER X26 CEW pulse duration is approximately 0.1 ms. The RMS value of the output current of a typical TASER X26 CEW is 55 mA_{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

   a. (07/31/2010 Adler) See also: Test Procedures for Conducted Energy Weapons, Version 1.1, dated July 31, 2010. Authors: Andy Adler (Carleton University), Dave Dawson (Carleton University), Ron Evans (Datrend Systems Inc), Laurin Garland (Vernac Ltd.), Mark Miller (Datrend Systems Inc.), and Ian Sinclair (MPB Technologies).

   a. “This also allows for the risk assessment of CEWs by comparison to international electrical safety standards. The output of these weapons appears to be well below the VF risk limits as set by these standards.”
   b. “The value of 20 mC [millicoulombs] is also what the IEC (International Electrotechnical Commission) considers to be in the VF risk range for chest exposures.1 Note that the 20 mC value is 200 times that of the typical 100 μC of a CEW and thus there is no risk from a single CEW pulse falling on a T-wave.” Page 257.


6. Jaycor references (included in TASER training materials):
Underwriters’ Laboratories, Inc. (electric fence safety guideline) defined safe electrical current for people between 2 - 75 years of age. IEC 479 is a safety standard commonly used in Europe and Australia. The key concept of this slide is that students see the electrical output of the TASER is at a fraction of the danger level on the chart – a significant safety margin.

INSTRUCTOR NOTES: The X and Y axis of this chart (Body Current and Pulse Width) are logarithmic. The increments are exponential. Hence the M26 and X26 are nowhere close to the dangerous ventricular fibrillation levels in the red zone.
CEW Testing Procedures


ANSI/AAMI NS4:2013 Transcutaneous electrical nerve (TENS) stimulators

1. Transcutaneous electrical nerve stimulators (TENS) guidance:
   a. ANSI (American National Standards Institute)
   b. AAMI (Advancing Safety in Medical Technology)
   c. ANSI/AAMI NS4:2013 Transcutaneous electrical nerve stimulators

2. TASER X26(E) CEW meets the standard:
   a. [Charge] Per section 3.2.2.2, at the duration defined by the standard (i.e. 50% of amplitude) the X26(E) CEW delivers ≈ 50 µC (at 50% of amplitude as defined by the standard)
   b. [Current] Standard stated the average current limit is 10 milliamperes (mA), X26(E) CEW is ≈ 2.1 mA.

   (1) Nerve stimulators have much higher pulse rates than CEWs.
   c. [Warnings are given] “3.1.1 Device Markings If the output of the stimulus generator exceeds Q microcoulombs (μC) per pulse into a 500-ohm load, as defined in 3.2.2.2 (1), the following warning statement, in these or substantially similar words, shall be placed on the device: ‘Not Recommended for Transthoracic Use.’”

3. Standard does not cover electromuscular incapacitation devices
   a. “1.3 Exclusions … 1.3.2 This standard does not cover requirements for line-powered TENS devices, diagnostic stimulators, stimulators for muscle exercise, electrostatic stimulators, electromagnetically coupled stimulators, or electrosleep devices.

4. TASER X26(E) CEW falls below the absolute safety threshold envisioned by the standard committee
   a. X26(E) CEW falls right in the middle of the Q range provided in the rationale for the safety requirement (section B.3.2.2.2 - page 10). The committee reasoned for charge limits in the 25 to 75 microcoulombs (μC). Per section 3.2.2.2, at the duration defined by the standard (i.e. 50% of amplitude) the X26(E) CEW puts out about 50 μC, hence, middle of the range, and well below the 75 μC limit.)
b. The rationale states that the committee envisioned an absolute limit of 75 uC, which the X26(E) CEW certainly satisfies, as pulse duration is defined as 50% of amplitude, as measured per the standard.

3. Standard does not apply, because:

a. Standard is for “medical technology,” not weapons.

i. FDA definition – “medical device: (May 15, 1976) – diagnose or treated medical condition.

b. Standard specifically excludes application to “stimulators for muscle exercise.”

4. 1961 and 1964 Zoll papers used 90 millimeter (mm) (3.5 inches) [percutaneous pacing threshold]

a. [Used 90 mm needles] Zoll 1961, page 336 – “Two long subcutaneous needles (3½-inches [90 mm]), 18- or 19-gauge, spinal needles with shafts Teflon-coated to the terminal half inch) are introduced anteriorly at sites away from the line of the proposed incision, and are advanced in the subcutaneous tissue toward the heart with care to avoid deep penetration.”

b. [Electrodes at myocardiun] Zoll 1961, page 337 – “The distal wires and needles are cut off, and the uninsulated surfaces of the divided ends are turned against the myocardium to avoid stimulation of the phrenic nerve.”

c. Zoll 1964, page 932 – “long subcutaneous precordial needle”

d. [12x safety margin to VF] Zoll 1964, page 935 – “The current required to produce fibrillation was 12 times the stimulating threshold at 1 millisecond and about 25 fold at 2 to 3 milliseconds. This wide margin of safety is greatly reduced at longer durations. Here is a second reason for keeping the stimulus short, for safety as well as for efficiency.”

5. US Food and Drug Administration (FDA)

a. The FDA TENS guidance specifically states that it does not apply to muscle stimulators. For cardiac pacing look to the transcutaneous pacing (TCP) literature which finds thresholds on the order of 1600 µC. Klein L, Miles W, Heger J, Zipes D. Transcutaneous Pacing: Patient Tolerance, Strength-

b. Was withdrawn by the FDA. The final FDA guidelines for both TENS and for muscle stimulators do NOT have any charge/pulse limits.

c. The draft standard is for “medical technology” used to treat medical conditions including pain; not for weapons expressly designed to cause neuromuscular incapacitation and pain. Indeed, the standard specifically excludes application to “stimulators for muscle exercise” at § 1.3.2.

d. Applying the charge duration defined by the draft TENS standard (50% of amplitude at § 3.2.2.2), the X26 CEW delivers ≈ 50 microcoulombs (μC). Accordingly, the X26 falls right in the middle of the Q range and well below the TENS 75 μC safety limit. The standard further states the average current limit is 10 milliamperes (mA), and the X26(E) CEW is ≈ 2.1 mA.

e. TASER has always rated its weapons extremely conservatively by including the low current/low-voltage “tail” of the pulse that really makes minimal contributions. This is why nerve and muscle stimulator standards like this one typically ignore the waveform “tail” and measure the width of the pulse half way up (50%) to the peak of the waveform. As shown in the figure below, the X26(E) CEW pulse width is 42.6 μs:

The first question is the width of the output pulse. Just like the question of how wide a tree is the width must be measured at a certain height above the ground. Otherwise, the roots are included in the width of the tree. The standard definition for nerve and muscle stimulators is that the width is measured half ways up (50%) to the peak of the waveform. See Error! Reference source not found. below which shows that the post duration is 42.6 μs. Note that this number is about half of the typical specification for the X26E CEW (≈ 100 μs) which includes the low current and low-voltage “tail” that really makes minimal contributions. This is why standards typically ignore the “tails” of a waveform. Axon/TASER, on the other hand, has always rated its weapons extremely conservatively by including the tails.
Figure 42 The X26E pulse width is 42.6 µs.

The charge in the X26E CEW pulse is 46.4 µC as seen in Figure 43. Note that this number is about half of the typical specification for the X26E CEW (≅ 100 µC) which includes the low current and low-voltage "tail" that really make minimal contributions.
Figure 43. The X26E CEW net charge is 46.4 µC.
Pain – Electrically Induced


Abstract: In the present human study, we aimed to investigate the facilitation of both the subjective pain responses, and the withdrawal reflex to consecutive transcutaneous electrical stimuli as measures of temporal summation. The frequency (0.5±20 Hz) and intensity (0.4±0.8 times the reflex threshold, xRT) of the electrical stimuli were systematically varied. When using repeated stimulation, the stimulus intensity that evoked pain was lower than that required by a single stimulus (temporal summation). Temporal summation leading to pain was found to depend significantly upon both frequency and intensity (e.g. stimulation at 1 Hz caused summation at 0.8 x RT, whereas stimulation at 20 Hz caused summation at 0.6 x RT). The strongest reflex facilitation, and hence the strongest pain intensity was obtained for stimulation at 10±20 Hz at an intensity of 0.8 x RT. In conclusion, the results of the present human study demonstrate clearly that a stimulus that is perceived as a localised, repetitive tactile tap can be integrated and cause severe pain. This suggests that pathologically generated sparse nociceptive afferent activity causes strong pain by central integration. This might be one mechanism to explain why clinical conditions can become excruciatingly painful despite the fact that the pathophysiological changes seem to be marginal (e.g. minor nerve trauma).
Electroconvulsive Therapy (ECT), Seizure Threshold (ST)

Bui (2009)\textsuperscript{166} temporal case report regarding alleged CEW induced-seizure.

Factors Suggesting that the X26(E) CEW Did Not Electrically-Induce a Seizure:

- Non-optimal dart-contact locations to electrically-induce seizure:
  - The CEW darts contacted in the occiput and upper back (in his body armour).
  - Occipital bone is the densest, thickest bone of the skull. Due to its very high electrical resistivity, bone is known to attenuate electrical currents significantly.

- CEW dart apparently did not penetrate occipital bone

- CEW discharge less than the seizure threshold (ST) (even in optimal seizure-inducing head locations). The ST is many times the delivered output (charge and energy) of the X26(E) CEW.

- CEW probes to head and eye are generally not reported to have induced a seizure.

- Numerous authors inappropriately conflate Bui’s “may result” to confirmed or “did” result in seizure.

- Case reports (e.g. Bui) and case series are not reliable for determining causation.

- March 17, 2009 – Bui case report

  - “Our [case] report shows that a taser shot to the head may result in brain-specific complications. It also suggests that seizure should be added to the list of taser-related adverse events.” Bui, at 625 (highlighting added).

Electrical Characteristics of TASER X26(E) Conducted Electrical Weapon (CEW) (X26(E) CEW):\textsuperscript{167}

- The mean X26(E) CEW pulse (P) rate is 17.5 ± 1.7 pulses per second (PPS)

- The net charge per pulse is 107.8 ± 7.6 µC.

- For a 5-second delivery, the total charge is: 9.4 mC = 5 s • 17.5 PPS • 107.8 µC.

Basic Analogy Example to an Electroconvulsive Therapy (ECT) Device

An ECT device is used to deliver an electrical stimulus to the brain as a therapy for severe depression and other psychiatric conditions. The Somatics® Thymatron® System IV delivers 0.9 A constant current with a pulse width of 0.25 to 1.5 ms in 0.25 ms increments, for up to 8 s pulse train duration.\textsuperscript{168} This gives a total of up to 1008 mC of total charge and up to 188.8 J of energy—directly to anterior areas of the head. This is over 20 times more energy than delivered by the TASER X26(E) CEW over a full 5-second application. Similarly, MECTA spectrum 4000/5000 Q™ or M™ devices deliver pulses of up to 1 ms width, up to 8 s application duration, 800 mA amplitude, and up to 202.8 J total energy and 1152 mC total charge.\textsuperscript{169} Similarly, ECTonustim series 6, made by Ectron, Ltd., Bristol, United Kingdom (“UK”), delivers 0.9 A of constant current and 200 to 1000 mC of total charge.\textsuperscript{170} As illustrated in cited specifications, a typical ECT unit delivers between 500 and 900 mA of current, while the X26(E) CEW delivers 1.9 mA aggregate current.

\textsuperscript{166} Bui ET, Sourkes M, Wennberg R. Generalized tonic-clonic seizure after a taser shot to the head. Cmaj 2009;180:625-6.


\textsuperscript{168} See http://www.thymatron.com/main_home.asp.


\textsuperscript{170} See https://www.ectron.co.uk/ectonustim-constant-current-series-61.
Table 57 Electrical Characteristics ECT Compared with CEW

<table>
<thead>
<tr>
<th>Electrical Characteristic</th>
<th>ECT Somatics</th>
<th>ECT MECTA</th>
<th>ECTonstim</th>
<th>X26(E) CEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy per session (J)</td>
<td>Up to 188.8 J</td>
<td>Up to 202.8 J</td>
<td>Not specified</td>
<td>9 J</td>
</tr>
<tr>
<td>Pulse charge (µC)</td>
<td>Up to 1350 µC</td>
<td>Up to 1152 µC</td>
<td>Up to 900 µC</td>
<td>108 µC</td>
</tr>
<tr>
<td>Pulse width (µs)</td>
<td>250–1500 µs</td>
<td>300–1000 µs</td>
<td>600–1000 µs</td>
<td>100 µs</td>
</tr>
<tr>
<td>Application time (duration) (s)</td>
<td>Up to 8 s</td>
<td>Up to 8 s</td>
<td>Not specified</td>
<td>5 s (officer can stop early)</td>
</tr>
</tbody>
</table>

United States (U.S.) Food and Drug Administration (FDA):

The FDA has issued regulatory guidance for ECT devices. The predicate devices discussed by this FDA guidance deliver safe total charge levels of 576 mC and total energy levels of 101.4 J. Note that the corresponding adverse event rate for these ECT devices is very low. Their charge and energy levels are at least 58 and 11 times greater than the respective X26(E) CEW levels. Hence, adverse event rates with X26(E) CEW, if any, should be correspondingly much lower than those for FDA-approved ECT devices. A summary of electrical outputs is provided in the following Table.

Bui (17 March 2009) Published Case Report:

Statement of Incident from Bui (17 March 2009) Case Report:

The patient was a previously well police officer in his 30s who took part in a police chase involving a suspected robber. He and a colleague cornered the suspect, who initially appeared to surrender but then attempted an escape. The officer had begun to chase the suspect on foot when he experienced a sudden, severe pain in the back of his head. He later described the moment as feeling like he had been “hit by a bat.” He recalled letting out a brief gasp before losing consciousness. He had no recollection of falling to the ground on top of the suspect. Police records indicate that the officer’s colleague had fired a taser shot meant for the suspect but that the 2 copper darts had instead struck the officer in the occiput and upper back. The officer had been wearing an armoured vest. Immediately after being shot, he was found by his colleague to be unresponsive and foaming at the mouth. His eyes were rolled upward and he had generalized tonic-clonic movements with apnea lasting for about 1 minute. He did not have urinary incontinence. Postictally, he was initially confused and combative. Emergency medical services personnel were able to restrain him. They recorded a Glasgow Coma Score of 9 within 5 minutes after arrival; 5 minutes later, his score was 13.

---

Bones of the human skull

Figure 44 Bones of Human Skull and Occipital Bone

**Thickness of the Occipital Bone in Adult (including 35-year-old) Males:**

- “The thickness of mid-occipital point was the highest and measured 9.5 mm”
- “The maximum thickness of the occipital bone could be measured at the external occipital protuberance (mean 15.4 mm; range 9–29.3 mm).”
- The electrical resistivity of the human bone tissue is, on average, 1,000,000 Ω·cm, much higher than that of any other human tissue.

**Electrically-Induced Seizure Thresholds:**

1. Deng et al. studied E fields in the brain that are capable of triggering seizures. They used ECT pulses with a duration of 0.3 ms. For such duration, E fields of 0.85 V/cm were the lowest proven to be capable of inducing seizures. As discussed in their article and as known by biomedical scientists, electric fields are responsible for setting up voltage gradients sufficient to depolarize nerve cell membranes. In other words, if the voltage gradient across a nerve cell membrane does not exceed a known threshold, then the nerve would be excited and would not propagate excitations. According to Deng et al., for seizure induction with 0.3 ms pulse duration this threshold is 0.85 V/mm. The duration of X26(E) CEWs is approximately 0.1 ms. As such, accounting for the nerve response time of 0.15 – 1 ms, the Weiss-Lapicque strength-duration formula provides for a X26(E) CEW seizure induction threshold of 2.5 V/cm, or 0.25 V/mm. Adler et al. tested 208 X26(E) CEWs and found that none had peak output voltages which exceeded 2300 V. Sinclair, on behalf of MPB Technologies,

---


tested 412 X26(E) CEWs. All devices had peak voltages within manufacturer’s specifications. X26(E) CEW specifications list a maximum peak voltage value of 2520 V.

2. Comparison of Electroconvulsive Therapy (ECT) Seizure Thresholds (ST): Table V presents ECT dosage for induction of seizure in patients.

Table 58 ECT device dosage for induction of seizure.

<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>n</th>
<th>Pulse Width (ms)</th>
<th>Pulse Current (mA)</th>
<th>Charge per pulse (µC)</th>
<th>Total charge of session (mC)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>Sackeim</td>
<td>52</td>
<td>UNK</td>
<td>UNK</td>
<td>UNK</td>
<td>154 ± 86.8</td>
<td>RUL &amp; BL</td>
</tr>
<tr>
<td>1995</td>
<td>Coffey</td>
<td>19</td>
<td>1</td>
<td>800</td>
<td>800</td>
<td>66.5 ± 26.3</td>
<td>RUL Males</td>
</tr>
<tr>
<td>1998</td>
<td>Devanand</td>
<td>12</td>
<td>1</td>
<td>800</td>
<td>800</td>
<td>90 ± 27.3</td>
<td>RUL &amp; BL</td>
</tr>
<tr>
<td>1998</td>
<td>Devanand</td>
<td>12</td>
<td>1</td>
<td>800</td>
<td>800</td>
<td>114 ± 35.6</td>
<td>RUL &amp; BL</td>
</tr>
<tr>
<td>2001</td>
<td>Chanpattana</td>
<td>88</td>
<td>1</td>
<td>600-900</td>
<td>1200-1920</td>
<td>103.1 ± 45.5</td>
<td>Bilateral</td>
</tr>
<tr>
<td>2002</td>
<td>Chung</td>
<td>54</td>
<td>1</td>
<td>800</td>
<td>800</td>
<td>117.4 ± 65.6</td>
<td>Bilateral</td>
</tr>
<tr>
<td>2012</td>
<td>Swartz</td>
<td>18</td>
<td>0.5</td>
<td>900</td>
<td>450</td>
<td>162.8 ± 98.4</td>
<td>Bilateral</td>
</tr>
<tr>
<td>2012</td>
<td>Swartz</td>
<td>18</td>
<td>0.5</td>
<td>1150</td>
<td>575</td>
<td>125.1 ± 55.5</td>
<td>Bilateral</td>
</tr>
<tr>
<td>2015</td>
<td>Gálvez</td>
<td>179</td>
<td>0.3</td>
<td>800</td>
<td>240</td>
<td>31.7 ± 22.2</td>
<td>RUL</td>
</tr>
</tbody>
</table>

RUL = Right Unilateral, BL = Bilateral

Figure below shows a significant separation between the X26(E) CEW 5 s total charge spec (9.4 mC – green line) and the seizure thresholds from numerous studies.

---

There are 2 critical metrics for pulse trains causing seizures. The 1st is the pulse charge as it must be large enough to cause any stimulation. The studies above — using optimal electrode placement — required 600–1150 µC compared to the net charge of the X26(E) CEW of ~ 108 µC. The 2nd is the cumulative effect of multiple pulses as measured with Total Session Charge in mC. Chung attempted ECT stimulation at initial charge levels of 48 mC and 80 mC for female and male patients, respectively. Charge outputs below these initial values were ineffective. Note that the above thresholds ranged from 32 to 163 mC compared to 9.4 mC for a 5-second X26(E) CEW discharge. Thus, even had the dart been at the sensitive frontotemporal location — which it was not — the X26(E) CEW could not have induced a seizure.

Additionally, the studies cited above all show that long-duration seizure correlate with stronger pulse trains. Typically, as per studies above, pulse trains carrying total charge levels at the seizure threshold (ST) are capable of inducing short events that last only about 30 s. If Bui (2009) case report hypothesis was correct, implying that the subject suffered a seizure that lasted minutes (i.e. Dr. Bui contended that the Glasgow Coma Score recovered only after more than 5 min), such event would have required application of electrical charge levels significantly in excess of minimal seizure thresholds. As explained in the paragraph above, the X26(E) CEW delivers charge levels which are at least 5 times lower than

---


minimal seizure thresholds even at the seizure-inducing optimal locations. Therefore, a seizure of the duration claimed by the Bui (2009) case report could have not been induced by the low output charge delivered by X26(E) CEW.

Additionally, finite element analyses (FEA) have shown that, due to its high electrical resistivity, bone tissue attenuates significantly CEW currents.\textsuperscript{187,188,189} Previous FEA studies have estimated the CEW-current attenuation caused by the bone to exceed 50%. As such, seizure thresholds discussed in the literature, as cited in the table above, should be increased by at least a factor of 2 before being extrapolated to CEW devices.

