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[[Denotes that study was partial or fully funded by TASER International

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A

Ad Hoc Committee on Electronic Control Weapons, A. b. t. G. A. o. C. o. P. E. B. (2005). Electronic Control Weapons Review and Recommendations Ad Hoc Committee on Electronic Control Weapons, Adopted by the Georgia Association of Chiefs of Police Executive Board**:** 55.

Albuquerque New Mexico Police Department, B. S. (2002). Use of Force Analysis A. C. A. Ron Bratton. Albuquerque, NM, City of Albuquerque Risk Management Division Loss Prevention Section**:** 11.

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Anders, S., M. Junge, et al. (2003). "Cutaneous current marks due to a stun gun injury." J Forensic Sci **48**(3): 640-2.

> Histological changes of the skin following electrical injury with a stun gun have rarely been described. We report the case of a 61-year-old man who died after having been tortured with a stun gun during a robbery. At autopsy two reddish, dot-like lesions where found on the chest and histological examination revealed electric current-related changes. Only a few reports concerning micromorphological cutaneous changes following stun gun injury have been reported; therefore further investigations concerning the frequency and type of histological findings due to stun gun injuries will be necessary in order to provide sufficient characteristic data for a conclusive interpretation.

Austin Police Department (2005). City Policy on TASER Use. Austin, TX, City of Austin.

> On April 7, 2005, the Austin City Council heard a presentation concerning the City’s policy on the use of Tasers, a brand of non-lethal weapon. Police Chief Stanley L. Knee discussed the use of Tasers, policy and an analysis of their use by Austin police. He was joined by Dr. Edward Racht, Emergency Medical Services Director; and Dr. Pat Crocker, director of emergency services for Brackenridge Hospital, who provided information about the medical implications of the use of the Tasers.

B

Banaschak, S., H. Milbradt, et al. (2001). "[Evidence for use of electroshock devices]." Arch Kriminol **208**(5-6): 149-58.

The authors tested whether use of an electro shock weapon (stun gun) leaves marks on skin which can be found in an exterior examination. On pig skin such marks could not be produced postmortally. An experiment on one of the authors caused reddish skin marks which persisted for about 2 h. Inability to act as promised by the weapons' manufacturers did not occur in our experiments, exactly as previously described by other authors. Use of an air tester which shoots barbed electrodes ought to produce bleedings if the electrodes actually penetrate the skin.

Barnes, D. G., Jr., J. E. Winslow, III, et al. (2006). "Cardiac Effects of the Taser Conducted Energy Weapon: 340." Annals of Emergency Medicine **48(4)**(Supplement): S102.

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Beach, C. o. L. (2005). TASER Stun Device Proves To Be An Effective New Tool. Long Beach, CA**:** 1.

Ben Welch, E. and B. J. Gales (2001). "Use of stun guns for venomous bites and stings: a review." Wilderness Environ Med **12**(2): 111-7.

During the past 2 decades, articles suggesting that stun guns be utilized to treat venomous bites and stings have appeared in both the lay and medical press. Although never widely considered to be standard therapy for venomous bites and stings, stun guns are still considered to be a treatment option by some medical practitioners and outdoor enthusiasts. A Medline search was performed using these terms: venomous bites, venomous stings, snake bites, spider bites, electrical, stun gun, high voltage electricity, low amperage electricity, direct current, and shock therapy. Articles selected included laboratory-based isolated venom studies, animal studies, and case reports involving humans in which a stun gun or some other source of high voltage, low amperage direct current electric shocks were used to treat actual or simulated venomous bites or stings. We concluded that the use of stun guns or other sources of high voltage, low amperage direct current electric shocks to treat venomous bites and stings is not supported by the literature.

Bernstein, T. (1976). Letter to the Consumer Product Safety Commission. C. P. S.

Commission, University of Wisconsin-Madison.

Bernstein, T. (1985). Evaluation of the Electric Shock Hazard for the NOVA XR 5000 Stun Gun, University of Wisconsin-Madison.

Bleetman, A., Richard Steyn (2003). The Advanced TASER: A Medical Review, University of Birmingham, UK**:** 30.

Bleetman, A., R. Steyn, et al. (2004). "Introduction of the Taser into British policing. Implications for UK emergency departments: an overview of electronic weaponry." Emerg Med J **21**(2): 136-40.

> The Taser is a development of the stun gun. It has recently been introduced into British policing as a "less lethal" weapon to fill the operational gap between the baton and the gun for controlling potentially dangerous and violent suspects. It is inevitable that "tasered" victims will be brought to hospitals. A review of clinical experience with electronic weaponry is presented. Suggestions for managing "tasered" subjects are provided.

Bouton, K., G. Vilke, et al. (2007). Physiological Effects of a Five Second TASER Exposure. San Diego State University San Diego Heart Institute, Society for Academic Emergency Medicine.

> The TASER® X26 has gained popularity by law enforcement agencies as a less lethal weapon. However, there have been a number of sudden deaths of suspects following TASER exposure. The purpose of this study was to examine the effects of a single TASER exposure on markers of physiological stress. Cardiorespiratory and blood parameters were followed before and for 60 min after a 5 s TASER exposure on 21 men and women law enforcement officer volunteers.

Bozeman, W. D, et al. (2007). Injury Profile of Electrical Conducted Energy Weapons American College of Emergency Physcians Research Forum, Wake Forest University Louisiana State University.