**Electroconvulsive Therapy (ECT) Electrode Locations:**\textsuperscript{190,191,192}

![ECT Electrode Locations](image)

Fig. 1. Simulation models of BL, BF, RUL, FEAST, and FM ECT as well as CIRC MST (top row). E-field stimulation strength relative to neural activation threshold (\(E_a\)) at current of 800 mA for BL, BF, and RUL ECT, 612 mA for FEAST, 560 mA for FM ECT, and 100% Magstim Theta output for CIRC MST coil configuration on the cortical surface (middle row) and in a representative coronal slice (bottom row). \(E_a\) is 0.25 V/cm for ECT and 0.64 V/cm for MST. R: right.

**Figure 46 Lee WH, Lisanby SH, Laine AF, Peterchev AV. Stimulation strength and fociality of electroconvulsive therapy and magnetic seizure therapy in a realistic head model. Conf Proc IEEE Eng Med Biol Soc 2014;2014:410-3.**


\textsuperscript{192} Deng ZD, Lisanby SH, Peterchev AV. Electric field strength and fociality in electroconvulsive therapy and magnetic seizure therapy: a finite element simulation study. *Journal of neural engineering* 2011;8:016007.
Additional Materials:


  “Seizures, although not observed in field usages, were believed to have a probability of 0.7%, based on a worst case scenario. This worst case scenario was based on a probe striking the head area with an accompanying electrical exposure that exceeded the seizure threshold.” Page 20


  “The risk for experiencing a seizure (similar to a grand mal seizure induced during electroconvulsive therapy) after receiving a CEW head shot, although speculated in the literature as being relatively high (Reilly & Diamant, 2011), has only been documented in a single case study that involved a CEW shot to the upper back and head (Bui et al., 2009).” (page 5)

Below from bottom of page 88

The Goudge (2013), relying on Reilly (2011)194, relying on Bui (2009) inaccurately conflates the occurrence of CEW-induced seizure, just as other literature also errs.

Table 59 ECT Bui (temporal), Reilly (2011), and Goudge (2013) Excerpts

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title: “Generalized tonic-clonic seizure after a taser shot to the head” [temporal, not causal]</td>
<td>“We are aware of one well-documented incident of an induced seizure from a Taser shot (Bui et al, 2009).” Reilly, at 187 (highlighting added).</td>
<td>“The risk for experiencing a seizure (similar to a grand mal seizure induced during electroconvulsive therapy) after receiving a CEW head shot, although speculated in the literature as being relatively high (Reilly &amp; Diamant, 2011), has only been documented in a single case study that involved a CEW shot to the upper back and head (Bui et al., 2009).” Goudge, at 5 (highlighting added).</td>
</tr>
</tbody>
</table>

---


Just as Dyer\(^{195}\) inappropriately conflated the Bui “may result” to “[k]nown health risks include ... tonic-clonic seizures in healthy people” [citing Bui][highlighting emphasis added].

Reilly (2011):

Reilly (2011) inappropriate conflated Bui’s “may” (as Bui expressed temporally) to “did”.

In Reilly’s book. In Chapter 10 [Electric Stun Devices and Electric Shock], Mr. Reilly states that CEWs deliver charge levels close to ECT threshold. As evidence, he cites Table 9.1 [Chapter 9: Electrostimulation of the Central Nervous System]. However, Table 9.1 has nothing to do with charge, does not even mention ECT or charge. Instead, Table 9.3 provides ECT thresholds.

Unfortunately, Table 9.3, does not provide independent ECT charge thresholds. Instead, Table 9.3 provides ECT thresholds which were computed by Mr. Reilly, rather than being cited from independent sources. Even more troublesome, Mr. Reilly implied that Weaver and Williams (1986) provided support for Mr. Reilly’s ECT threshold data. However, Weaver and Williams (1986) did not provide any ECT thresholds which were in the µC range. Instead, Weaver and Williams’ ECT charge thresholds were in the 100+ mC range, a level which is at least 11 times greater than the charge delivered by TASER X26 CEWs. The fine print below Table 9.3 clearly indicates that the ECT thresholds were based on Mr. Reilly’s computational model from section 10.6.2. Thus, this is a vicious scientifically unreliable and unsupported circle because in Chapter 10 Mr. Reilly refers the reader to Chapter 9 for ECT thresholds, but in Chapter 9 he refers the reader back to Chapter 10 for a justification of the numbers in Chapter 9. Reilly’s methodology in this regard is highly flawed and his thresholds are wholly unsupported and inconsistent with the abundant ECT seizure-threshold literature. Furthermore, the computational model from Mr. Reilly’s section 10.6.2, if applied to data provided in Table 9.3, seems to imply that the entire amount of current applied by an ECT device reaches deep to the nerve structures responsible for seizure induction. As well known, current travels through the skull before reaching brain structures. In such process, significant attenuation occurs. In Table 9.3, as per model in section 10.6.2, Mr. Reilly merely multiplies the 60-Hz current output of an ECT device, 587 mA, by nerve fiber time constant of 0.15 ms and obtains an ECT charge threshold of 88 µC. This modality of estimating ECT charge threshold for short pulses does not take into account the attenuation of the currents delivered by ECT devices. The implied ECT charge threshold of 88 µC might be correct if the entire magnitude of stimulation current were applied directly to the nerve fiber. But that is not the case, as the stimulation current is significantly attenuated by the skull and other tissues before it reaches nerve fibers responsible for seizure induction. If such attenuation were taken into account, the ECT charge threshold, as computed at the stimulator output, would be significantly higher. Mr. Reilly’s computational model presented in section 10.6.2 is also in

---

contradiction with decades-old data published in the field of cardiac stimulation.\textsuperscript{196,197,198,199,200,201,202} For example, the IEC 60479-1 gives the transcutaneous 60 Hz threshold for induction of ventricular fibrillation (VF) equal to 38 mA_{\text{rms}}.\textsuperscript{27} Using the chronaxie value for direct cardiac stimulation of 240 \mu s, Mr. Reilly’s model would yield a transcutaneous VF charge threshold of about 12 \mu C. Such low value is in direction contradiction with transcutaneous cardiac stimulation results published by Berliner \textit{et al.}, Vorhees \textit{et al.}, Zoll \textit{et al.}, etc.\textsuperscript{29, 30, 31, 32} These publications provide transcutaneous cardiac stimulation thresholds of at least 500 \mu C. According to results published by Zoll\textsuperscript{32}, transcutaneous VF thresholds are between 5 – 10 cardiac stimulation thresholds. Hence, transcutaneous VF thresholds should exceed 2.5 mC, according to published results.\textsuperscript{29, 30, 31, 32} These results are also consistent with more recent data published by Walcott \textit{et al.}\textsuperscript{33} Of course, as per studies cited above, transcutaneous VF threshold depend on electrode configurations, geometry, size, waveform, etc. An oversimplified model, such as Mr. Reilly’s does not take these variables into account. The discussion presented above underlines the danger and the inaccuracy of oversimplified excitation models, such as that presented by Mr. Reilly in section 10.6.2 of his book.\textsuperscript{25} Consequently, given its likely large threshold estimation errors, Mr. Reilly’s excitation model cannot be applied to derive ECT thresholds.

Also, CEW probes to the head\(^\text{203,204}\), including the eye\(^\text{205,206,207,208,209,210,211,212,213}\), are not reported to have electrically-induced a seizure.

**Case Reports (such as Bui) and Case Series are not Reliable for Determining Causation:**

Karch (2007)\(^\text{214}\) “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;”

Ho (2008)\(^\text{215}\) “Case series generally provide weak evidence of causality because they are particularly prone to bias and confounding.” ... In the hierarchy of scientific evidence a case series has important weaknesses, including: “[l]ack of comparison group markedly limits conclusions about causality” and “[r]isk, incidence, prevalence cannot be ascertained.”

---


Zipes’ 2012 and 2014 “Case Series” and Selected Related Documents

(Zipes’ CEW Pacing → VF Theory) Mortality and Timing Death: Runaway Pacemakers


   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


   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. (11/2014) Letters regarding Kroll and Zipes’ papers:


   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**

“In the field, there has not been a conclusive case of fatal ventricular fibrillation caused solely by the electrical effects of a CEW (NIJ, 2011). A small number of human cases have found a temporal relationship between CEWs and fatal cardiac arrhythmias (Swerdlow et al., 2009; Zipes, 2012) but they do not allow for confirmation or exclusion of a clear causal link. The study by Zipes (2012) is particularly questionable since the author had a potential conflict of interest and used eight isolated and controversial cases as part of the analysis (Myerburg & Junttila, 2012). In addition, both studies examined individual cases of CEW proximal deaths without any corresponding data from control cases where death was not

---

the outcome (Swerdlow et al., 2009; Zipes, 2012).” (emphasis added) (pg 36)

October 2013 (Canada) Hall RESTRAINT Quote:217

“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.218 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.219

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.220 Whether such combination functions as a marker for the severity of the agitation or as a causative factor is unstudied.” (Page 15-16).

Zipes’ (2012) Paper is a “Case Series”

Zipes’ paper is a “case series.”

Dr. Douglas P. Zipes' paper is a “case series.” “Case series generally provide weak evidence of causality because they are particularly prone to bias and confounding.”221 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.”222

Zipes’ “Case Series” Related Documents


   a. “Conclusion: ECD stimulation can cause cardiac electrical capture and provoke cardiac arrest resulting from ventricular tachycardia/ventricular fibrillation. After prolonged ventricular tachycardia/ventricular fibrillation without resuscitation, asystole develops.”

   b. The case series premise is that an X26 CEW delivered sufficient electrical charge stimulating the hearts of eight individuals to induce cardiac arrest. Seven of the eight subjects died. None of the seven forensic pathologists (medical doctors) involved in the autopsies agreed with Zipes’ conclusion.

---


222 http://circ.ahajournals.org/site/misc/about.xhtml. (accessed September 22, 2013).

   a. “The source of the data leads to some concerns about distortions and biases that can develop during the adversarial litigation process, but overall there is enough objective data to support reasonable judgments in the individual cases, if not definitive conclusions generalizable to all cases. Based on the circumstances, timing, and rhythm strips provided, and the pathological data provided, it seems reasonable to conclude that some finite number of these cases, >0, but likely <8, demonstrates a direct association between delivery of an ECD shock and the onset of cardiac arrest in an individual in whom other possible causes are not present.” (emphasis added).

   i. “One of the problems in interpreting the data is that there were undisputed pathological findings of a normal heart in only 2 of the 7 autopsied fatal cases, with a mildly elevated heart weight and a blood alcohol level of 0.25 g/100 mL in 1 of these 2. In both of these cases, the descriptions of the incidents and supporting data lend credence to the likelihood of an association that is strong enough to demonstrate a cause-and-effect relationship.”


223 (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.”


   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.”

---

224 (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**


a. Epinephrine initially decreased VFT, then increased VFT. (Figure 1).

*Table 60 Zipes, 1975 Epinephrine increased VFT. (pg III-123)*

<table>
<thead>
<tr>
<th>Some Factors that Affect Refractory Period Dispersion or Ventricular Fibrillation Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased RPD or decreased VFT</td>
</tr>
<tr>
<td>Myocardial ischemia</td>
</tr>
<tr>
<td>Slower heart rates without ischemia</td>
</tr>
<tr>
<td>Faster heart rates with ischemia</td>
</tr>
<tr>
<td>Sympathetic nerve stimulation</td>
</tr>
<tr>
<td>Ventricular premature systoles</td>
</tr>
<tr>
<td>Acidity</td>
</tr>
<tr>
<td>Osmotic toxicity</td>
</tr>
<tr>
<td>Aminophylline</td>
</tr>
<tr>
<td>Digitalis with autonomic denervation or propranolol</td>
</tr>
<tr>
<td>Hypothermia</td>
</tr>
<tr>
<td>Quinidine (high doses)</td>
</tr>
<tr>
<td>Chloroform</td>
</tr>
</tbody>
</table>

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

**Zipes: (1988) Transcutaneous Cardiac Pacing Thresholds (1800-4000 µC)**


a. Cardiac Pacing Thresholds:

i. Minimum cardiac pacing threshold: 1800 microcoulomb (μC).

ii. Minimum range cardiac pacing threshold: 1800–4000 μC.

iii. Mean cardiac pacing threshold: 2440 μC.

b. Also, the 1988 Klein paper (their Fig. 2) showed that it took another 20 mA (milliamperes) (= 800 μC) to get more rapid pacing similar to that attainable with an internal pacemaker. And, this was at a pacing rate still far slower than the rate required or necessary to induce ventricular fibrillation (VF).
Zipes: (1977) VFT in Dogs (mean: 43.2 ± 25 µC)


a. Mean ventricular fibrillation threshold (VFT): 43.2 ± 25 µC. (4 ms times 10.8 mA)

b. “Ventricular fibrillation threshold was initially measured repeatedly at the same site in 11 dogs using an electrode sutured to the left ventricular epicardium. In five of these dogs, after four to six determinations, the ventricular fibrillation threshold increased from 10.8 ± 6.2 to 21.5 ± 8.5 ma (mean).” Page 930. (emphasis added).

c. “Ventricular fibrillation threshold: This was determined by delivering in the T wave of every 10th regularly paced beat a 200 msec train of stimuli that spanned the T wave but did not extend into the T wave of the first premature ventricular beat.” Page 930.
Selected Scientific Literature Criteria

Case Series Not Reliable for Determining Causation

   a. “…We did not include specific case reports or case series which in and of themselves cannot support any causal connection between CEWs and physiologic changes. …” (page 601)
   b. “… We also did not include animal studies, which are often more limited in scope and have questionable applicability to clinical human findings.” (pages 601-602)

   a. “Case series generally provide weak evidence of causality because they are particularly prone to bias and confounding.”
   b. In the hierarchy of scientific evidence a case series has important weaknesses, including: “[l]ack of comparison group markedly limits conclusions about causality” and “[r]isk, incidence, prevalence cannot be ascertained.”

Case Reports Not Reliable for Determining Causation

   a. “Case reports are incomplete, uncontrolled, retrospective, lack operational criteria for identifying when an adverse event has actually occurred, and resemble nothing so much as hearsay evidence, a type of evidence that is prohibited in all courts in all of industrialized societies;”

Selected Scientific Logical Fallacies

1. Scientific logical error of the “residue fallacy.” Simply put, conspiracy fans often go to the rare residues while scientists reject them as lacking in statistical significance and contradicting the larger body of evidence. Conspiratorialist things: “After all the bad data, fakes, and errors are weeded out, there are still a few unexplained cases that indicate a real phenomenon. Scientific thinking: if 99
% of the data is contrary to the conspiracy theory, what makes you think the residue isn't as well?

2. **Logical error of the “Argument from Ignorance fallacy.”** An argument is fallacious when it maintains that a proposition is true because it has not been proved false or false because it has not been proved true. As an example, in some cases plaintiffs try to suggest that the TASER CEW provably caused a cardiac arrest in a certain individual, and unless TASER can prove an alternative causation. Over 1000 human beings suffer a cardiac arrest every day in the USA and about 3 people suffer an arrest-related-death (ARD) every day in the USA. By selecting rare cases where an ARD was not prevented by a TASER CEW, the plaintiffs may attempt to argue that that somehow proves that the CEW actually caused an ARD or cardiac arrest. Plaintiffs might as well “prove” that the handcuffs caused a cardiac arrest by phrasing the allegations slightly differently.
Quantum of Force

1. Possible Quantum of Force Probe versus Drive Stun Table (many variables to determine quantum of force for each CEW exposure):

<table>
<thead>
<tr>
<th>Probe Deployment (&lt;i&gt;Bryan v. MacPherson&lt;/i&gt;&lt;sup&gt;225&lt;/sup&gt;)</th>
<th>Drive–Stun (single set of electrodes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;[TASER CEW], in general, is more than a non-serious or trivial use of force but less than deadly force,，“</td>
<td>Factors:</td>
</tr>
<tr>
<td>• Intermediate quantum of force</td>
<td>• painful, only transitory, localized pain</td>
</tr>
<tr>
<td>• Significant quantum of force</td>
<td>• non-incapacitating effect</td>
</tr>
<tr>
<td>• Justified by a strong government interest</td>
<td>• without incapacitating muscle contractions</td>
</tr>
<tr>
<td>Factors:</td>
<td>• without significant lasting injury</td>
</tr>
<tr>
<td>• Pain was intense, felt throughout the body,</td>
<td>• has markedly different physiological effects</td>
</tr>
<tr>
<td>• CEW effectively commandeered the person's muscles and nerves</td>
<td>Basics:</td>
</tr>
<tr>
<td>Holding:</td>
<td>• Less-than-intermediate quantum of force</td>
</tr>
<tr>
<td>• X26 CEW is “an intermediate or medium, though not insignificant, quantum of force.”</td>
<td>• Amount of force more on par with pain compliance techniques</td>
</tr>
<tr>
<td>• use of a [TASER X26 CEW], in a manner equivalent to dart mode, “constitute[s] an intermediate, significant level of force that must be justified by a strong government interest that compels the employment of such force.”</td>
<td></td>
</tr>
<tr>
<td>Injuries in Bryan (as stated in &lt;i&gt;Brooks v. Seattle&lt;/i&gt;):</td>
<td></td>
</tr>
<tr>
<td>• excruciating pain throughout his entire body,</td>
<td></td>
</tr>
<tr>
<td>• temporary paralysis, [resulting in fall to hard surface]</td>
<td></td>
</tr>
<tr>
<td>• facial abrasions,</td>
<td></td>
</tr>
<tr>
<td>• shattered teeth, and</td>
<td></td>
</tr>
<tr>
<td>• a sharp barb lodged into his flesh.</td>
<td></td>
</tr>
</tbody>
</table>

---

<sup>225</sup> "We recognize the important role controlled electric devices like the [TASER X26 CEW] can play in law enforcement. The ability to defuse a dangerous situation from a distance can obviate the need for more severe, or even deadly, force and thus can help protect police officers, bystanders, and suspects alike. We hold only that the X26 and similar devices constitute an intermediate, significant level of force that must be justified by "a strong government interest [that] compels the employment of such force.""
Legal: Selected Court Cases Regarding CEWs as a Level of Force

Inappropriate CEW Use on Pre-Trial Detainees


Selected General Force Statements

  - "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."
  - "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)."
  - "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)."

  - "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."
  - "...‘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

“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**


- 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, holding:

If true that a policy existed in which officers were trained to use only their own subjective judgment when firing a Taser, such a policy would be in violation of the constitutional standards for use of force. Therefore, provided it was the moving force behind the violation, the policy would subject the municipality to liability. Id.

The court agrees with Judge Campbell’s analysis and finds that the Alusas have demonstrated that there are disputed issues of material fact regarding what training standards were used by Salt Lake County regarding the use of force and whether the training was inadequate as a result. While the Alusas still have to prove that the County was deliberately indifferent and that the inadequate training was the cause of Mr. Alusa’s constitutional deprivation, a reasonable jury could answer these questions in favor of the Alusas. Accordingly, the Defendants’ Motion for Summary Judgment is DENIED as it pertains to the Alusas’ failure to train claim.


In denying law enforcement defendant’s motion for summary judgment on failure to train on use of force the Court stated “…although the officers were trained on the proper use of the [TASER CEW], there is no indication that the officers were trained on the constitutional limitations of excessive force.” 913 F.Supp. at 680.

- Cavanaugh v. Woods Cross City, Not Reported in F.Supp.2d, 2009 WL 4981591 (D.Utah, December 14, 2009); aff’d, 625 F.3d 661 (10th Cir. (Utah) Nov 03, 2010); jury’s defense verdict aff’d, 718 F.3d 1244 (10th Cir. (Utah) Jun 12, 2013):
Specifically, Plaintiffs allege that Woods Cross’s unwritten policy, established by Chief Howard, allowed for use of a Taser in the sole discretion of the officer without reference to warnings, violence of the offender, or danger to others. FN6 Chief Howard clearly testified that he ordered trainers to abandon the written use of force policy and replace it with a “reasonably necessary” policy. Although Chief Howard’s deposition is somewhat confused, he also consistently and repeatedly testified that officers were told in their training that the decision to use force is a solely subjective analysis. FN7

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

  o “In sum, the jury concluded that the City of Bainbridge Island failed to provide any training to its officers on how to deal with the mentally ill. That failure led Officers Benkert and Portrey to confront Douglas Ostling without any pressing need and without any forethought as to how the schizophrenic man might react. The jury was entitled to believe that just such a confrontation was foreseeable, avoidable,
and ultimately caused the deprivation of William and Joyce Ostling’s substantive due process right to the society of their son.”

- **III. CONCLUSION.** Defendants’ remaining arguments follow mainly from their erroneous premise—that the City and Chief Fehlman cannot be liable absent a determination that Officer Benkert was individually liable. (See Defs.’ Mot. for J. at 16–23). The Court must reject these arguments en masse. As the foregoing discussion indicates, the evidence presented at trial was sufficient to permit the jury to find that the City and Chief Fehlman failed to train their officers in their own policies on confronting the mentally ill. That failure led Officers Benkert and Portrey to forcibly and needlessly confront a schizophrenic man, creating a situation in which they were forced to shoot him. Defendants’ Renewed Motion for Judgment (Dkt.# 148) is DENIED.”

**Failure to Train: Use of Force on Injured Suspects**

  - Court denied law enforcement motion for summary judgment on plaintiff’s failure to train theory of: “the Court finds that the Department did not offer any training on injured subjects as part of its in-service trainings; nor did the department issue guidelines on handling injured persons in its general orders dealing with use of force.”
  - Officer had been POST certified and department trained, but, not on guidelines or use of force on handling injured persons.
Targeting

  - “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.

  - “The only direct evidence we have on that score comes from Officer Harris who expressly disclaimed any such state of mind, saying that he aimed for Mr. Wilson’s body, not his head. Of course that testimony is self-serving, but it seems to bear corroboration in other facts found by the district court, including the fact the two men were running “headlong” through rough terrain as they approached the second fence; they were “about 15 feet” away from each other at the time; and events unfolded extremely rapidly as Mr. Wilson approached the second fence. See D.Ct. Op. at 12–13. Neither do we have any evidence about the taser's record of accuracy, let alone under such dynamic and unstable circumstances. Cf. *Forrest v. Prine*, 620 F.3d 739, 746 (7th Cir.2010) (“No reasonable jury could believe that a police officer, although trained in the use of tasers, always hits precisely his target when the target is moving.”). Given all this, we simply cannot share the dissent and Wilsons' confidence that the officer's testimony is worthy of no credence and he “‘intentionally’ shot Wilson in the head in the same way [he] ‘intentionally’ [chose] to use a taser to stop the defendant instead of tackling him.” Dissent at 787.” (highlighting emphasis added)

  - Here, Plaintiff’s evidence is weaker than that found insufficient to create a genuine issue in *Forrest*. At the time of the incident, Defendant was working in the control booth in Facility C, Housing Unit C–4. (SUF No. 11.) Plaintiff does not challenge Defendant’s assertion that Defendant was at least 65' away when he fired the 40mm gun.15 (SGI No. 15.) It is undisputed that the control booth from which Defendant viewed Plaintiff was elevated by at least 12'. (SUF No. 14: SGI No. 14; Tull Decl., ¶ 3; Plaintiff Depo. at 55.)
o “Plaintiff argues that Defendant must have intentionally aimed at his head because he was trained in the use of a 40 mm gun. (Plaintiff Depo. at 16.) Just as in Forrest, however, Plaintiff’s argument does not create a genuine issue of material fact. Plaintiff did not dispute that he circled around inmate Williams and moved from side to side in a fighting stance. (SUF No. 19; SGI No. 19.) Given that Plaintiff was a moving target, Defendant’s training in the use of a 40 mm launcher does not create a genuine issue of material fact as to Defendant’s intent. Forrest, 620 F.3d at 745–46;” (highlighting emphasis added)

o “Plaintiff’s argument that he saw Defendant aim at his head is insufficient. Plaintiff was even further away than the plaintiff in Forrest. A distance of 65 feet is significant, the control booth was elevated, and Plaintiff was moving around Williams in a fighting stance.”

TASER Ventricular Fibrillation (VF) Research

  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); *1162 United 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."


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

  - “Thus, the taser logs show that, over the course of the approximately eight minutes and fourteen seconds that the officers attempted to remove Plaintiff from his vehicle, the officers’ tasers were deployed a total of seventeen times, for a total of approximately one minute and twenty-three seconds.” (highlighting emphasis added)
  - "In essence, there remain no genuine disputes of material fact as to Plaintiff’s claims. In light of the circumstances of the encounter, Defendants’ conduct was not unreasonable, and Defendants are immune for the actions they took in effecting Plaintiff’s arrest. Accordingly, Defendant’s motion for summary judgment is now granted in full."

  - 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.

  - In *Turner*, where plaintiff was tased five times, the court found that there was no excessive force because he was resisting throughout the entire encounter.

  - “Mr. Hughes received an electrical current from the responding officers’ tasers a total of twelve separate times.”
  - “For the foregoing reasons, the district court's grant of summary judgment in favor of the responding officers is AFFIRMED.”

  - “… 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
Everything has the “Potential” to be “Lethal”

- Peanuts have the potential to be lethal to someone with peanut allergies.
- Acetaminophen, the active ingredient in Tylenol and Nyquil is responsible for over 33,000 hospitalizations each year and 1,567 deaths in the last decade.
- Highchairs have labels warning of the risk of death, as do household fans.
- Pencils can be lethal.

Deadly vs. Non-Deadly Under Fourth Amendment

  - “Although respondent’s attempt **1778 to craft an easy-to-apply legal test in the Fourth Amendment context is admirable, in the end we must still slosh our way through the fact bound morass of “reasonableness.” Whether or not Scott’s actions constituted application of “deadly force,” all that matters is whether Scott’s actions were reasonable.”

TASER CEW “drive stun” “is non-deadly force”

  - “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


- *Marquez v. City of Phoenix*, 693 F.3d 1167, 1176 (9th Cir. (Ariz.) 2012), as amended on denial of reh’g (Oct. 4, 2012), cert. denied, 133 S. Ct. 1468 (U.S. 2013) (“We are not convinced that the use of an X26 involves deadly force.”).
TASER CEW is a “non-deadly weapon”

- *Fils v. City of Aventura*, 647 F.3d 1272 (11th Cir. (Fla.) July 28, 2011)
- *Jackson v. Johnson*, 797 F. Supp. 2d 1057, 1067 (D. Mont. 2011) (“unlike a firearm, a taser does not constitute deadly force”)
- Steen v. City of Pensacola, 809 F. Supp. 2d 1342, 1350 (N.D. Fla. 2011) (citing *Fils v. City of Aventura*) (taser is a non-deadly weapon)

TASER CEW is “non-deadly force”


TASER CEW is “less-than-lethal” force

  - “deployed the less-than-lethal taser in probe mode”
  - “In *Bryan*, the United States Court of Appeals for the Ninth Circuit indicated that arresting officers have a duty to consider all less intrusive alternatives prior to utilizing more intrusive ones. 630 F.3d 805. While Sheffey cites this case and argues generally that the officers failed to consider such less intrusive alternatives, it seems that the officers did just that in choosing to take Mr. Hughes to the ground and to tase him, rather than allowing the situation to reach a level that would have required obviously lethal force. At oral argument, Sheffey argued that the officers could have simply wrestled with Mr. Hughes until they brought him into compliance rather than tasing him after he was brought to the ground. However, Sheffey does not offer any evidence or argument regarding the effectiveness of this option, nor does she respond to the aggravating circumstances present here, including the level of Mr. Hughes’s resistance after he was taken to the ground, and the fact that he was reasonably considered to be in possession of, and actively reaching for, a firearm.”
• **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”**


**TASER CEW is “non-lethal”**


- *Caetano v. Massachusetts*, 136 S.Ct. 1027, 1030 (Mar. 21, 2016), Fn 2 .... "As the Commonwealth’s witness testified at trial, these sorts of electrical weapons are “non-lethal force” “designed to incapacitate”—“not kill”—a target. Id., at 27." (highlighting emphasis added)
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).

Smith v. LePage, Jr., 834 F.3d 1285, 1295 (CA11 (Ga.) Aug. 25, 2016).

Even so, our precedent does not necessarily require that a noncompliant suspect be armed to justify the use of a nonlethal taser. See, e.g., Zivojinovich, 525 F.3d at 1073 (holding that it was permissible to tase a handcuffed arrestee because he belligerently sprayed blood at an officer when he spoke); Draper, 369 F.3d at 1278 (holding that it was permissible to tase an unarmed truck driver because he was belligerent and noncompliant during a traffic stop). In this tense situation, we cannot say that the officers’ single use of a taser on Mr. Smith was unreasonable.\footnote{For the same reasons, the officers did not violate Georgia law by deploying their tasers. See City of East Point v. Smith, 258 Ga. 111, 365 S.E.2d 432, 434 (1988) (using the same test of objective reasonableness applied in Fourth Amendment cases for a search and seizure claim brought under the Georgia Constitution).}

The Eleventh Circuit has described the use of a taser as “nonlethal” force in addressing excessive force claims against police officers. See Smith v. LePage, 834 F.3d 1285, 1295 (11th Cir. 2016). Although a taser has a “unique capability to cause high levels of pain without long-term injury, we have not categorized the taser as an implement of force whose use establishes, as a matter of law, more than de minimis injury.” Hollingsworth v. City of St. Ann, 800 F.3d 985, 990-91 (8th Cir. 2015).

The Eleventh Circuit has held that the use of a taser is “moderate, non-lethal force.” Buckley v. Haddock, 292 Fed.Appx. 791, 795 (11th Cir. 2008). Plaintiff has alleged only that the use of a taser on him rendered him weak and unable to walk straight. (Doc. 1 at 3 ¶ 7). He has not alleged any more serious injury or lasting effects from the use of the taser on him.

- State v. Herr, 346 Wis.2d 603, 828 N.W.2d 896 (Wis.App., February 6, 2013)
  - FN10. All circuits that have considered the question, including the Ninth Circuit, designate taser use generally as non-lethal or less-than-lethal force. See Bryan, 630 F.3d at 825 (citing similar findings from other circuits). There nevertheless have been numerous cases in Ninth Circuit courts in which a suspect died after being tased by police officers, though the connection between the use of force and the suspect’s death is a subject of ongoing debate and ambiguity. See, e.g., 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).
  - 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."


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. However, case law indicates that Tasers are generally considered non-lethal or less lethal force. See **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.*

- *United States v. Fore,* 507 F.3d 412, 413 (C.A.6 (Ky.) November 8, 2007)
- “The officers warned defendant that a Taser, a non-lethal weapon that emits an electrical charge to incapacitate a subject, would be used if he did not comply with their instructions." *Fore,* at 413.
- *San Jose Charter of Hells Angels Motorcycle Club v. City of San Jose,* 402 F.3d 962, 969 n. 8 (C.A.9 (Cal.) April 4, 2005)

**TASER CEW is not “lethal” force**

TASER CEW is “less-lethal” weapon


  - “… less-lethal options such as the ECW.”

- Phillips v. Community Ins. Corp., 678 F.3d 513 (CA7 (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 (CA9 (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.”

- [European CPT] VIII. Electrical discharge weapons. European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT)

- “less lethal weapons” such as EDW” [electrical discharge weapons], page 100, ¶ 68. [highlighting added]

- [European CPT] Electrical discharge weapons, Extract from the 20th General Report of the European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT). Published in 2010. Available at: https://rm.coe.int/16806ccee1c (accessed 22 May 2018).

- “less lethal weapons” such as EDW” [electrical discharge weapons], ¶ 68. [highlighting added]

- Mercado v. City of Orlando, 407 F.3d 1152, 1157 (CA11 (Fla.) April 29, 2005):
  - Under Florida law, “deadly force” means any “force that is likely to cause death or great bodily harm,” but does not include “the discharge of a firearm by a law enforcement officer or correctional officer during and within the scope of his or her official duties which is loaded with a ‘less lethal munition.’” Fla. Stat. § 776.06. “Less-lethal munition” is, in turn, defined as “a projectile that is designed to stun, temporarily incapacitate, or cause temporary discomfort to a person without penetrating the person’s body.”

- Deorle v. Rutherford, 272 F.3d 1272 (CA9 (Cal.), March 16, 2001)

Cases Citing the May 24, 2011 NIJ CEW Study


- Hagans v. Franklin County Sheriff's Office, 695 F.3d 505, 510 (CA6 (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 (CA6 (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 (CA9 (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 (CA7 (Ill.) December 19, 2006):

   a. The Seventh Circuit has stated that “the violation of police regulations or even a state law is completely immaterial as to the question of whether a violation of the federal constitution has been established.”

(a) “However, while the [PERF] Guidelines and Sheriff’s Procedures may be inadmissible to show a constitutional violation has been established, that does not necessarily mean that information contained in these documents is irrelevant or inadmissible for other purposes.”
Lay/Expert Testimony: CEWs

1. In order for expert testimony to be admissible, it must be both relevant and reliable. Before considering expert opinion, the Court must determine whether the expert’s testimony “will assist the trier of fact to understand the evidence or to determine a fact in issue.” Federal Rule of Evidence 702; see also Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579 (1993); Kumho Tire Co., Ltd. v. Carmichael, 526 U.S. 137 (1999); Chesebrough-Pond’s, Inc. v. Faberge, Inc., 666 F.2d 393, 398 (9th Cir. 1982) (affirming exclusion of expert’s affidavit regarding marks’ dissimilarity because it was not of any “real assistance to the trier of fact”); Arner v. Sharper Image Corp., 39 U.S.P.Q.2d 1282 (C.D. Cal. 1995) (excluding industrial design expert’s testimony under Rule 702 as unhelpful because it addressed what an “ordinary purchaser” would perceive); Taser Int’l, Inc. v. Bestex Co., 84 U.S.P.Q.2d 1186 (C.D. Cal. 2007) (holding that expert’s declaration failed to satisfy Rule 702’s reliability requirement).

2. Flanagan v. City of Dallas, 2017 WL 2817424 (N.D.Texas May 25, 2017) (The Court now considers Defendants’ Motion to Exclude Testimony of the Plaintiffs’ Retained Expert Witness Jerry Staton. Doc. 94. For the reasons that follow, the motion is GRANTED IN PART as specified herein.)

3. 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 ‘after 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:

![Airbag Warning Sign](image)
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).²²⁶

2. Amnesty International report has been deemed inadmissible and unreliable. See:

Dziekanski / Braidwood / Williams Timeline

### Table 62 Dziekanski / Braidwood / Williams Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct. 14, 2007</td>
<td>Date of Death: Robert Dziekanski</td>
</tr>
<tr>
<td>Jan. 29, 2008</td>
<td>Dziekanski autopsy report received by Ministry of Solicitor General</td>
</tr>
<tr>
<td>Feb. 15, 2008</td>
<td>Braidwood was appointed as sole Commissioner</td>
</tr>
<tr>
<td>May–June 2008</td>
<td>Braidwood convened for 15 days of informal, non-adversarial public forums</td>
</tr>
<tr>
<td>Dec. 12, 2008</td>
<td>Canadian public statements regarding Dziekanski death</td>
</tr>
<tr>
<td>June 18, 2009</td>
<td>Braidwood 1 released</td>
</tr>
<tr>
<td>June 2012</td>
<td>Williams’ Paper</td>
</tr>
</tbody>
</table>

   a. Autopsy: Cause of Death:
      Part 1. Principal Cause of Death:
      a. Sudden Death During Restraint
      Part 2. Contributory Factors:
      f. Chronic Alcoholism
      g. The TASER CEW was not implicated in the Autopsy Report as a cause or contributor to Dziekanski’s death.

   a. “Findings – Evidence from the existing literature does not support the Commission’s findings regarding the medical risks of the use of TASER technology. Recommendations to restrict the use of TASER devices are unlikely to reduce arrest-related deaths, but they are likely to result in increased injuries to officers and suspects. Other recommendations, including training standards, testing requirements, reporting requirements, medical assistance, and research and review, are consistent with other reviews on the use of TASER technology and are necessary and appropriate to restore public confidence in police use-of-force.” (emphasis added)

---

Temporal Association and Proximate Causation

1. “Temporal” is not “causal."

2. *McClain v. Metabolife Int'l, Inc.*, 401 F.3d 1233, 1243 (11th Cir. 2005) (Any effort to establish cause-and-effect merely based on a chronological relationship, i.e., “*post hoc ergo propter hoc,*” after this, therefore because of this, should fail); *Hasler v. U.S.*, 718 F.2d 202, 205 (6th Cir. 1983) (“Without more, [a] proximate temporal relationship will not support a finding of causation”).
Sudden Cardiac Death: Law Enforcement


2. Varvarigou/Krexi:

**Figure 48 Krexi/Varvarigou Stress-Induced Sudden Cardiac Death.**


   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.
Law-Enforcement-Related Deaths


Police-Related Cardiac Arrest


Mortality Example: Hospitals

Hospital Mortality Example: As a temporal mortality example, in hospitals the temporal mortality rate for hospital admission is ≈ 1 death for 100 patients admitted.\textsuperscript{228,229} Non-teaching hospitals have higher mortality rates than teaching hospitals.\textsuperscript{230} And, there are Increased patient mortality rates during medical resident handoff periods.\textsuperscript{231}


   a. Non-teaching hospitals have higher mortality rates than teaching hospitals.

   a. Medical error—the third leading cause of death in the US.

   a. And, there are Increased patient mortality rates during medical resident handoff periods.


   a. in hospitals the temporal mortality rate for hospital admission is ≈ 1 death for 100 patients admitted,


   a. in hospitals the temporal mortality rate for hospital admission is ≈ 1 death for 100 patients admitted,
Mortality Example: Jails

Jail Detainee Mortality Example: The number of inmates who die while in the custody of local jails generally ranges from 1 death for 700–951 inmates.\(^{232}\) In Ontario, Canada “[t]he crude rate of death among male inmates was 420.1 per 100 000 ...” (or 1 death per 238 inmates).\(^{233}\)


Mortality Example: Marijuana


   a. **Conclusions**: the results of the study show an elevated risk of death for consumers of cannabis, a percentage of which probably also consumed other substances, and a very few which presented themselves for treatment at a public drug treatment center.


   **Abstract**

   **Background**: Cannabis, or Marijuana, remains one of the most universally used recreational drugs. Over the last four decades, its popularity has risen considerably as it became easily accessible and relatively affordable. Peak use is amongst the young aged 18 to 25 years, although these figures are now shifting towards earlier teens. A strongly installed culture still regards cannabis a harmless drug, yet as more reports have shown there are considerable adverse cardiovascular events linked with its use.

   **Case Presentation**: In this paper, we present the case of a 15-year-old male who suffered a cardiac arrest following cannabis use and survived the episode.

   **Conclusion**: Cardiac arrest is a rare and possibly fatal consequence of cannabis use. Public awareness should be raised by extensively promoting all potential complications associated with its use.


   a. Marijuana use might affect coronary microcirculation and cause ventricular tachycardia.

   b. This case demonstrates that marijuana smoking might be associated with ventricular tachycardia. This could be caused by a decrease in coronary blood flow, possibly through coronary spasm.
c. It is hypothesis generating and should open the door for more definitive controlled studies to investigate the effects of marijuana use on the heart, an issue of increasing importance, particularly with the recent moves to legalize the drug.


Abstract

*We report six cases of possible acute cardiovascular death in young adults, where very recent cannabis ingestion was documented by the presence of tetrahydrocannabinol (THC) in postmortem blood samples. A broad toxicological blood analysis could not reveal other drugs. Similar cases have been reported in the literature, but the toxicological analysis has been absent or limited to urine samples, which represent a much broader time window for cannabis intake. This paper presents six case reports, where cannabis alone was detected in blood. Further, an overview over previously published cases, clinical trials and possible patho-physiological mechanisms are presented.*
Deaths Undermined or Sudden Unexplained Death (“SUD”)

<table>
<thead>
<tr>
<th>Date</th>
<th>% of Deaths Undetermined or Sudden Unexplained Death (“SUD”)</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep. 2016</td>
<td>18% SUD</td>
<td>Harmon\textsuperscript{234}, Incidence and Etiology of Sudden Cardiac Arrest (SCA) and Death in High School Athletes in U.S. Rate of SCA/D in male high school athletes was 1:44,832 athlete-years (AY).</td>
</tr>
<tr>
<td>Jun. 2016</td>
<td>40% SUD</td>
<td>Bagnall\textsuperscript{235}, unexplained sudden cardiac death (40% of cases) was the predominant finding among persons in all age groups</td>
</tr>
<tr>
<td>May 2015</td>
<td>25% AN SUD</td>
<td>Harmon\textsuperscript{236}, autopsy negative (AN) sudden unexplained death</td>
</tr>
<tr>
<td>Jan. 2015</td>
<td>53% SUD</td>
<td>Krexi\textsuperscript{237}, Sudden cardiac death with stress and restraint (n=110)</td>
</tr>
<tr>
<td>Apr. 2014</td>
<td>31% SUD</td>
<td>Risgaard\textsuperscript{238}, Sudden cardiac death in persons aged 1-49 years</td>
</tr>
<tr>
<td>Apr. 2014</td>
<td>28% SUD</td>
<td>Winkel\textsuperscript{239}, Sudden cardiac death in children (1-18 years)</td>
</tr>
<tr>
<td>Mar. 2014</td>
<td>20% undetermined</td>
<td>Harmon\textsuperscript{240}, Etiologies of SCD in NCAA Athletes</td>
</tr>
<tr>
<td>Feb. 2014</td>
<td>9% unresolved</td>
<td>Maron\textsuperscript{241}, U.S. college athletes</td>
</tr>
<tr>
<td>Oct. 2012</td>
<td>Up to 36% Denmark</td>
<td>Winkel\textsuperscript{242}, cause of sudden death in young people (≤ 35) remains unknown in up to 36% of postmortem cases</td>
</tr>
<tr>
<td>2012</td>
<td>3–53% Autopsy negative SUD young</td>
<td>Tester\textsuperscript{243}, Molecular autopsy (summary figure: Prevalence of Autopsy Negative SUD in the Young)</td>
</tr>
<tr>
<td>Sep. 2011</td>
<td>41.3% &lt; 35 years; 20.7% unexplained</td>
<td>Eckart\textsuperscript{244}, young athletes; &lt; 35 years of age sudden unexplained death</td>
</tr>
</tbody>
</table>


\textsuperscript{243} Tester, D. J., & Ackerman, M. J. (2012). The molecular autopsy: should the evaluation continue after the funeral?. *Pediatric cardiology*, 33(3), 461-470.

<table>
<thead>
<tr>
<th>Date</th>
<th>% of Deaths Undetermined or Sudden Unexplained Death (“SUD”)</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jun. 2007</td>
<td>Up to 50% (Australia)</td>
<td>Doolan\textsuperscript{245}, cause of sudden death in young people (≤ 35) remains unknown in up to 50% of postmortem cases</td>
</tr>
<tr>
<td>Dec. 2004</td>
<td>35% undetermined</td>
<td>Eckart\textsuperscript{246}, military 25-year study</td>
</tr>
<tr>
<td>1995</td>
<td>5% undetermined</td>
<td>Van Camp\textsuperscript{247}, sports death high school/college athletes</td>
</tr>
</tbody>
</table>


![Prevalence of Autopsy Negative SUD in the Young](image)

Figure 49, Tester: Prevalence of Autopsy Negative SUD in the Young


Medical Examiner/Death Investigator Guidance


Black Athletes and Military Recruits at Higher Risk of Sudden Death

Table 64 Black Athletes and Military Recruits at Higher Risk of Sudden Death

<table>
<thead>
<tr>
<th>Date</th>
<th>Paper</th>
<th>Black athletes at Higher Risk of Sudden Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2015</td>
<td>Reinier(^{248})</td>
<td>Sudden cardiac death (SCD) two-fold higher among black men and women compared to white men and women.</td>
</tr>
<tr>
<td>May 2015</td>
<td>Harmon(^{249})</td>
<td>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 &lt; .00001).</td>
</tr>
<tr>
<td>Mar. 2015</td>
<td>Ellison(^{250})</td>
<td>Up to 25% of these deaths occur during sports. More than 50% of athletic deaths owing to SCD occur in black athletes.</td>
</tr>
<tr>
<td>Feb. 2014</td>
<td>Maron(^{251})</td>
<td>U.S. college athletes, &quot;cardiovascular deaths were 5-fold more common in African-American athletes than whites (3.8 vs. 0.7/100,000; p &lt;0.01). but did not differ from the general population of the same age and race (p = 0.6).&quot;</td>
</tr>
<tr>
<td>2006</td>
<td>Eckart(^{252})</td>
<td>This study sought to examine the incidence of sudden death in a large, multiethnic cohort of young women. Approximately 852,300 women entered basic military training from 1977 to 2001. During this period, there were 15 sudden deaths in female recruits (median age 19 years, 73% African-American), occurring at a median of 25 days after arrival for training. Of the sudden deaths, 13 (81%) were due to reasons that may have been cardiac in origin. Presumed arrhythmic sudden death in the setting of a structurally normal heart was seen in 8 recruits (53%), and anomalous coronary origins were found in 2 recruits (13%). The mortality rate was 11.4 deaths per 100,000 recruit-years (95% confidence interval 6.9 to 18.9). The rate was significantly higher for African-American female recruits (risk ratio 10.2, p &lt;0.001). Sudden death with a structurally normal heart was the leading cause of death in female recruits during military training.</td>
</tr>
</tbody>
</table>


   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.”


\(^{250}\) 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.


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).”


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.


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. …”

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.


a. “Sudden arrhythmic death syndrome (SADS) defines a sudden unexpected cardiac death that remains unexplained after comprehensive postmortem examination, histology, and toxicology studies. It accounts for ≈500 deaths in the United Kingdom every year, corresponding to an annual incidence of 1.38/100,000 population. 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).”

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, focusing on genetics and family phenotyping. Curr Opin Cardiol. 2013;28:19–25.]


a. 20% the cause could not be determined

   a. **METHODS:** A prospective observational study of 2149 US high schools participating in the National Registry for AED Use in Sports was conducted from August 2009 to July 2011. Schools were contacted quarterly to collect and review SCA cases occurring on school campus. Ninety-five percent (2045) of the schools confirmed participation for the entire 2-year period.

   b. **RESULTS:** The average numbers of total students and student athletes per school were 963 and 367, respectively, providing more than 4.1 million total student-years and more than 1.5 million student athlete-years of surveillance. Twenty-six cases of SCA occurred in students, including 18 cases in student athletes-all during exercise. The incidence of SCA in all students was 0.63 per 100,000; in student athletes, 1.14 per 100,000; and in student nonathletes, 0.31 per 100,000. The relative risk of SCA in student athletes vs nonathletes was 3.65 (95% confidence interval 1.6-8.4; P < .01). Sixteen of 18 (89%) student athletes with SCA were boys, resulting in an incidence of 1.73 per 100,000 in boys and 0.31 per 100,000 in girls and a relative risk in male compared with female student athletes of 5.65 (95% confidence interval 1.3-24.6; P < .01).

   c. **CONCLUSION:** The incidence of SCA in high school student athletes is higher than previous estimates and may justify more advanced cardiac screening and improved emergency planning in schools.


   a. Cardiovascular Mortality Rates: “confirmed cardiovascular disease (n = 47; 4/year; 1.2/100,000); combined confirmed or presumed cardiovascular disease (n = 64; 6/year; 1.6/100,000).”

   b. “cardiovascular deaths were 5-fold more common in African-American athletes than whites (3.8 vs. 0.7/100,000; p <0.01), but did not differ from the general population of the same age and race (p = 0.6).”

   c. “In 17 of the 64 athletes, collapse occurred virtually instantaneously following physical activity during competition or practices,”
Objectives. Reliably define the incidence and causes of sudden death in college student-athletes.

Background. Frequency with which cardiovascular-related sudden death (SD) occurs in competitive athletes importantly impacts considerations for preparticipation screening strategies.

Methods. We assessed databases (including autopsy reports) from both the U.S. National Sudden Death in Athletes Registry and National Collegiate Athletic Association (NCAA) (2002-2011).

Results. Over the 10 year period, 182 SDs occurred (ages 20 ± 1.7; 85% males; 64% white): 52 resulting from suicide (n = 31) or drug abuse (n = 21), and 64 probably or likely attributable to cardiovascular causes (6/year). Of the 64 athletes, 47 had a confirmed post-mortem diagnosis (4/year), most commonly hypertrophic cardiomyopathy in 21, and congenital coronary anomalies in 8. The 4,052,369 athlete participations (in 30 sports over 10 years) incurred mortality risks of: suicide and drugs combined, 1.3/100,000 athlete-participation-years (5 deaths/year); and documented cardiovascular disease, 1.2/100,000 (4 deaths/year). Notably, cardiovascular deaths were 5-fold more common in African-American athletes than whites (3.8 vs. 0.7/100,000; p <0.01), but did not differ from the general population of the same age and race (p = 0.6).

Conclusions. In college student-athletes, SD risk due to cardiovascular disease is relatively low, with mortality rates similar to suicide and drug abuse, and less than expected in the general population, although highest in African-Americans. A substantial minority of confirmed cardiovascular deaths would not likely have been reliably detected by preparticipation screening with 12-lead ECGs.

Abstract

BACKGROUND: Sudden cardiac arrest (SCA) is the leading cause of death in athletes during exercise. The effectiveness of school-based automated external defibrillator (AED) programmes has not been established through a prospective study.

METHODS: A total of 2149 high schools participated in a prospective observational study beginning 1 August 2009, through 31 July 2011. Schools
were contacted quarterly and reported all cases of SCA. Of these 95% of schools confirmed their participation for the entire 2-year study period. Cases of SCA were reviewed to confirm the details of the resuscitation. The primary outcome was survival to hospital discharge.

**RESULTS:** School-based AED programmes were present in 87% of participating schools and in all but one of the schools reporting a case of SCA. Fifty nine cases of SCA were confirmed during the study period including 26 (44%) cases in students and 33 (56%) in adults; 39 (66%) cases occurred at an athletic facility during training or competition; 55 (93%) cases were witnessed and 54 (92%) received prompt cardiopulmonary resuscitation. A defibrillator was applied in 50 (85%) cases and a shock delivered onsite in 39 (66%). Overall, 42 of 59 (71%) SCA victims survived to hospital discharge, including 22 of 26 (85%) students and 20 of 33 (61%) adults. Of 18 student-athletes 16 (89%) and 8 of 9 (89%) adults who arrested during physical activity survived to hospital discharge.

**CONCLUSIONS:** High school AED programmes demonstrate a high survival rate for students and adults who suffer SCA on school campus. School-based AED programmes are strongly encouraged.


a. "an estimated 30% of these causes of death cannot be identified reliably by preparticipation screening, even with ECG. Page 1090.


a. 35% of deaths unexplained.

b. “sudden nontraumatic death occurred at a rate of 13.0 per 100 000 recruit-years.”

c. “Among 6.3 million military recruits age 18 to 35 years, sudden nontraumatic death occurred at a rate of 13.0 per 100 000 recruit-years. Over half of the 126 autopsied decedents had an identifiable cardiac abnormality; one third had an anomalous coronary artery. More than one third of deaths had no explanation.”
TASER International, Inc. Historic Information

TASER CEW Handheld Model Development/Life Timeline

1. TASER CEW Handheld Model Development/Life Timeline:

<table>
<thead>
<tr>
<th>No.</th>
<th>Year</th>
<th>Date</th>
<th>CEW Model</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1976</td>
<td>1976</td>
<td>TF-76 electric weapon</td>
<td>Available</td>
</tr>
<tr>
<td>2</td>
<td>1994</td>
<td>1994</td>
<td>AIR TASER Model 34000</td>
<td>Available</td>
</tr>
<tr>
<td>3</td>
<td>1999</td>
<td>Nov. 1999</td>
<td>ADVANCED M26 CEW</td>
<td>Available</td>
</tr>
<tr>
<td>4</td>
<td>2003</td>
<td>May 2003</td>
<td>X26(E) CEW</td>
<td>Available</td>
</tr>
<tr>
<td>5</td>
<td>2007</td>
<td>Jan. 2007</td>
<td>(C) C2 Personal Protector</td>
<td>Available</td>
</tr>
<tr>
<td>6</td>
<td>2009</td>
<td>Jul. 2009</td>
<td>X3 CEW (with charge metering)</td>
<td>Available</td>
</tr>
<tr>
<td>7</td>
<td>2011</td>
<td>Apr. 2011</td>
<td>X2 CEW (with charge metering and APPM)</td>
<td>Available</td>
</tr>
<tr>
<td>8</td>
<td>2011</td>
<td>Q4 2011</td>
<td>X3 CEW</td>
<td>End of life</td>
</tr>
<tr>
<td>9</td>
<td>2013</td>
<td>Jan. 2013</td>
<td>X26(P) CEW (with charge metering and APPM)</td>
<td>Available</td>
</tr>
<tr>
<td>10</td>
<td>2014</td>
<td>Dec. 2014</td>
<td>X26(E) CEW</td>
<td>End of life</td>
</tr>
<tr>
<td>12</td>
<td>2017</td>
<td>Jan. 1, 2017</td>
<td>Smart cartridge: “SP” probe replaced the “XP” probe</td>
<td>Available</td>
</tr>
</tbody>
</table>

# Designates civilian CEW, not intended for law enforcement or military use.

Electronic weapons’ names, acronyms

2. Electronic weapons’ names, acronyms:

<table>
<thead>
<tr>
<th>No.</th>
<th>Year</th>
<th>Date</th>
<th>Acro</th>
<th>CEW known as</th>
<th>Org/Rpt/Bk Chap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1996</td>
<td>Apr. 1, 1996</td>
<td>ERD</td>
<td>Electronic Restraint Device</td>
<td>IACP</td>
</tr>
<tr>
<td>2</td>
<td>2004</td>
<td>Aug. 2004</td>
<td>ECW</td>
<td>Electronic Control Weapon</td>
<td>IACP</td>
</tr>
<tr>
<td>3</td>
<td>2005</td>
<td>Oct. 25, 2005</td>
<td>CED</td>
<td>Conducted Energy Device</td>
<td>PERF</td>
</tr>
<tr>
<td>5</td>
<td>2006</td>
<td>Nov. 2006</td>
<td>CED</td>
<td>Conducted Energy Device</td>
<td>DOJ, NIJ, COPS, PERF</td>
</tr>
<tr>
<td>6</td>
<td>2007</td>
<td>May 2007</td>
<td>ECD</td>
<td>Electronic Control Device</td>
<td>AELE</td>
</tr>
<tr>
<td>7</td>
<td>2009</td>
<td>Jun. 15, 2009</td>
<td>CED</td>
<td>Conducted Electrical Device</td>
<td>AMA</td>
</tr>
<tr>
<td>8</td>
<td>2009</td>
<td>Aug. 2009</td>
<td>CED</td>
<td>Conducted Energy Device</td>
<td>PERF</td>
</tr>
<tr>
<td>9</td>
<td>2010</td>
<td>Apr. 2010</td>
<td>ECW</td>
<td>Electronic Control Weapon</td>
<td>IACP</td>
</tr>
<tr>
<td>10</td>
<td>2010</td>
<td>2010</td>
<td>EDW</td>
<td>Electrical Discharge Weapons</td>
<td>CPT³⁵³</td>
</tr>
<tr>
<td>11</td>
<td>2011</td>
<td>Mar. 2011</td>
<td>ECW</td>
<td>Electronic Control Weapon</td>
<td>DOJ, NIJ, COPS, PERF</td>
</tr>
<tr>
<td>12</td>
<td>2011</td>
<td>2011</td>
<td>CEW</td>
<td>Conducted Energy Weapon</td>
<td>AAEM</td>
</tr>
<tr>
<td>13</td>
<td>2012</td>
<td>Jul. 27, 2012</td>
<td>CED</td>
<td>Conductive Energy Device, or Electronic Control Device</td>
<td>CRD/DOJ Seattle, WA</td>
</tr>
<tr>
<td>14</td>
<td>2012</td>
<td>Oct. 2012</td>
<td>ECD</td>
<td>Conductive Energy Device, or Electronic Control Device</td>
<td>AELE</td>
</tr>
<tr>
<td>15</td>
<td>2012</td>
<td>Dec. 21, 2012</td>
<td>ECW</td>
<td>Electronic Control Weapon</td>
<td>CRD/DOJ Puerto Rico</td>
</tr>
</tbody>
</table>

³⁵³ European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT)
<table>
<thead>
<tr>
<th>No</th>
<th>Year</th>
<th>Date</th>
<th>Acro</th>
<th>CEW known as</th>
<th>Org/Rpt/Bk Chap</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>2013</td>
<td>Jan. 1, 2013</td>
<td>CEW</td>
<td>Conducted Electrical Weapon</td>
<td>TASER</td>
</tr>
<tr>
<td>17</td>
<td>2013</td>
<td>Jan. 30, 2013</td>
<td>ESW</td>
<td>Electroshock Weapon</td>
<td>NIST/IEC</td>
</tr>
<tr>
<td>18</td>
<td>2013</td>
<td>Oct. 15, 2013</td>
<td>CEW</td>
<td>Conducted Energy Weapon</td>
<td>Canada Science</td>
</tr>
<tr>
<td>20</td>
<td>2015</td>
<td>May 2015</td>
<td>CED</td>
<td>Conductive Energy Devices</td>
<td>President’s Task Force</td>
</tr>
<tr>
<td>21</td>
<td>2016</td>
<td>Jul. 1, 2016</td>
<td>ECD</td>
<td>Electronic Control Device</td>
<td>Miami-Dade PD</td>
</tr>
<tr>
<td>22</td>
<td>2016</td>
<td>Mar. 2016</td>
<td>CED</td>
<td>Conducted Energy Device</td>
<td>Roberts bk chap</td>
</tr>
<tr>
<td>23</td>
<td>2016</td>
<td>Oct. 12, 2016</td>
<td>CEW</td>
<td>Conducted Energy Device</td>
<td>UK SACMILL</td>
</tr>
<tr>
<td>24</td>
<td>2017</td>
<td>Jan. 2017</td>
<td>ECW</td>
<td>Electronic Control Weapon</td>
<td>CRD/DOJ</td>
</tr>
<tr>
<td>25</td>
<td>2017</td>
<td>Mar. 2016</td>
<td>CED</td>
<td>Conducted Energy Device</td>
<td>Nakajima bk chap</td>
</tr>
<tr>
<td>26</td>
<td>2018</td>
<td>Oct. 6, 2018</td>
<td>CEW</td>
<td>Conducted Energy Weapon</td>
<td>Axon/TASER</td>
</tr>
</tbody>
</table>
CEW Definitions Examples

1. *Bryan v. MacPherson*, 630 F.3d 805, 815 (9th Cir. (Calif.) Nov. 30, 2010):
   
a. “VII. We explicitly “recognize[d] the important role controlled electric devices like the Taser X26 can play in law enforcement” to “help protect police officers, bystanders, and suspects alike.” *Bryan*, 608 F.3d at 622. This recognition, however, which is shared by Judge Tallman, is entirely consistent with the eminently reasonable principle that the majority of active judges on our court, along with many other judges and law enforcement personnel, have also recognized: the X26 taser and similar devices, when used in dart mode, constitute an “intermediate, significant level of force that must be justified by the governmental interest involved.” *Bryan*, 608 F.3d at 622,”

2. *Young v. County of Los Angeles*, 655 F.3d 1156, 1161 (9th Cir. (Calif.) Aug. 26, 2011):
   
a. “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); *United States v. Mohr*, 318 F.3d 613, 623 (4th Cir.2003).”

   
a. **III. DEFINITIONS.** Electronic control weapon (ECW): A weapon that uses electricity to override voluntary motor responses, or apply pain in order to gain compliance or overcome resistance.

   
a. **Conducted Energy Device (CED).** See **Electronic Control Weapon (ECW).**
   
b. **Electronic Control Weapon (ECW).** A weapon designed primarily to discharge electrical charges into a subject that will cause involuntary muscle contractions and override the subject’s voluntary motor responses. Originally called Conducted Energy Device (CED).

5. *CRD/DOJ Seattle, filed with Court July 27, 2012*:
   
a. 20. “CED” means Conductive Energy Device, also referred to as ECD (electronic control device) and TASER.
6. IEC 62792 Edition 1.0 2015-02, Measurement method for the output of electroshock weapons, page 8:

a. **3.4 electroshock weapon** ESW weapon that generates a high-voltage transient electrical signal that is transmitted to a person

   Note 1 to entry: The ESW comprises, at a minimum, a signal generator located in the body of the ESW and a pair of electrical contacts to make electrical connection between the generator and a person.

b. **3.4.1 long-range wired ESW** ESW that uses propelled, tethered, skin-penetrating or adhering (for example, to clothing) barbed darts as the electrical contacts

   Note 1 to entry: Adhering darts attach sufficiently close to the surface of the person to complete a circuit capable of delivering an electrical charge to that person. These barbed darts are tethered to the ESW cartridge that is mechanically attached to the body of the ESW and travel away from the cartridge when deployed. The ESW cartridge is often used to convert a contact ESW to a long-range wired ESW.

c. **3.4.2 long-range wireless ESW** ESW that is compact in size and that is fired or launched from a separate and independent firearm, device, or apparatus and to which there is no physical connection between the ESW and the firearm, device, or apparatus after it is fired or launched

d. **3.4.3 ESW contact** ESW that uses fixed metal electrodes located on the body or cartridge of the ESW as the electrical contacts
TaserTron TF-76 CEW Electrical and Operational Basics

1. TaserTron TF-76 CEW Electrical and Operational Basics:

   a. Tasertron TF-76 CEW electrical characteristics:

   Table 67 Comparison between output parameters X26(E) and TF-76 CEWs output parameters.

<table>
<thead>
<tr>
<th>CEW Model</th>
<th>Year</th>
<th>Energy per pulse Joule (J)</th>
<th>pulses per second (PPS)</th>
<th>Power watts (W)</th>
<th>Charge microcoulombs (µC)</th>
<th>Peak current amperes (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF-76 CEW</td>
<td>1976</td>
<td>0.336</td>
<td>12.1</td>
<td>4.07</td>
<td>86</td>
<td>11.6</td>
</tr>
<tr>
<td>X26(E) CEW</td>
<td>May 2003</td>
<td>0.095</td>
<td>18.5</td>
<td>1.75</td>
<td>97</td>
<td>2.9</td>
</tr>
</tbody>
</table>

   Figure 50 X26(E) and TF-76 CEWs output waveforms.
Selected General Numbers and Mortality/Injury Statistics

Basic Selected TASER CEW Statistics

- As of July 17, 2018:\(^{254}\)
  - TASER has sold approximately 1,000,000 CEWs worldwide (does not include civilian TASER CEWs)\(^{255}\)
  - 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 300,000 civilian TASER CEWs have been sold to the general public since 1994\(^{256}\)

- Estimated CEW exposure numbers (Data from: [https://www.axon.com/lives-saved](https://www.axon.com/lives-saved)):
  - CEW Field Use/Suspect Applications: 3,755,000 ± 2% (as of July 17, 2018)
  - CEW Training/Voluntary Applications: 2,461,330 ± 7% (as of July 17, 2018)
  - Total CEW Human Applications: 6,216,330+

---

\(^{254}\) TASER® Conducted Electrical Weapons (CEWs): Field Data and Risk Management (PowerPoint®), dated July 17, 2018. 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.

\(^{255}\) As of Q4 2017: 166,158 X26P CEWs, 137,196 X2 CEWs.

\(^{256}\) Including as of Q4 2017: 25,073 Pulse CEWs.
Law Enforcement-Person Contacts, Use of Force, Excessive Force, Deaths:

Law Enforcement Officer (LEO) Temporal Related Deaths per Category Table:

Table 68 Law Enforcement Officer (LEO) Temporal Related Deaths Per Category Summary Table

<table>
<thead>
<tr>
<th>Category of deaths (mortality)</th>
<th>Deaths per temporal factor 1 death per</th>
<th>Deaths per 100,000 of specific incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death per encounter\textsuperscript{257}</td>
<td>31,898 encounters</td>
<td>3.13 per 100,000 encounters</td>
</tr>
<tr>
<td>Death per stops/arrests\textsuperscript{258}</td>
<td>14,144.3 stops/arrests</td>
<td>7.07 per 100,000 stops/arrests</td>
</tr>
<tr>
<td>Death per arrests\textsuperscript{259}</td>
<td>15,384.6 arrests</td>
<td>6.5 per 100,000 arrests</td>
</tr>
<tr>
<td>Pepper spray deaths per uses\textsuperscript{260}</td>
<td>600 uses of pepper spray</td>
<td></td>
</tr>
<tr>
<td>LEOs use of weapons deaths</td>
<td>323 arrests using weapons</td>
<td></td>
</tr>
<tr>
<td>Jail inmates’ deaths per year</td>
<td>658–709 jail inmates</td>
<td>150 per 100,000 inmates</td>
</tr>
<tr>
<td>LEOs deaths per year</td>
<td>year for every 5,521 LEOs</td>
<td>18 per 100,000 LEOs</td>
</tr>
<tr>
<td>LEOs deaths per year\textsuperscript{261}</td>
<td>year for every 6,666+ LEOs</td>
<td>15-16 per 100,000 LEOs</td>
</tr>
<tr>
<td>LEOs SCDs per year\textsuperscript{262}</td>
<td>year for every 95,238 LEOs</td>
<td>1.05 per 100,000 LEOs</td>
</tr>
</tbody>
</table>

LEO CEW Fall Mortality Risk:


   a. Results: We found 16 probable cases of fatal brain injuries induced by electronic control from electrical weapons. Out of 3 million field uses, this gives a risk of 5.3 ± 2.6 PPM which is higher than the theoretical risk of electrocution. The mean age was 46 ± 14 years which is significantly greater that the age of the typical ARD (36 ± 10). Probe shots to the subject’s back may present a higher risk of a fatal fall.

   b. Conclusions: The use of electronic control presents a small but real risk of death from fatal traumatic brain injury. Increased age represents an independent risk factor for such fatalities.


CEW (Theoretical) Probability of VF (in Perspective of General Population 2012):

3. A few examples to put this very low CEW VF mortality risk into perspective:

<table>
<thead>
<tr>
<th>No.</th>
<th>Causes of death</th>
<th>Death Rate Per Population (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Accidents/Unintentional Injuries</td>
<td>1 death per 2,558 people</td>
</tr>
<tr>
<td>2</td>
<td>Poisoning</td>
<td>1 death per 6,803 people</td>
</tr>
<tr>
<td>3</td>
<td>Suicide</td>
<td>1 death per 7,936 people</td>
</tr>
<tr>
<td>4</td>
<td>Motor vehicle traffic</td>
<td>1 death per 9,009 people</td>
</tr>
<tr>
<td>5</td>
<td>Firearm</td>
<td>1 death per 9,346 people</td>
</tr>
<tr>
<td>6</td>
<td>Fall</td>
<td>1 death per 10,526 people</td>
</tr>
<tr>
<td>7</td>
<td>(Theoretical) CEW VF Mortality Risk</td>
<td>1 death per 2,532,500,000 people</td>
</tr>
</tbody>
</table>

It is important to note that the mortality numbers in the above table are from the 2012 general population. The mortality risk statistics for CEWs are from human field use exposures to CEWs, not from the much larger general population. There has never been a death temporal to a CEW training/volunteer exposure. For 2012 the U.S. Census Bureau’s estimate of the U.S. population was of 313,998,379 people. There are 310 000 annual CEW field uses. In 2012 the probability of being exposed to a CEW [313,998.379 people divided by 310,000 annual CEW uses] yields 1 CEW field use for every 1,013 people in the general U.S. population. Thus, using the 2010 Sun/Webster probability of human VF in those exposed to a CEW of 0.000006 or 1 in 161,000, the CEW mortality risk in the general population was 1 in 163,093,000. Using Kroll, Lakkiiredy, Rahko, and Panescu’s 2011 CEW VF in humans exposed to a CEW theoretical mortality risk of 1 in 2.5 million, the CEW-induced VF mortality risk in the general population the probability was 1 in 2,532,500,000. Using the 2015 Panescu CEW VF in humans theoretical mortality risk of 1 in 2.9 million yields a greater probability.

CEW (Theoretical) Direct Cardiac VF Effect Mortality Rates Table:

---


### Table 70 CEW (Theoretical) Direct Cardiac VF Effect Mortality Rates Table:

<table>
<thead>
<tr>
<th>Date/Lead Author</th>
<th>Probability</th>
<th>Risk</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (07/2016) Kroll(^{267})</td>
<td></td>
<td>(\approx 0.3 \text{ PPM})</td>
<td>Hypothetical risk of electrocution which has been estimated at (\approx 0.3 \text{ PPM})</td>
</tr>
<tr>
<td>2 (09/2015) Panescu(^{268})</td>
<td>(&lt; 0.000 \ 000 \ 35)</td>
<td>(&lt; 1:2.9 \text{ M})</td>
<td>overall theoretical VF risk estimated, consistent with epi CEW statics.</td>
</tr>
<tr>
<td>3 (11/2014) Graham(^{269})</td>
<td></td>
<td></td>
<td>Whether an ECD has in fact actually caused the death of a human via the direct effect of electricity - electrocution - is controversial</td>
</tr>
<tr>
<td>4 (01/2014) Kroll(^{270})</td>
<td></td>
<td>(&lt; 1 \text{ per M})</td>
<td>demonstrated incidence of ECD-induced cardiac arrest extremely low, if not zero. Conclusions of connection between ECD use and cardiac arrest are speculative at best.</td>
</tr>
<tr>
<td>5 (10/2013) Goudge(^{271})</td>
<td></td>
<td></td>
<td>no confirmation/exclusion clear causal link</td>
</tr>
<tr>
<td>6 (08/2012) White(^{272})</td>
<td></td>
<td></td>
<td>disproving hypothesis that CEW application anywhere on chest presents risk of VF</td>
</tr>
<tr>
<td>7 (05/2012) Bozeman(^{273})</td>
<td>0.0–0.6</td>
<td>0.0–0.6</td>
<td>Gender, BMI, and swine / human VF refinements to Wu and Sun models</td>
</tr>
<tr>
<td>8 (09/2011) Kroll(^{274})</td>
<td>0.000 000 4</td>
<td>1,250,000</td>
<td>risk of human death due directly/primarily to CED electrical effects not conclusively demonstrated</td>
</tr>
<tr>
<td>9 (05/2011) Hughes(^{275})</td>
<td></td>
<td></td>
<td>Based on 2 Wu studies (gel and no-gel)</td>
</tr>
<tr>
<td>10 (04/2010) Sun(^{276})</td>
<td>0.000 006</td>
<td>1:161,000</td>
<td>0 deaths out of 1,101 attributed to CEW</td>
</tr>
<tr>
<td>11 (12/2009) Strote(^{277})</td>
<td></td>
<td></td>
<td>0 deaths out of 1,201 attributed to CEW</td>
</tr>
<tr>
<td>12 (04/2009) Bozeman(^{278})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 (02/2009) Kroll(^{279})</td>
<td>The probability of VF with a chest application of a CEW is essentially zero for the weight of the typical excited delirium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---


\(^{270}\) 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 Supplement] [* By the statistical "rule of 3" we have 95% confidence that the risk is as shown.]

\(^{271}\) 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 Cou...Circulation. 2014;129:93-100. doi: 10.1161/CIRCULATIONAHA.113.004401. [Including Supplement] [* By the statistical "rule of 3" we have 95% confidence that the risk is as shown.]


<table>
<thead>
<tr>
<th>Date/Lead Author</th>
<th>Probability</th>
<th>Risk</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>fatality case. The theoretical possibility of CEW induced VF does not appear to be a plausible explanation for arrest-related deaths.</td>
</tr>
<tr>
<td>14 (06/2008) Eastman\textsuperscript{280}</td>
<td></td>
<td></td>
<td>0 deaths out of 426 attributed to CEW</td>
</tr>
<tr>
<td>15 (03/2007) Wu\textsuperscript{281}</td>
<td>0.000 172</td>
<td></td>
<td>Bored gel-filled tunnel, blunted probe</td>
</tr>
</tbody>
</table>


## Temporal Arrest–Related Deaths Per Uses of Force (estimates):

### Table 71 Estimates: Temporal Arrest–Related Deaths per Uses of Force

<table>
<thead>
<tr>
<th>Year</th>
<th>Source</th>
<th>Type of Force</th>
<th># Force</th>
<th>Deaths</th>
<th>Ratio</th>
<th>Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Shane282</td>
<td>CEW</td>
<td>1:449</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Kroll283</td>
<td>CEW</td>
<td></td>
<td></td>
<td>All 1:1000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CEW</td>
<td></td>
<td></td>
<td>1:3500</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Heide284</td>
<td>(Deaths in Police Custody)</td>
<td>All 1:1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Karch285</td>
<td>(quotes Hall (2012))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Kroll286</td>
<td>(all uses of force)</td>
<td>1:1:000</td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>2015</td>
<td>Hall287</td>
<td>(all uses of force)</td>
<td>4,828</td>
<td>1</td>
<td>1:4,828</td>
<td>0.02</td>
</tr>
<tr>
<td>2014</td>
<td>Graham288</td>
<td>(quotes Hall (2012))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Hall289</td>
<td>(all uses of force)</td>
<td>4,992</td>
<td>7</td>
<td>1:713</td>
<td>0.14</td>
</tr>
<tr>
<td>2012</td>
<td>Hall290</td>
<td>(all uses of force)</td>
<td>1,269</td>
<td>1</td>
<td>1:1,269</td>
<td>0.07</td>
</tr>
<tr>
<td>2012</td>
<td>Okoye291</td>
<td>(Nebraska, U.S.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Strote292</td>
<td>(CEW epi study)</td>
<td>1,101</td>
<td>0</td>
<td>0:1,101</td>
<td>0.00</td>
</tr>
<tr>
<td>2009</td>
<td>Bozeman293</td>
<td>(CEW epi study)</td>
<td>1,201</td>
<td>2</td>
<td>1:600</td>
<td>0.01</td>
</tr>
<tr>
<td>2008</td>
<td>Eastman294</td>
<td>(CEW epi study)</td>
<td>426</td>
<td>1</td>
<td>1:426</td>
<td>0.02</td>
</tr>
<tr>
<td>2003</td>
<td>Koehler295</td>
<td>(all uses of force)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>NJJ296</td>
<td>(pepper spray)</td>
<td>63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>Stratton297</td>
<td>(ExDS deaths Los Angeles)</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>Okoye298</td>
<td>(Nebraska, U.S.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>ACLU299</td>
<td>(pepper spray)</td>
<td>26</td>
<td></td>
<td>1:600</td>
<td></td>
</tr>
</tbody>
</table>

296 The Effectiveness and Safety of Pepper Spray, NJJ Research for Practice, Office of Justice Programs, National Institute of Justice, Office of Justice Programs, U.S. Department of Justice, April 2003, NCJ 195739.
Table 72 Estimates: Law Enforcement Encounters, Arrests, Force, Deaths

<table>
<thead>
<tr>
<th>Event (estimates)</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Population (2010)</td>
<td>308,745,538</td>
<td>1:1</td>
<td>100%</td>
</tr>
<tr>
<td>Police-Public Face-to-Face (FTF) Contacts (total) (2008)</td>
<td>39,914,000</td>
<td>1:6</td>
<td>16.9%</td>
</tr>
<tr>
<td>Force Used or Threatened on those FTF Contacts (2008)</td>
<td>776,000</td>
<td>1:51</td>
<td>1.4%</td>
</tr>
<tr>
<td>Force Used Against Them Felt Force Excessive (2008)</td>
<td>447,000</td>
<td>1:1.74</td>
<td>74.3%</td>
</tr>
<tr>
<td>Force, Person Believed Excessive Filed Complaint</td>
<td>61,249</td>
<td>1:7.3</td>
<td>13.7%</td>
</tr>
<tr>
<td>Arrest – Force – Death Numbers (estimates)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US Population 2010</td>
<td>308,745,538</td>
<td>1:1</td>
<td>100%</td>
</tr>
<tr>
<td>Arrests (2010) (BJS FBI statistics and definitions)</td>
<td>13,122,000</td>
<td>1:23.5</td>
<td>4.2%</td>
</tr>
<tr>
<td>Force Used Per Arrests (calculated 1.5%)</td>
<td>196,830</td>
<td>1.5–2:100</td>
<td></td>
</tr>
<tr>
<td>Deaths Per BJS/FBI Arrests (estimated)</td>
<td>600</td>
<td>1:328</td>
<td>0.003%</td>
</tr>
</tbody>
</table>

Police-Person Contacts, Use of Force, and Excessive Force (2008): 301

Table 73 Police-Person Contacts, Use of Force, and Excessive Force (2008)

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Face-to-Face (FTF) Contacts (total)</td>
<td>39,914,000</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Force Used or Threatened on those FTF Contacts</td>
<td>776,000</td>
<td>1:51</td>
<td>1.4%</td>
</tr>
<tr>
<td>Force Used Against Them Felt Force Excessive</td>
<td>447,000</td>
<td>1:74</td>
<td>74.3%</td>
</tr>
<tr>
<td>Force, Person Believed Excessive Filed Complaint</td>
<td>61,249</td>
<td>1:7.3</td>
<td>13.7%</td>
</tr>
</tbody>
</table>

- “A majority of the people who had force used or threatened against them said they felt it was excessive.”
- “More than half of police use-of-force incidents involved the police pushing or grabbing the individual”
- “In 2008, 9.6% of persons who were suspected of wrongdoing by police experienced the use or threat of force.”
- “Of those who experienced the use or threat of force in 2008 and felt the police acted improperly, 13.7% filed a complaint against the police.”
- “As was the case in 2002 (90.1%) and 2005 (90.4%), the vast majority of residents (89.7%) with police contact during 2008 felt the officer or officers acted properly. In addition, about 9 out of 10 (91.8%) residents who experienced a contact in 2008 reported that the police were respectful.”
- “About 1 out of 10 searches conducted during traffic stops uncovered illegal items.”

---

• “Residents who experienced a police contact that involved force were asked if they felt any of the physical force used or threatened against them was excessive. The PPCS did not define excessive for the respondent. Most (74.3% or about 417,000) people whose most recent contact with police in 2008 involved force or the threat of force thought those actions were excessive.”

**Police-Person Contacts, Use of Force, and Excessive Force (2005):**

Table 74 Police-Person Contacts, Use of Force, and Excessive Force (2005)

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Face-to-Face (FTF) Contacts (total)</td>
<td>43500000</td>
<td>1:62.5</td>
<td>2.3%</td>
</tr>
<tr>
<td>Force Used or Threatened on those FTF Contacts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force Used Against Them Felt Force Excessive</td>
<td></td>
<td></td>
<td>83%</td>
</tr>
</tbody>
</table>

• “An estimated 19% [43.5 million] of U.S. residents age 16 or older had a face-to-face contact with a police officer in 2005.”

  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:**

Table 75 Hall (2013): Police Interactions, Use of Force, Death Statistics

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Interactions (total)</td>
<td>3,594,812</td>
<td>1:1720</td>
<td>0.14%</td>
</tr>
<tr>
<td>Police Use of Force Occurred (total)</td>
<td>4,992</td>
<td></td>
<td>0.14%</td>
</tr>
<tr>
<td>Deaths Per Use of Force (7 deaths)</td>
<td>7</td>
<td>1:713</td>
<td>0.14%</td>
</tr>
<tr>
<td>Sudden In Custody Death (1 death)</td>
<td>1</td>
<td>1:4.992</td>
<td>0.02%</td>
</tr>
</tbody>
</table>

**Hall (2012) Law Enforcement Officer (LEO) Interactions, Use of Force, Deaths:**

Table 76 Hall (2012): Police Interactions, Use of Force, Death Statistics

<table>
<thead>
<tr>
<th>Event</th>
<th>Total Number</th>
<th>Ratio</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police-Public Interactions (total)</td>
<td>1566908</td>
<td>1:1234</td>
<td>0.08%</td>
</tr>
<tr>
<td>Police Use of Force Occurred (total)</td>
<td>1,269</td>
<td></td>
<td>0.08%</td>
</tr>
<tr>
<td>Deaths Per Use of Force (1 death)</td>
<td>1</td>
<td>1:1269</td>
<td>0.002%</td>
</tr>
</tbody>
</table>


  o "During the study interval, there were 1,566,908 total police-public interactions. Police use of force occurred in 1,269 of those 1,566,908 interactions (0.08% of all police–public interactions; 95% CI = 0.08%, 0.086%)."

  ▪ 1 use of force for every 1,234 police–public interactions
  ▪ 1 death for every 1,269 uses of force

  o "The sudden in-custody death rate following police use of force was low overall (0.08%, 95% confidence interval (CI) = 0.002, 0.44) and the difference in the proportion of subjects who died suddenly in either position was not significant at 0.14%, (95% CI = −0.8, 0.9). Our results indicate that prone positioning was common and was not associated with death in our cohort of consecutive subjects following police use of force."

**Risk Factors Associated with Legal Intervention:**


**Basic Arrest–Related Death (“ARD”) Numbers:**

- **Pepper spray** – approximately 1 in 600 will die

  o “The study of in-custody deaths concluded that pepper spray contributed to death in two of the 63 cases, both involving people with asthma.”

  o “The [26 deaths] fatality total suggests that one person dies after being pepper sprayed for about every 600 times the spray is used by police.”

- **Positional asphyxia** – in a pepper spray study in 7 out of 63 “clear cut” cases of suspect death the death was attributed to positional asphyxia.

---

305. *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.


Pre-Arrest/Arrest Risk of Death (no listing of CEW):\textsuperscript{308}

- Pre-arrest/arrest risk of death is 6.5 deaths per 100,000 arrests or
- 1 death per 15,384.6 arrests

Table 77 Pre-Arrest/Arrest risk of death

<table>
<thead>
<tr>
<th>Event Type</th>
<th>No. of Deaths (n=77)</th>
<th>%</th>
<th>Risk of Death per 100,000</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Events Prior / During Arrest</td>
<td>14 deaths</td>
<td>18.1 %</td>
<td>6.5 per 100,000 arrests</td>
<td>1:15,384</td>
</tr>
<tr>
<td>Police Pursuits or Chases</td>
<td>10 deaths</td>
<td>12.9 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport of Suspects</td>
<td>2 deaths</td>
<td>2.6 %</td>
<td>0.93 per 100,000 arrests</td>
<td>1:107.527</td>
</tr>
<tr>
<td>During Incarceration</td>
<td>51 deaths</td>
<td>66.2%</td>
<td>268 per 100,000 inmates</td>
<td>1:323</td>
</tr>
</tbody>
</table>

Selected (US) Societal Problems Influencing Force Response:

<table>
<thead>
<tr>
<th>Societal Problem</th>
<th>Number</th>
<th>%</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Illicit Drug Abusers (2009)</td>
<td>21,800,000</td>
<td>8.7%</td>
<td>1:11</td>
</tr>
<tr>
<td>DSM-IV Substance Dependence (2009)</td>
<td>22,500,000</td>
<td>8.9%</td>
<td>1:11</td>
</tr>
<tr>
<td>Drug Caused Emergency Department Visits (2007)</td>
<td>1,900,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People in Serious Psychological Distress (2007)</td>
<td>23,400,000</td>
<td>10.9%</td>
<td>1:9</td>
</tr>
<tr>
<td>Drunk/Drugged Driving</td>
<td>10,200,000</td>
<td>13.2%</td>
<td>1:8</td>
</tr>
<tr>
<td>Mental Disorder: Children (13–20%) [up to 1 in 5]</td>
<td>13–20%</td>
<td>1.5–7</td>
<td></td>
</tr>
<tr>
<td>Suicide: Children (annually) (4.5 per 100,000)</td>
<td>1,926</td>
<td>0.0045%</td>
<td>1:22,222</td>
</tr>
</tbody>
</table>

Current Illicit Drug Abusers (“CIDA”):

- increasing annually (current drug use means use of an illicit drug during the month prior to the survey interview):
  - (2009) 21,800,000 CIDA age 12 and older (8.7% of population)\(^{309}\)
  - (2004) 19,100,000 CIDA age 12 and older (7.9% of population)\(^{310}\)

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).\(^{311}\)

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.”\(^{312}\)

People in serious psychological distress (“SPD”) annually in the U.S.:

- (2007) 23,400,000 SPD (10.9% of adults)\(^{313}\)

---


Drunk or Drugged Driving (2006–2009): 315

- “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.”


- A total of 13% to 20% of children living in the United States experience a mental disorder in a given year, and surveillance during 1994–2011 has shown the prevalence of these conditions to be increasing.
- The overall suicide rate for persons aged 10–19 years was 4.5 suicides per 100,000 persons in 2010 (a total of 1,926 deaths). (1 in 22,222 annual suicide rate.)
- Up to 1 out of 5 children experience a mental disorder in a given year and an estimated $247 billion is spent each year on childhood mental disorders.
- Data collected from a variety of data sources 2005–2011 show:
  - Children aged 3–17 years currently had:
    - ADHD (6.8%)
    - Behavioral or conduct problems (3.5%)
    - Anxiety (3.0%)
    - Depression (2.1%)
    - Autism spectrum disorders (1.1%)
    - Tourette syndrome (0.2%) (among children aged 6–17 years)
  - Adolescents aged 12–17 years had:
    - Illicit drug use disorder in the past year (4.7%)
    - Alcohol use disorder in the past year (4.2%)

- Cigarette dependence in the past month (2.8%)
Basic Selected Mortality Summary Numbers:

[“LEO” refers to “Law Enforcement Officer;” “SCD” refers to “sudden cardiac death”; “NCAA” refers to the “National Collegiate Athletic Association;” “CSP” refers to “competitive sports participants;” and “SUD” refers to “sudden unexplained death”]:

Abbreviated summary of selected approximate mortality numbers:

- 1.6 deaths per 100 hospital emergency room admissions (weekdays)
- 1.8 deaths per 100 hospital emergency room admissions (weekends)
- 1 death per 126 people in the U.S. population (annual 2009)
- 1 death per 323 LEOs’ uses of weapons
- 1 death per 600 LEOs’ uses of pepper spray
- 1 death per 700–800 persons jailed
- 1 death per 5,521 LEOs (annually)
- 1 death per 7,692 Military recruit-years (non-traumatic sudden death) (35% unexplained)
- 1 death per 15,385 law enforcement arrests

Sudden Cardiac Death (SCD):[317]

- 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:[318]

- Overall incidence of 2.28 SCA per 100 000 person-years [1 in 43,859]:
  - 2.1 per 100 000 in those 0–2 years of age [1 in 47,619],
  - 0.61 per 100 000 in those 3–13 years of age [1 in 163,934]

---


318 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.
- 1.44 per 100,000 in those 14–24 years of age [1 in 69,444], and
- 4.40 per 100,000 in those 25–35 years of age [1 in 22,727].

**Sudden Cardiac Death (SCD) Minnesota (MN) High School CSP:**
- 1 SCD death per 72,500 MN high school CSP over 3 years of high school
- 1 SCD death per 217,400 MN high school CSP per year

**Sudden Deaths in Young Competitive Athletes in U.S.: 1980–2006:**
- 1 sudden death per 163,934 young competitive athletes

**Sudden Cardiac Death (SCD) Children:**
- 1 SCD death per 12,438 children age 1–18 (in patient years)
- 1 SCD death per 15,698 children age 12–18 (in patient years)

**Sudden Cardiac Death (SCD) NCAA Participants:**
- 1 SCD death per 1,282 NCAA basketball black male athletes per year
- 1 SCD death per 3,126 NCAA basketball Division I male athletes per year
- 1 SCD death per 11,394 NCAA basketball athletes per year
- 1 SCD death per 12,990 NCAA black male athletes per year
- 1 SCD death per 21,293 NCAA swimming participants per year
- 1 SCD death per 23,397 NCAA lacrosse participants per year
- 1 SCD death per 38,497 NCAA football participants per year
- 1 SCD death per 41,695 NCAA cross-country participants per year

---

• 1 SCD death per 43,770 NCAA participants per year

**Probability, see, Hirsch v. CSX Transp., Inc., 656 F.3d 359 (6th Cir. (Ohio) 2011):**


• 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.

---

324 Available at http://www.hcra.harvard.edu/quiz.html.

Figure 51 US Deaths 2000–2010 Drugs, Suicide, Firearms, and Alcohol

![Graph showing US Deaths 2000 through 2010](image_url)

Deaths 2000 through 2010
Drugs, Suicide, Firearms, and Alcohol
(1,285,196 deaths)
2009 – US Population Death/Mortality Numbers:

- In 2009 there was 1 death for every 126 people in the U.S. population:
  - 2009 U.S. population = 307,006,550
  - 2009 total U.S. deaths = 2,436,682
  - 307,006,550 population ÷ 2,436,682 deaths = (1 death per) 126 people

- In 2009, of those 2,436,682 who died in the U.S., there were 129,523 (132,538 in 2010) deaths from drugs, suicide, firearms, or alcohol.
  - 2009 U.S. deaths from:
    - Drugs – 37,485 or a rate of 12.2 per 100,000 people in population
    - Suicide – 36,547 or a rate of 11.9 per 100,000 people
    - Firearms – 31,228 or a rate of 10.2 per 100,000 people
    - Alcohol – 24,263 or a rate of 7.9 per 100,000 people

- In 2009 for every 18.81 people who died, one of those 18.81 people died from drugs, suicide, firearms, or alcohol.
- In 2009 for every 65 people who died, one of those 65 people died from drugs.

Table 79 Cause of death rates per 100,000 of general population

<table>
<thead>
<tr>
<th>Cause of Death (death rates per 100,000 of general population)</th>
<th>2010</th>
<th>2009</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>All causes of Death</td>
<td>798.7</td>
<td>793.7</td>
<td>813.2</td>
</tr>
<tr>
<td>Infant Death Rate All Causes</td>
<td>614.0</td>
<td>642.1</td>
<td>659.3</td>
</tr>
<tr>
<td>Major Cardiovascular Diseases</td>
<td>251.8</td>
<td>253.9</td>
<td>264.7</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>16.0</td>
<td>16.5</td>
<td>18.0</td>
</tr>
<tr>
<td>Transport Accidents</td>
<td>12.2</td>
<td>12.7</td>
<td>14.1</td>
</tr>
<tr>
<td>Drugs</td>
<td>12.2</td>
<td>12.2</td>
<td>12.4</td>
</tr>
<tr>
<td>Suicide</td>
<td>12.2</td>
<td>11.9</td>
<td>11.8</td>
</tr>
<tr>
<td>Firearm</td>
<td>10.2</td>
<td>10.2</td>
<td>10.4</td>
</tr>
<tr>
<td>Alcohol</td>
<td>8.2</td>
<td>7.9</td>
<td>7.9</td>
</tr>
<tr>
<td>Falls</td>
<td>8.4</td>
<td>8.1</td>
<td>7.9</td>
</tr>
<tr>
<td>HIV</td>
<td>2.7</td>
<td>3.1</td>
<td>3.4</td>
</tr>
<tr>
<td>Injury at Work</td>
<td>1.6</td>
<td>1.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Peptic Ulcer</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Influenza</td>
<td>0.2</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Complications of Medical and Surgical Care</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Hernia</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Pregnancy, Childbirth, and the Puerperium</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>0.9</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Death Rate in Jails (no listing of ECD):

- Local U.S. Jails 2010 (BJS/OJP/DOJ327):
  - Mortality rate:
    - 2010 – 918 deaths - 125 deaths per 100,000 jail inmates (1:800)
    - 2009 – 128 deaths per 100,000 jail inmates (1:781)
  - The number of inmates who died while in the custody of local jails declined in 2010, falling to 918 from the 951 deaths in 2009, representing the third consecutive annual decrease since the number of jail deaths peaked at 1,100 in 2007.
  - In 2010, males accounted for nearly 9 out of 10 jail inmate deaths (88%). In any single year between 2000 and 2010, males accounted for no less than 87% of jail deaths.


deaths.

- The number of jail inmate deaths from heart disease increased in 2010 to 240, up from 199 occurring in 2009. The annual average number of heart disease deaths was 222 over the past 10 years (excluding 2008 data as noted above).

- Jail inmates died of heart disease at a rate of 33 per 100,000 inmates in 2010, similar to rates between 2000 and 2006, but was slightly above the rate of 27 per 100,000 inmates in 2009.

  - 2009 – 948 deaths, 127 deaths per 100,000 inmates (1 death per 787 detainees).
  - 2008 – 960 deaths, 123 deaths per 100,000 inmates (1 death per 813 detainees).

**Figure 53 Jail inmate deaths in custody, 2000–2009**

---

  o 8,110 persons died in local jails from 2000 through 2007
    - Approximately 1 death per 658–709 inmates (depending on year)
  o Local jail in-custody rates of death for 2000 through 2007:
    - approximately 141–152 deaths per 100,000 inmates (depending on year)

• “Nevada’s rate of custody deaths of 247 per 100,000 inmates is similar to the
  national average (250 per 100,000 inmates), but is substantially higher than the
  average for other Western states (219 per 100,000 inmates).”330

• 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.”331

US ARDs, BJS, Deaths in Custody Reporting Act (“DICRA”).332

**Figure 54 US ARDs, BJS, Deaths in Custody Reporting Act (“DICRA”)**

![Graph showing Arrest-Related Deaths in the U.S. BJA Deaths In Custody Reporting Act (DICRA)]


• January 2003-December 2009 DICRA Report:
  o A total of 4,813 deaths were reported to the Arrest-Related Deaths program from January 2003 through December 2009.
  o Of reported arrest-related deaths, 61% (2,931) were classified as homicides by law enforcement personnel, 11% (541) were suicides, 11% (525) were due to intoxication, 6% (272) were accidental injuries, and 5% (244) were attributed to natural causes.

(2004) U.S. Medical Examiners and Coroners’ Numbers:

• 2,000 Medical Examiner (“ME”) / Coroner (“C”) Offices in U.S.:
  o 7,320 ME/C full-time equivalent ME/C employees
  o $718,500,000.00 total ME/C annual budgets

• 2,398,000 human deaths:
  o 956,000 deaths referred to ME/C offices
    ▪ 487,000 deaths accepted for investigation
      - 677 Arrest Related Deaths (“ARDs”) (all causes)
    • 9 ARDs involved the use of ECDs or other conducted-energy devices

Additional Mortality Numbers:

Hospital Emergency Department Mortality Rates:

• 1.8 out of 100 – hospital emergency department mortality rate on weekends

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: 338

- 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.

---

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\textsuperscript{339} Athletes:\textsuperscript{340}

- 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:

\textsuperscript{339} NCAA – National Collegiate Athletic Association.

- SCD incidence (risk) in NCAA white male athletes – 1:21,824 per year
- SCD incidence (risk) in NCAA black male athletes – 1:5,743 per year
  - SCD incidence (risk) of NCAA Division I male – 1:3,126 per year
    - 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 81 Incidence of SCD - NCAA Athletes 2004-2008

<table>
<thead>
<tr>
<th></th>
<th>No. of Athlete-Years</th>
<th>No. of Deaths</th>
<th>Death Rate (per Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAA athletes</td>
<td>1,969,663</td>
<td>45</td>
<td>1:43.770</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1,126,557</td>
<td>34</td>
<td>1:33.134</td>
</tr>
<tr>
<td>Female</td>
<td>843,106</td>
<td>11</td>
<td>1:76.846</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>300,835</td>
<td>17</td>
<td>1:17.093</td>
</tr>
<tr>
<td>White</td>
<td>1,563,828</td>
<td>27</td>
<td>1:58.053</td>
</tr>
<tr>
<td>By division</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Division I</td>
<td>788,023</td>
<td>27</td>
<td>1:29.186</td>
</tr>
<tr>
<td>Division II</td>
<td>424,572</td>
<td>10</td>
<td>1:42.457</td>
</tr>
<tr>
<td>Division III</td>
<td>760,258</td>
<td>8</td>
<td>1:95.032</td>
</tr>
</tbody>
</table>

SCD indicates sudden cardiac death; NCAA, National Collegiate Athletic Association.

- Incidence of NCAA SCD by Sport, 2004–2008:
### Table 82 Incidence of NCAA SCD by sport 2004–2008

<table>
<thead>
<tr>
<th>Sport</th>
<th>Overall Incidence</th>
<th>Incidence in Males</th>
<th>Incidence in Females</th>
<th>Incidence in African Americans</th>
<th>Incidence in Caucasians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division I</td>
<td>1:5.451</td>
<td>1:3.126</td>
<td>1:2.901</td>
<td>1:5.284</td>
<td>1:8.135</td>
</tr>
<tr>
<td>Division III</td>
<td>1:24.681</td>
<td>1:13.646</td>
<td>1:6.952</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swimming</td>
<td>1:21.293</td>
<td>1:34.552</td>
<td>1:16.452</td>
<td></td>
<td>1:20.981</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>1:23.357</td>
<td>1:19.770</td>
<td>1:30.531</td>
<td></td>
<td>1:23.357</td>
</tr>
<tr>
<td>Football</td>
<td>1:38.497</td>
<td>1:38.497</td>
<td>1:59.814</td>
<td></td>
<td>1:14.401</td>
</tr>
<tr>
<td>Cross-country</td>
<td>1:41.696</td>
<td>1:59.466</td>
<td>1:32.801</td>
<td>1:12.043</td>
<td>1:51.033</td>
</tr>
</tbody>
</table>

NCIA indicates National Collegiate Athletic Association; SCD, sudden cardiac death.
*SCD incidence is expressed as number of athletes per year.
†No deaths for incidence calculation.

### Table 3. Capture-Recapture Analysis

<table>
<thead>
<tr>
<th>No. of Deaths in Aggregate Database</th>
<th>Cap-Recap Estimate of No. of Deaths</th>
<th>95% Confidence Interval</th>
<th>No. of Athletes</th>
<th>Aggregate Database Incidence</th>
<th>Cap-Recap Incidence Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>45</td>
<td>49.6</td>
<td>45.4–50.4</td>
<td>1,963,663</td>
<td>1:43.770</td>
</tr>
<tr>
<td>Division I</td>
<td>27</td>
<td>28.4</td>
<td>27.4–32.5</td>
<td>786,023</td>
<td>1:29.186</td>
</tr>
<tr>
<td>Division II</td>
<td>18</td>
<td>22.4</td>
<td>18.8–34.3</td>
<td>1,184,830</td>
<td>1:18.824</td>
</tr>
</tbody>
</table>

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:

- “During the study period there were 1,453,280 overall sports participations and 651,695 student athlete participants among the 27 high school sports. The calculated risk for sudden death was 1:500,000 participations and 1:217,400 participants per academic year (or 0.46/100,000, annually). Over a 3-year high school career for a student athlete the estimated risk was 1:72,500.”
  - Calculated risk for sudden cardiac death (SCD) was:
    - 1:500,000 participations
    - 1:217,400 participants per academic year
    - 1:72,500 over a 3-year high school competitive sports career

---

Out-of-Hospital Non-traumatic Cardiac Arrest (OHCA): Children:\textsuperscript{342}

- The incidence of pediatric OHCA:
  - 8.04 per 100,000 person-years (1:12,438):
    - 72.71 in infants (1:1,375);
    - 3.73 in children (1:26,809); and
    - 6.37 in adolescents (1:15,698);
  - versus 126.52 per 100,000 person-years for adults (1:790).

- Survival for:
  - all pediatric OHCA was 6.4%:
    - 3.3% for infants;
    - 9.1% for children; and
    - 8.9% for adolescents:
  - versus 4.5% for adults.

Sudden Non-Traumatic Sudden Death in Military Recruits:\textsuperscript{343}

- Non-traumatic sudden death rate: military recruit-years: 13.0/100,000 or 1 in 7,692
  - “a substantial number of deaths remained unexplained (44 of 126 recruits [35%])”

- No recruit was noted to have pre-entry cardiovascular disease, and postmortem toxicology reports showed no evidence of illicit drug use.

- Conclusions: Cardiac abnormalities are the leading identifiable cause of sudden death among military recruits; however, more than one third of sudden deaths remain unexplained after detailed medical investigation.


Routine Cardiac Ablation Procedures Rates of Major Complications/Deaths:  
- Mortality rate – 1,000 deaths per million, or 1 in 1,000
- Major complications rate from routine cardiac ablation – 3.8 out of 100

Severe Mental Illness Mortality Rates:  
- A 2–3 fold increased mortality rate

“People with severe mental illnesses (SMI), such as schizophrenia, depression or bipolar disorder, have worse physical health and reduced life expectancy compared to the general population .... Evidence shows that they have a 2–3 fold increased mortality rate and that the mortality gap associated with mental illness compared to the general population has widened in recent decades.”

Antipsychotics and the Risk of Sudden Cardiac Death:  
- 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.”

344 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.


346 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."\(^{347}\)
- "Approximately 2 million people in the United States have epilepsy."\(^{348}\)
- "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."\(^{349}\)
- "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."\(^{350}\) [citation omitted]
- "People with epilepsy have a 2.6-fold increased risk of premature death compared with the general population."\(^{351}\)
- "The risk of sudden death in young adults with epilepsy is increased 24-fold."\(^{352}\)
- 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."\(^{353}\)
- "In children with epilepsy, the cumulative risk of dying suddenly is 7% within 40 years."\(^{354}\)

Law Enforcement Officer (LEO) Mortality, Assaults, and Injuries:\(^{355}\)

- Averages over 2000–2009 decade:
  - 900,000 LEOs

---

348 Id.
349 Id.
350 Id.
352 Id.
353 Id.
o 163 LEO deaths per year
o 50,069 LEO assaults per year
o 16,041 LEO injuries per year

• Thus, annually:
  o 1 LEO death per year per 5,521 officers
  o 1 LEO injured per year per 56 officers
  o 1 LEO assault per year per 18 officers

Other Numbers:

1. (Near Earth Object (NEO) Collision) According to NASA you have about one chance in 40,000 of dying as a result of a near earth object (“NEO”) [asteroid or comet] collision.356

---

Chemical Aerosol Weapons (OC, CN, CS, Pava):

Chemical Aerosol Weapons – Sampling of Legal Statements:


   Pepper spray is regarded as an “intermediate force” that presents a significant intrusion upon an individual’s liberty interests. Nelson v. City of Davis, 685 F.3d 867, 878 (9th Cir. 2012). 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.” Young v. Cty. Of L.A., 655 F.3d 1156, 1162 (9th Cir. 2011) (quoting Headwaters Forest Def. v. Cty. 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) ). Under our case law, a reasonable officer would be on notice in 2015 “that police officers employ excessive force in violation of the Fourth Amendment when they use pepper spray upon an individual who is engaged in the commission of a non-violent misdemeanor and who is disobeying a police officer’s order but otherwise poses no threat to the officer or others.” Young, 655 F.3d at 1168. See also Nelson, 685 F.3d at 885 (stating that the use of pepper spray was “an unreasonable application of force against individuals who were suspected of only minor criminal activity, offered only passive resistance, and posed little to no threat of harms to others”).

   *3 Viewing the facts in the light most favorable to Appellees, considering the number of times Haleck was pepper-sprayed, the three Graham factors, the availability of alternative means for executing arrest, and Haleck’s vulnerable mental state, there is a factual issue for the jury whether Appellants’ use of force violated both the Fourth Amendment and clearly established law. See Smith v. City of Hemet, 394 F.3d 689, 704 n.7 (9th Cir. 2005).

Chemical Aerosol Weapons – Standards:


Chemical Aerosol Weapons – Sampling of Literature:

synthetic and natural origin, Inhalation Toxicology, 30:2, 89-97, DOI: 10.1080/08958378.2018.1451575. Published online: 29 Mar 2018.


Personal Defense Aerosols Sprays – A Sampling of Basics

The Petty (2004)\textsuperscript{357} study, funded by the National Institute of Justice (NIJ), United States (U.S.) Department of Justice (DoJ), observed that “[t]he effectivity of O.C. is approximately 1 in 5 [20%], but this study included “violent” subjects alone, so violent that death ensued, from the confrontation.” With regard to Petty (2004), in April 2003 the NIJ published \textit{The Effectiveness and Safety of Pepper Spray}\textsuperscript{358} that included “[t]he [Petty (2004)] study of in-custody deaths concluded that pepper spray contributed to death in two of the 63 cases, both involving people with asthma. In the other cases, the researcher concluded that [OC use temporal] death was caused by the arrestee’s drug use, disease, positional asphyxia, or a combination of these factors.”

The Bertilsson (2017)\textsuperscript{359} study looked at “situational conditions and effectiveness of using OC spray … in one of Sweden’s then [21] Police Departments, the Skåne (Scania) County Police Department, during a 7-year period from 2006 to 2012.” The study found in part “the operative range [of pepper spray] was often <2 m and it took between 3 and 5 s of spraying before obtaining effect, partly owing to the difficulties of hitting a small, sometimes erratically moving target. Collateral hits were noted in 24% of the incidents, whereof 90% were other officers. Noteworthy, in 21% of incidents officers put themselves at large personal risk by using OC at close range against people armed with lethal weapons. Hence, OC emerges as a suitable tool for handling low threat situations but lacks key traits to ensure safe and efficient policing of high threat situations,” The study also included significant analysis of “[t]he design of the OC device can influence a number of the operative parameters, e.g., the maximum range, precision, sensitivity to wind and time to reach effect (Heal et al., 2010).”

As Bertilsson (2017) includes “collateral hits were noted in 24” of incidents.” This is important because pepper spray, and similar aerosol weapons, can have significant negative collateral effects if used in in-door, enclosed, or crowded environments, such as shopping malls, businesses, schools, hospitals, personal residences, apartment buildings, or at sporting events, concerts, fairs, etc.

Haar’s (2017)\textsuperscript{360} paper found “… chemical weapons … have significant potential for misuse, leading to unnecessary morbidity and mortality.” In reviewing 31 studies

\textsuperscript{357} Petty, Charles S. "Deaths in police confrontations when oleoresin capsicum is used." unpublished report prepared for the US Department of Justice 9 (2004).
from 11 countries identified “5131 people who suffered injuries, two of whom died and 58 of whom suffered permanent disabilities. Out of 9261 total injuries, 8.7% were severe and required professional medical management, while 17% were moderate and 74.3% were minor. Severe injuries occurred to all body systems, with the majority of injuries impacting the skin and eyes.” The Haar (2017):

**Abstract:**

**Background:** Chemical irritants used in crowd control, such as tear gases and pepper sprays, are generally considered to be safe and to cause only transient pain and lacrimation. However, there are numerous reports that use and misuse of these chemicals may cause serious injuries. We aimed to review documented injuries from chemical irritants to better understand the morbidity and mortality associated with these weapons.

**Methods:** We conducted a systematic review using PRISMA guidelines to identify injuries, permanent disabilities, and deaths from chemical irritants worldwide between January 1, 1990 and March 15, 2015. We reviewed injuries to different body systems, injury severity, and potential risk factors for injury severity. We also assessed region, context and quality of each included article.

**Results:** We identified 31 studies from 11 countries. These reported on 5131 people who suffered injuries, two of whom died and 58 of whom suffered permanent disabilities. Out of 9261 total injuries, 8.7% were severe and required professional medical management, while 17% were moderate and 74.3% were minor. Severe injuries occurred to all body systems, with the majority of injuries impacting the skin and eyes. Projectile munition trauma caused 231 projectile injuries, with 63 (27%) severe injuries, including major head injury and vision loss. Potentiating factors for more severe injury included environmental conditions, prolonged exposure time, and higher quantities of chemical agent in enclosed spaces.

**Conclusions:** Although chemical weapons may have a limited role in crowd control, our findings demonstrate that they have significant potential for misuse, leading to unnecessary morbidity and mortality. A nuanced understanding of the health impacts of chemical weapons and mitigating factors is imperative to avoiding indiscriminate use of chemical weapons and associated health consequences.

**Keywords:** Crowd control, Less lethal weapons, Tear gas, Pepper spray, Protests, Demonstrations, 2-chlorobenzalmalonitrile (agent CS), Oleoresin capsicum (agent OC), Pelargonic acid vanillylamide or capsaicin II (PAVA)

The Kearney (2014)\(^{361}\) paper looked at “a total of 4,544 cases were identified and 3,671 met the inclusion criteria. Of these, 249 cases (6.8%) were found to have more severe symptoms that warranted a medical evaluation. There were no reported deaths. The cases with more severe symptoms most commonly involved the ocular (53.8%), respiratory (31.7%), and dermal (17.7%) organ systems." And, the conclusion included:

---

a “1 in 15 potential risk for more severe adverse health effects in persons exposed to pepper spray that warranted a medical evaluation.” The Kearney (2014) Abstract:

**Background.** Pepper spray is a common lacrimator used by law enforcement and the public to subdue individuals and for self-defense. The risk factors for severe injury due to pepper spray exposure are not well documented and there is a lack of guidelines to identify patients that require transport and medical evaluation in an emergency department.

**Objective.** The aim of this study was to determine the prevalence of and circumstances associated with symptoms suggestive of tissue injury beyond transient irritation in persons exposed to pepper spray.

**Methods.** We reviewed all human exposures to pepper spray reported to a poison control system between 2002 and 2011. Cases were differentiated into 2 outcome groups: minor or self-limiting symptoms versus those with more severe symptoms suggestive of tissue injury that warranted a medical evaluation. A comparison of the variables between the outcome groups was performed using odds ratios (ORs), 95% confidence intervals (CIs), and associated P values.

**Results.** A total of 4,544 cases were identified and 3,671 met the inclusion criteria. Of these, 249 cases (6.8%) were found to have more severe symptoms that warranted a medical evaluation. There were no reported deaths. The cases with more severe symptoms most commonly involved the ocular (53.8%), respiratory (31.7%), and dermal (17.7%) organ systems. Factors with largest independent associations with more severe outcomes were use for law enforcement training (OR, 7.39; 95% CI, 2.98–18.28), direct intentional exposure for purposeful use to incapacitate (OR, 3.02; 95% CI, 1.80–5.06), and for law enforcement on individual target suspects or crowd control (OR, 2.45; 95% CI, 1.42–4.23).

**Conclusions.** There was a low 1 in 15 potential risk for more severe adverse health effects in persons exposed to pepper spray that warranted a medical evaluation. The risk was highest when used for training of law enforcement personnel and involved severe ocular symptoms. This suggests that routine use of pepper spray for training of law enforcement or military personnel be reconsidered. Protective goggles may be an option when direct spraying into the face of trainees. Transport for medical evaluation should be considered for exposed persons that manifest persistent ocular or respiratory symptoms.

**Key words:** capsaicin; tear gas; pepper spray; eye injury; respiratory injury

The U.S. Department of Transportation considers pepper spray a hazardous material. In *Young v. County of Los Angeles* the United States Court of Appeals for the Ninth Circuit stated that “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

---

362 49 CFR § 173.140(a) and § 173.115.
363 *Young v. County of Los Angeles*, 655 F.3d 1156 (C.A.9 (Cal.), August 26, 2011).
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."


Also, 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."
Selected Bath Salt Papers


   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.”


   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

Book Chapters:


Restraint – Miscellaneous Papers:


Restraint-related Asphyxia:


Fatal Compression Asphyxia:


Abstract

“Deceased individuals may be found in a position that raises the question of whether or not the individual died from being in that position. We describe 3 victims of 35, 84 and 54 years of age, respectively. All were found in an unusual position that may have impeded breathing. Breathing may be impaired by compression of the thoracic wall or by extrathoracic airway obstruction caused by the position. Reduced independence, with causes varying from dementia to inebriation, is a risk factor for positional asphyxia. Restraining a person in the so-called "hogtie position" does not lead to positional asphyxia. Positional asphyxia in individuals dying in the hogtie
position must not be confused with excited delirium syndrome (EDS). On the other hand, the diagnosis of positional asphyxia must be seriously considered in deceased individuals found in a position that may impede breathing.” (highlighting emphasis added)


Abstract

**Background:** Fatalities from acute compression have been reported with soft-drink vending machine tipping, motor vehicle accidents, and trench cave-ins. A major mechanism of such deaths is flail chest but the amount of force required is unclear. Between the range of a safe static chest compression force of 1000N (102 kg with earth gravity) and a lethal dynamic force of 10–20 kN (falling 450 kg vending machines), there are limited quantitative human data on the force required to cause flail chest, which is a major correlate of acute fatal compression asphyxia.

**Methods:** We modeled flail chest as bilateral fractures of six adjacent ribs. The static and dynamic forces required to cause such a ribcage failure were estimated using a biomechanical model of the thorax. The results were then compared with published historical records of judicial “pressing,” vending machine fatalities, and automobile safety cadaver testing.

**Results and conclusion:** The modeling results suggest that an adult male requires 2550±250 N of chest-applied distributed static force (260±26 kg with earth gravity) or 4050±320N of dynamic force to cause flail chest from short-term chest compression.

**Prone Position Affect on Respiration:**


   a. **Authors’ conclusions:** We found no convincing evidence of benefit nor harm from universal application of PP in adults with hypoxaemia mechanically ventilated in intensive care units (ICUs). Three subgroups (early implementation of PP, prolonged adoption of PP and severe hypoxaemia at study entry) suggested that prone positioning may confer a statistically significant mortality advantage. Additional adequately powered studies would
be required to confirm or refute these possibilities of subgroup benefit but are unlikely, given results of the most recent study and recommendations derived from several published subgroup analyses. Meta-analysis of individual patient data could be useful for further data exploration in this regard. Complications such as tracheal obstruction are increased with use of prone ventilation. Longterm mortality data (12 months and beyond), as well as functional, neuro-psychological and quality of life data, are required if future studies are to better inform the role of PP in the management of hypoxaemic respiratory failure in the ICU."


   a. MRI studies of healthy volunteers show lung perfusion is significantly greater in the prone position than when studied in volunteers lying supine.

**Prone Restraint:**


   a. "Positional asphyxia" or "restraint asphyxia," the theories most frequently proposed, are terms often used synonymously. The term "restraint asphyxia" came into use when the notion of "positional asphyxia" fell from favor (it was retracted in court testimony by its author, Reay) and was replaced with the phrase "restraint asphyxia," which is used in exactly the same way, and should be considered to have the same meaning.

   b. Those who accept the theory of "positional or restraint asphyxia" assume that prone positioning is clearly harmful, even though all of the available peer-reviewed evidence suggests that quite the opposite is the case.

   c. Attempts at introducing the newly defined "positional asphyxia" into the court system have been rejected by several United States courts. In *Garcia v City and County of San Francisco* (State of California, Superior Court, Case #984e221), the presiding judge ruled that "reliance by plain tiffs on the theory of positional asphyxia is irrelevant ... the original proponent of the theory, Dr. Donald Reay, has now retracted it ... Indeed, even Dr. Reay himself acknowledges the 1997 UCSD (University of California, San Diego) study
refutes his earlier work. Everyone now agrees that there is no scientific evidence to support the idea that hog-tying or any other body position plays any role in causing life-threatening respiratory effects."

d. Positional asphyxia, as the term is used in court today, is an interesting hypothesis unsupported by any experimental data.


a. The death rate of individuals restrained for ExDS is so low that drawing any conclusions based on statistical studies or on isolated case report could be hazardous.


a. Ross and Hazlett conducted a prospective study examining 1085 violent arrests occurring over a 1-year period in 17 different police jurisdictions across the United States. Police placed all of the arrestees in the prone position for 1-5 minutes; forcible measures were used to get them prone in 71% of cases. Handcuffs were used in 96% of the incidents and were first applied when the arrestee was prone in a one-fourth of the cases. Hobble restraints were used in about one-fourth of the cases. No deaths were recorded during the study and only 1 fracture occurred. The authors concluded "the use of prone position with violent arrestees is a safe restraint method."

b. "The results show that the use of the prone position with violent arrestees is a safe restraint method and that the officers' use of force is rare."

c. Abstract

Placing a combative person in the prone position occurs numerous times daily throughout the country without the incident resulting in serious injury to the person, let alone a sudden death. In statistically rare incidents, the individual may unexpectedly and suddenly die within a short amount of time after restraint. Questions may arise which implicate the officers use of force measures asserting that placing the arrestee in the prone position caused the death. What remains unanswered in majority of the sudden in custody restraint incidents is the question of whether prone restraint caused the death.
Using a prospective design, this study examined the outcomes of 1085 violent arrest incidents over 12 months with 17 police agencies in the United States. Male arrestees accounted for 85 percent and arrestees were placed in the prone position from about 1 to 5 minutes. About 84 percent of the arrestees exhibited behaviors resembling chemical substance use, psychiatric impairment, or both. Police officers commonly used several force measures to control and restrain the arrestee including: empty-hand control techniques; a TASER; an aerosol; applying weight force on the back of the arrestee; a hobble strap; and handcuffs. None of the arrestees died during the study period and moderate injuries were sustained in 16 percent of the incidents and significant injuries were sustained in 4 percent. Arrestee’s injuries were associated with their active behaviors of resistance during the arrest and continued resistance after restraint. Regression analysis revealed three predictive outcome models (p=0.001) showing the relationships among common variables when using the prone position revealing that arrestees rarely sustain an injury. The results show that the use of the prone position with violent arrestees is a safe restraint method and that the officers’ use of force is rare.


In 2007, Michalewicz investigated the ventilatory and metabolic demands in healthy adults who had been placed in the prone maximal restraint position (PMRP).364 Maximal voluntary ventilation (MVV) was measured in seated subjects (n=30), in the PMRP (hogtied), and when prone with up to 90.1 or 102.3 kg of weight on their backs. MVV with >100 kg on their backs was 70% of the seated MVV {122±28 and 156±38 L/min, respectively; p<.001). However measurable decreases were observed in a second phase of the study when subjects were made to struggle vigorously before being studied; a decline in maximal minute ventilation (MMV) of 44% was observed. The researchers concluded the decrease in MVV was of no clinical importance in these subjects, and that even in PMRP ventilatory exchanges was still adequate to supply the ventilatory needs, a judgement that would be shared by any pulmonologist.

In 2012, Hall published her epidemiological study "Incidence and outcome of prone positioning following police use of force."365 In her study, data from a single police force serving >1.1 million people were collected for 3 consecutive years. Officers prospectively documented the final position of the subject, among other data points, via electronic study forms embedded in standard force reporting forms. Final resting position was available for 1255/1269 subjects. Force was required in 1269 cases. The majority (52%) were not

---


left in a prone position. There was 1 death, and that occurred in a prisoner not in the prone position. The authors concluded "prone positioning was common and was not associated with death in our cohort of consecutive subjects following police use of force."

In 2015, Hall published her further study reporting 4828 consecutive force events in seven police agencies in four cities, concluding that their data support the human laboratory data that the prone position has no clinically significant effects on subject physiology. In 2013, Savas's group evaluated the effect of maximal prone restraint (PMPR) on a group aged 22-42 years old. Each volunteer was hogtied and tested in five different positions: supine, prone, prone maximal restraint with no weight force, prone maximal restraint with 50 lbs added to the subject's back, and prone maximal restraint with 100 lbs added to the subject's back for three minutes. Heart rate (HR), blood pressure (BP) and oxygenation saturation (O2 sat) were monitored for each volunteer in each position. In addition, echocardiography was performed to measure left ventricular outflow tract diameter. HR, MAP or O2 sat were statistically no different in any of the positions.

In 2014, Sloane extended the work even further measuring the ventilatory and cardiovascular parameters in 10 intensely exercising volunteers (85% of their measured VO2 max) who were placed in PMPR after exercising and then studied while in three different positions for 15 minutes: (1) seated with hands behind the back, (2) prone with arms to the sides, and (3) PMPR position. Cardiovascular parameters (oxygenation, stroke volume, inferior vena cava diameter, cardiac output, cardiac index, oxygenation, stroke volume, IVC diameter, cardiac output and cardiac index) were all measured. There was no evidence of hypoxia or hypoventilation during any of the monitored 15-minute position periods. Numerous other papers confirm the findings summated above.


   a. Our epidemiologic data of real police public interactions support the human laboratory data that the prone position has no clinically significant effects on subject physiology.


---


a. 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.


a. "...Consequently, positioning alone, even prone in the hog-tied position, does not cause a clinically significant change in arterial blood gases. …”


a. "**Interpretation:** Restraint may contribute to the death of people in states of excited delirium, and further studies to test this hypothesis are recommended. Meanwhile, law enforcement authorities and others should bear in mind the potential for the unexpected death of people in states of excited delirium who are restrained in the prone position or with a neck hold.”

**Prone Maximal Restraint (PMR)**


a. Conclusion: In this small study of obese subjects, there were no clinically significant differences in the cardiovascular and respiratory measures comparing seated, prone, and PMR position following exertion.


a. Conclusions: [Prone Maximal Restraint (PMR)] with and without weight force did not result in any changes in CO or other evidence of cardiovascular or hemodynamic compromise.

   a. Abstract

   The use of the hogtie restraint (also known as hobble or prone maximal restraint) by law enforcement and prehospital personnel has come under scrutiny because of reports of sudden deaths in persons placed in this restraint position. Some contend that this body position restricts chest and abdominal movement to the point that individuals are at risk for hypoventilatory respiratory compromise and "positional" asphyxiation. We review case reports of custody deaths in subjects placed in the hogtie position, as well as related medical literature regarding positional asphyxia. We also review the current research findings from human physiology studies that have investigated the effects of the hogtie position on respiratory and pulmonary function. **We conclude that the hogtie restraint position by itself does not cause respiratory compromise to the point of asphyxiation and that other factors are responsible for the sudden deaths of individuals placed in this position.** (highlighting added)


   Abstract

   **STUDY OBJECTIVE:** To determine whether the "hobble" or "hog-tie" restraint position results in clinically relevant respiratory dysfunction.

   **METHODS:** This was an experimental, crossover, controlled trial at a university-based pulmonary function laboratory involving 15 healthy men ages 18 through 40 years. Subjects were excluded for a positive urine toxicology screen, body mass index (BMI) greater than 30 kg/m2, or abnormal screening pulmonary function testing (PFT). Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), and maximal voluntary ventilation (MVV) were obtained with subjects in the sitting, supine, prone, and restraint positions. After a 4-minute exercise period, subjects rested in the sitting position while pulse, oxygen saturation, and arterial blood gases were monitored. The subjects repeated the exercise, then were placed in the restraint position with similar monitoring.

   **RESULTS:** There was a small, statistically significant decline in the mean FVC (from 5.31 +/- 1.01 L [101% +/- 10.5% of predicted] to 4.60 +/- .84 L [88% +/- 8.8% of predicted]), mean FEV1 (from 4.31 +/- .53 L [103% +/- 8.4%]
to 3.70 +/- .45 L [89% +/- 7.7%]), and mean MVV (from 165.5 +/- 24.5 L/minute [111% +/- 17.3%] to 131.1 +/- 20.7 L/minute [88% +/- 16.6%]), comparing sitting with restraint position (all, P < .001). There was no evidence of hypoxia (mean oxygen tension [PO2] less than 95 mm Hg or co-oximetry less than 96%) in either position. The mean carbon dioxide tension (PCO2) for both groups was not different after 15 minutes of rest in the sitting versus the restraint position. There was no significant difference in heart rate recovery or oxygen saturation as measured by co-oximetry and pulse oximetry.

**CONCLUSION:** In our study population of healthy subjects, the restraint position resulted in a restrictive pulmonary function pattern but did not result in clinically relevant changes in oxygenation or ventilation.

**Physical Restraint:**


   a. Conclusion The scientific literature shows that certain restraint positions can impose a restrictive effect on respiratory function as measured by spirometry, but the effects on other physiological parameters are less clear. The reduction in spirometry measures was proportional to the extent of the restriction imposed by position, increasing weight applied on the torso and increasing obesity in the seated flexed position. The literature did not report that the reductions seen were clinically significant except for Parkes et al who reported the reductions seen in the flexed seated position with obese individuals were operationally significant. The lack of a clinically significant effect is incongruous with case study history and anecdotal evidence which suggest a link between restraint position and death. Future research should seek to better understand the phenomenon of metabolic acidosis by taking measurements while participants struggle in different restraint positions so as to ascertain which positions and/or techniques of restraint impede physiological function and pose the greatest risk of metabolic acidosis and subsequent dysrhythmia. This future research would be particularly important to understand, in prolonged restraints where fatigue may be induced further increasing the reduction in spirometry measures and/or where there are high levels of physiological arousal (delirium) present. 'Some, but not all, prone restraint positions cause significant restriction of lung function [and] some restraint positions are demonstrated to present a greater risk than others' (p.
The stresses imposed during restraint (physical, pharmacological, psychological) need to be considered as cumulative with future research seeking to tease out the exact contribution of each element. Future research should also seek to investigate the effect of other restraint positions/techniques on populations other than apparently healthy male adults. [citations removed]


   a. ABSTRACT: We investigated ventilatory and metabolic demands in healthy adults when placed in the prone maximal restraint position (PMRP), i.e., hogtie restraint. Maximal voluntary ventilation (MVV) was measured in seated subjects (n=530), in the PMRP, and when prone with up to 90.1 or 102.3 kg of weight on the back. MVV with the heaviest weight was 70% of the seated MVV (122 \pm 28 and 156 \pm 38 L/min, respectively; p<0.001). Also, subjects (n=527) were placed in the PMRP and struggled vigorously for 60 sec. During the restrained struggle, ventilator function (V˙E/MVV) was 44% of MVV in the resting PMRP. While prone with up to 90.1 or 102.3 kg on the back, the decrease in MVV was of no clinical importance in these subjects. Also, while maximally struggling in the PMRP, V˙E was still adequate to supply the ventilatory needs.

3. (2003 Paterson) Paterson, Brodie, Patrick Bradley, Cameron Stark, David Sadler, David Leadbetter, and David Allen. "Restraint-related deaths in health and social care in the UK: learning the lessons: Much debate has recently taken place around what represents good practice in terms of physical intervention. Unfortunately a shortage of good quality research has meant that aspects of this discussion have been over reliant on 'expert' opinion and unduly influenced by sensationalist media reporting, rather than systematically-collated evidence. Brodie Paterson and colleagues outline the results and discuss the ...." Mental Health Practice 6, no. 9 (2003): 10-17.

Conclusion: It has been argued that there is an urgent need for standards for violence management training in a number of areas including that of physical intervention (Paterson 2000, National Control and Restraint General Services Association 2000, Smith 1999). However, these standards must be based on evidence rather than opinion (Allen 2000, Wright 1999). The problem is, as a recent review on behalf of the American Medical Association concluded, that the current research literature on restraint is 'far too limited' to act as a basis for
'scientific guidelines on its use, on the training necessary for administering these methods and on the methods most appropriate for individual patients and particular situations' (Brown et al 2000).

In the absence of such research, recent good practice guidance on physical interventions (Department of Health 2000, Harris et al 1996), including suggestions that certain restraint positions should be avoided, are, to some extent, based on speculation about the potential risks involved rather than evidence of any real quality (Sailas and Fenton 1999). This situation is clearly unacceptable and a programme of funded research addressing the dearth of knowledge in this area is vital if practice in this most sensitive of areas is to become evidence based (Allen 2000).

If we accept the principle that restraint may be used where appropriate safeguards are in place to prevent its misuse, it is incumbent upon us to evaluate the potential risks involved so that potentially dangerous procedures can be eliminated from practice before, rather than after, tragedy.

The bio-mechanical evaluation of risks in carefully controlled experimental conditions can, however, never adequately imulate the dynamics of an actual violent incident where recall and thus the practice of physical restraint may only approximate to that originally taught (Bell and Stark 1998). This is of concern, given that relatively minor variations in some procedures, such as basket holds, may greatly affect the risk involved (Paterson and Leadbetter 1998). We must therefore seek to learn about the risks involved in the application of procedures, not just in the laboratory but in practice.

Restraint Chair


   a. **Conclusions** The available medical literature, though notably scarce in relation to primary human data, reveals that the restraint chair itself poses little to no medical risk. Additionally, when used appropriately and by following pre-set guidelines, the restraint chair alone carries little legal liability. With proper monitoring and adherence to set protocols, the restraint chair is a safe and appropriate device for use in restraining violent and dangerous individuals.


   a. **Conclusion:** In healthy subjects, placement in a restraint chair resulted in a small decrease in MVV, but did not result in any changes in O2sat or PETCO2.
Excited Delirium Guidance

ExDS Books:


2017 Related Book Chapters:


(1996–2017 IACP) International Association of Chiefs of Police


3. (04/2017 IACP) Excited Delirium, Need to know ...., April 2017, IACP Law Enforcement Policy Center.


(12/2011 NIJ/Penn State) NIJ Weapons and Protective Systems Technologies Center


(05/2016 UK) Royal College of Emergency Medicine

1. (05/2016) Guidelines for the Management of Excited Delirium / Acute Behavioural Disturbance (ABD), Independent Advisory Panel on Deaths in Custody, Best Practice Guideline, the Royal College of Emergency Medicine.


(02/2012 Ontario, Canada) ExDS Training Bulletin


(2010 IPICD) Institute for the Prevention of In-Custody Deaths

1. (2010 IPICD) Excited-Agitated Delirium & Sudden In-Custody Death, Excited Delirium (ED), Agitated Delirium (AD), Acute Behavioral Disorder, Institute for the Prevention of In-Custody Deaths, Inc. (IPICD), Roll Call Mini-Poster™.

(06/2009 Nova Scotia) Minister of Justice and Health


Other

Excited Delirium (ExDS) Features


   a. Key Point: ExDS is a condition that is a true medical emergency and requires rapid identification, control, sedation, and transport. Further research is required, but adverse effects seem trivial and TASERs have been considered useful in rapid control of these patients.


   a. “Conclusions: Elevated levels of dopamine coupled with failed dopamine transporter function leads to agitation, paranoia and violent behavior associated with ExDS. Increased dopamine levels also affect heart rate,
respiration, and temperature control with elevation resulting in tachycardia, tachypnea and hyperthermia. Hyperthermia is a hallmark of excited delirium and a harbinger of death in this syndromal disorder. Victims of excited delirium are in an extremely heightened emotional state with marked paranoia and mounting irrational fear. Central neuronal circuitry in the brain-heart axis may be a precipitant of sudden fatal arrhythmia, since hyperdopaminergic signaling in the limbic system translates extreme emotional stress into autonomic toxicity and the demise of the heart. The connection between hyperdopaminergia in ExDS and chaotic signaling in these higher brain autonomic regulatory centers may explain the abrupt loss of autonomic function that leads to sudden unexpected death of these victims. Excited delirium is a syndromal disorder, which is controversial and highly debated because the mechanism of lethality is unknown. Molecular studies of the brains of autopsy victims who died in states of excited delirium reveal the loss of dopamine transporter function as a possible trigger of a cascade of coordinated neural activity that contributes to asphyxia and sudden cardiac arrest.”


Results: 43,848 patients were screened; 0.72% (316) had excited delirium. 68 of these patients had blood testing. All vital signs and catecholamines showed a trend toward improvement during ED treatment. Results are listed in the below table. [highlighting added]

Conclusion: ED patients with ExDS have abnormal vital signs and serum catecholamines at baseline. pH derangement is less marked than previously described. All markers may improve with ED treatment of agitation.


22. (06/1998 Pollanen) Pollanen MS, Chiasson DA, Cairns JT, Young JG. Unexpected death related to restraint for excited delirium: a retrospective study
of deaths in police custody and in the community. CMAJ. 1998;158(12):1603-1607.


Excited Delirium – Partial History

The term “delirium excited,” in referring to “[d]elirious exclamations, in certain diseases,” appeared in the literature as early as 1798. The term “excited delirium” appeared in the medical literature as early as 1835, and in religious literature as early as 1835.

Table 83 Partial History: Excited Delirium

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>2018</td>
<td>Kroll (CEW, Serotonin, ExDS)</td>
</tr>
<tr>
<td>36</td>
<td>2018</td>
<td>Baldwin</td>
</tr>
<tr>
<td>35</td>
<td>2018</td>
<td>Ross, CEW, ExDS</td>
</tr>
<tr>
<td>34</td>
<td>2017</td>
<td>Gonin (Switzerland), ExDS</td>
</tr>
<tr>
<td>33</td>
<td>2017</td>
<td>Baker (UK), ExDS</td>
</tr>
<tr>
<td>32</td>
<td>2016</td>
<td>UK Royal College of Emergency Medicine</td>
</tr>
<tr>
<td>31</td>
<td>2015</td>
<td>Gerold (SOF Medical Professionals)</td>
</tr>
<tr>
<td>30</td>
<td>2014</td>
<td>Gill</td>
</tr>
<tr>
<td>29</td>
<td>2013</td>
<td>Gordon (ER Nurses Association)</td>
</tr>
<tr>
<td>28</td>
<td>2012</td>
<td>Ontario, Canada</td>
</tr>
<tr>
<td>27</td>
<td>2012</td>
<td>Vilke (ACEP) papers</td>
</tr>
<tr>
<td>26</td>
<td>2011</td>
<td>National Institute of Justice, U.S. Department of Justice, Penn State</td>
</tr>
<tr>
<td>25</td>
<td>2009</td>
<td>American College of Emergency Physicians (ACEP) Excited Delirium White Paper</td>
</tr>
<tr>
<td>24</td>
<td>2009</td>
<td>Nova Scotia, Canada</td>
</tr>
<tr>
<td>23</td>
<td>2009</td>
<td>Mash, D.</td>
</tr>
<tr>
<td>22</td>
<td>2008</td>
<td>Bunai Y</td>
</tr>
<tr>
<td>21</td>
<td>2005</td>
<td>Di Maio TG, Book: excited delirium</td>
</tr>
<tr>
<td>20</td>
<td>2004</td>
<td>Stephens BG; National Association of Medical Examiners (NAME) ExDS Position Paper</td>
</tr>
<tr>
<td>19</td>
<td>2001</td>
<td>Stratton SJ</td>
</tr>
<tr>
<td>18</td>
<td>2001</td>
<td>Allam S</td>
</tr>
<tr>
<td>17</td>
<td>2001</td>
<td>Morrison A</td>
</tr>
<tr>
<td>16</td>
<td>1999</td>
<td>Ruttenber AJ</td>
</tr>
<tr>
<td>15</td>
<td>1998</td>
<td>Pollanen MS</td>
</tr>
<tr>
<td>14</td>
<td>1998</td>
<td>Ross DL</td>
</tr>
<tr>
<td>13</td>
<td>1997</td>
<td>Ruttenber AJ</td>
</tr>
<tr>
<td>12</td>
<td>1996</td>
<td>International Association of Chiefs of Police (IACP), excited delirium resolution</td>
</tr>
<tr>
<td>11</td>
<td>1995</td>
<td>Wettli, C.V.</td>
</tr>
<tr>
<td>10</td>
<td>1993</td>
<td>O’Halloran RL</td>
</tr>
<tr>
<td>9</td>
<td>1987</td>
<td>Wettli, C.V.</td>
</tr>
</tbody>
</table>

369 Ferriar, J. (1798), Illustrations of Sterne, with other essays and verses. London, England: Cadell and Davies.


Partial History of Excited Delirium Papers/Documents


   a. In these incidents, officers should consider intervention options that provide greater time and distance from the subject (e.g., probe deployment of conducted energy weapon [CEW]), and also have lower injury rates when compared to the use of physical control (Baldwin et al., 2017; Bozeman et al., 2018). Given the nature of ExDS symptomology (e.g., pain tolerance, constant/near constant activity, superhuman strength), typical UoF interventions (e.g., physical control, pepper spray) that rely on pain compliance or manual force may be rendered ineffective, which should also be taken into account by responding officers (Blaskovits et al., 2017). In the past, ExDS deaths have been suggested to be a consequence of OC spray, the CEW, or the use of neck restraints on subjects (DiMaio & DiMaio, 2006). However, no study to date has established a causal relationship between these less lethal intervention options and fatal subject outcomes (e.g., Goudge et al., 2013; Michalewicz et al., 2007; Mitchell, Roach, Tyberg, Belenkie, & Sheldon, 2012; Petty, 2004).


38. (1849 Bell) Bell L. On a form of disease resembling some advanced stages of mania and fever, but so contradistinguished from any ordinary observed or described combination of symptoms as to render it probable that it may be overlooked and hitherto unrecorded malady. *American Journal of Insanity* 1849;6:97-127.

39. (1848 Yeoman) Yeoman, T.H., 1848, Dr. Yeoman on Consumption of the lungs, or decline: the causes, symptoms, and rational treatment. With the means of prevention. London: Sampson Low.

   a. pg 35 - "In other cases, but they prove the exception rather than the rule, the mind is comparatively torpid; the patient is indifferent to a return of health, or to a fatal issue; and in some cases an excited delirium attends the last days of life." (emphasis added)


   a. pg 210, ... and endured the usual treatment, but the disease ran to its usual crisis of great bodily prostration, with mental aberration and excited delirium. ... (emphasis added)


   a. pg 120 - “excited delirium” - When we view this servant of Jesus Christ continually expressing his emotions in the most unexceptionable manner, in the midst of an excited delirium, how pertinent the reflection of his physician; "How few would bear to have the veil thus raised from all their private thoughts and feelings and motives? How few would be willing to stand thus exhibited to surrounding friends in their habitual state of inmost character, in some degree as they will stand at last, when the secrets of all hearts shall be revealed! What a motive for the habitual government of our thoughts and feelings, as well as our words and actions, during all the active scenes of life!" (emphasis added)


   a. pg 595 - "... We have seen a person die of sympathetic adynamic fever in four days after the removal of piles by a most accomplished surgeon; the nervous system of this patient, prior to the operation, was disturbed, and the shock of the operation itself excited delirium and high febrile movement, which soon terminated in dissolution." (emphasis added)

44. (1798 Ferriar) Ferriar, J. (1798), Illustrations of Sterne, with other essays and verses. London, England: Cadell and Davies.

   a. pg 285 - “delirium excited” - ...Archbishop of York's Discovery of Popish Impostures, the girls who were exorcised had delirium excited, by nauseous potions and fumigations.

   b. Delirious exclamations, in certain diseases, have been received as indicators of future events; hence it has become necessary for those who aspired to the character of prophets, to make the multitude believe them to be afflicted with those diseases.* Lucian's Alexander learnt the art of frothing at the mouth, and the mob, as Lucian tells us, held his froth to be sacred. Epileptic complaints have certainly been familiar to men of great talents Caesar, Peter I., and several others of distinguished merit, were subject to epilepsy. But it cannot be supposed that they were improved by the disease.

   c. Even philosophers, of the mystic class, have thought the imputation of madness an addition to their fame. "Porphyrius *** se secreto multa mysterio ex divino afflatu interdum disseruisse, ideoque PRO FURENTE habitum fuisse JACTAT."Brucker. Hist. Crit. Philos. tom. ii, P• 245.

Sampling of Legal Cases that Include the Term “Excited Delirium”

1. Federal Courts of Appeal: (as of 2012--04-29 there are 16 cases that include the term "excited delirium", there are 75 District Court (DCT) cases that include the term "excited delirium")


   a. at 1299: FN4. Although not a validated diagnostic entity in either the International Classification of Diseases or the Diagnostic and Statistical Manual of Mental Disorders, “excited delirium” is a widely accepted entity in
forensic pathology and is cited by medical examiners to explain the sudden in-custody deaths of individuals who are combative and in a highly agitated state. “Excited delirium” is broadly defined as a state of agitation, excitability, paranoia, aggression, and apparent immunity to pain, often associated with stimulant use and certain psychiatric disorders. The signs and symptoms typically ascribed to “excited delirium” include bizarre or violent behavior, hyperactivity, hyperthermia, confusion, great strength, sweating and removal of clothing, and imperviousness to pain. Speculation about triggering factors include sudden and intense activation of the sympathetic nervous system, with hyperthermia, and/or acidosis, which could trigger life-threatening arrhythmia in susceptible individuals. Carolyn B. Robinowitz, MD, Report of the Counsel on Science and Public Health 453 (American Medical Association, annual meeting 2009).


5. Lewis v. City of West Palm Beach, Fla., 561 F.3d 1288 (C.A.11 (Fla.), 2009).


Sickle Cell Exertional Sudden Death


   a. Sickle cell trait was associated with 10 deaths (2%, 1:424,252 AY)


ABSTRACT: This study presents a series of 16 carriers of hemoglobin S (HbS) who died during various circumstances. Many of the cases were associated with mild to moderate exertion. The onset and/or duration of symptoms varied from a few minutes to several hours with many displaying a prolonged lucid interval with stable vital signs. Despite seeking medical treatment, sickle cell trait-related micro-occlusive crisis was never considered in the differential diagnosis. Several cases were associated with sudden death. In those deaths which were delayed, high anion gap and uncompensated metabolic acidosis were typical and were not heat related. Also characteristic were large increases in creatine kinase, alanine aminotransferase, and aspartate aminotransferase along with myoglobinemia. Although the antemortem diagnosis of rhabdomyolysis was made, the underlying cause was never deduced by the clinicians. The sickling found at autopsy is not always a postmortem artifact, and in the right circumstances can be diagnostic.

Ketamine


SPARK CEW (Brazil)


   a. “Conclusion: Physical, laboratory tests, 12-lead resting ECG, ECO TT and Holter tests showed no change when compared to pre-test results. There was no post-shock cardiac arrhythmias, or evidence of myocardial necrosis.”

   b. SPARK CEW electrical parameters according to this paper:

      - 18 pulses per second
      - 35 microsecond (µs) pulse duration
      - Delivered peak voltage – 7,000 volts (V)
      - Delivered current – 2.2 milliamperes (mA)
      - (calculated) delivered charge – 122 microcoulombs (µC)
      - Set 5 second shutoff regardless of trigger pull or hold back.
      - (interesting) considering a resistance of “60 [] Ω” (I assume this is a typo and should be 600 ohms)
      - average per pulse current is 3.5 amperes (A). Assuming 600 ohm load, this implies a 2.1 kilovolt (kV) average per pulse voltage, higher than that for X26 CEW. Their peak current equates to over 11 A, much higher than that for X26.
Phazzer Enforcer CEW:


Civil Rights Groups

European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT)