> After CEW use, 99.5% of 597 subjects had no injuries or mild injuries only. The observed significant injury rate was 0.5%, and is unlikely to be greater than 1.4%. No deaths related to CEWs occurred. These preliminary data represent the largest independent injury epidemiology study of these weapons to date and support the safety of CEW use. Data collection will continue through summer2007; final data will be presented at the fall ACEP meeting.

Bozeman, W. P. (2001). Medical Threat Assessment: The TASER M26 Less Lethal Weapon. TASER MTA version 1-5.

> A number of "less lethal" weapons have been developed and are commonly used by modern law-enforcement agencies and some military organizations. The intent of these weapons is to subdue or incapacitate violent or dangerous suspects without causing serious harm or death. Commonly used less lethal weapons include chemical irritant agents, explosive distraction devices, kinetic impact munitions, and electrical incapacitation devices. While less lethal weapons are significantly safer than traditional firearms, no weapon can be entirely non-lethal and no weapon can be made entirely safe. Medical providers may treat subjects exposed to less lethal weapons and should presume injury until proven otherwise. The following is a review article on the medical aspects of less lethal weapons.

Bozeman, W. P. (2005). "Withdrawal of taser electroshock devices: too much, too soon." Ann Emerg Med **46**(3): 300-1.

Bozeman, W. P. (2006). Unexpected Deaths in Police Custody. Florida SWAT Association

Bozeman, W. (2008). Safety and Epidemiology of Conducted Electrical Weapons (CEWs). Braidwood Commission Vancouver British Columbia.

Branch, H. O. S. D. (2007). Supplement to HOSDB Evaluations of Taser Devices A collection of medical evidence and other source material. D. I. Wilkinson. Sandridge St. Albans, Home Office Scientific Development Branch. **Publication Number 64/06**.

> This supplement is intended to complement the two PSDB reports on evaluations of taser devices published in 2002 and 2005. It is a collection of source material, commissioned during the evaluations, which has not been previously published. It contains seven full reports from the Defence Science and Technology Laboratory, which informed the DOMILL1 statements on the medical implications of taser use, the Association of Chief Police Officers report on the operational trial and a report on taser compatibility with commercial aircraft systems.

Breitreuz (2008). Study of the Conductive Energy Weapon–TASER®. Report of the Standing Committee on Public Safety and National Security, House of Commons, Canada, 39th Parliament, 2nd Session.

Brown, T. R. O. C. S. s. O. (2003). Request for TASER Information From the Citizen's Review Board. C. L. Behnke. Orange County**:** 3.

Burdett-Smith, P. (1997). "Stun gun injury." J Accid Emerg Med **14**(6): 402-4.

A case is presented of injury by a "stun gun." The different types of electric shock devices

produced commercially are summarised and the potential injuries discussed.

Butler, C. F. (2004). TASER Report TASER Report A Medical/Safety Review of the TASER Prepared for the Kalamazoo County Sheriff's Department, Kalamazoo County Sheriff's Department**:** 10.

Butski, A. P. (2004). Risks and Benefits of TASERs. Ypsilanti, MI, Eastern Michigan University**:** 21.

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Canadian Police Research Centre (2005). Review of conducted energy devices. Ottawa, ON, Canadian Police Research Centre 68.

Cao, M., J. S. Shinbane, et al. (2007). "Taser-induced rapid ventricular myocardial capture demonstrated by pacemaker intracardiac electrograms." J Cardiovasc Electrophysiol **18**(8): 876-9.

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

Cape Coral Florida Police Department, C., Bart (2004). M26 Air TASER Program Evaluation C. o. P. Dan Alexander, Cape Coral Police Department Professional Standards Bureau**:** 9.

Chairman, D. S.-C. o. M. I. o. L. L. W. (2004). United Kingdom DOMILL Report on TASER M26 Medical Implications, DSAC Sub-Committee on Medical Implications of Less lethal Weapons**:** 7.

Chan, T., C. Sloane, et al. (2007). "The Impact of the Taser Weapon on Respiratory And

Ventilatory Function in Human Subjects?" Acad Emerg Med **Volume 14, 5 Supplement 1 191-192**.

Introduction: The Taser has gained widespread popularity with law enforcement as a less lethal weapon to subdue combative individuals. Because sudden deaths have been associated with their use, concern has arisen regarding the physiologic effects of these devices, including respiratory function. Objectives: We sought to determine the effect of the Taser on respiratory physiology, and hypothesized that the Taser would not cause significant decrement in pulmonary function, oxygenation or ventilation in human subjects. Methods: We conducted a randomized crossover, controlled trial in 28 human volunteers who underwent a standard 5 second Taser X26discharge as part of law enforcement training. Subjects were monitored for tidal volume (TV), respiratory rate (RR), minute ventilation (VE), end-tidal CO2 (etCO2), and transcutaneous oximeter (SaO2) at baseline, during and 1, 10, 30 and 60 minutes after Taser discharge. Arterialized capillary samples for pH, pO2, and pCO2 were obtained at baseline, 1, 10, 30 and 60 minutes. Data were compared utilizing repeated measures ANOVA ($p < 0.05$) with differences and 95% confidence intervals [CI] reported (SPSS). Clinical significance was defined a priori as evidence of hypoxemia (SaO2 < 95%, pO2 < 85 mmHg) or hypoventilation (etCO2 or pCO2 > 45 mmHg).
Results: Mean VE, TV, and RR all increased at 1 min. after Taser discharge (increases of 12.8 L/m [8.5, 17.1], 0.5 L/ breath [0.3, 0.7], and 3.8 breaths/min [1.6, 5.9], respectively), and returned to baseline levels at 10, 30 and 60 min. Mean pH decreased at 1 min. (20.02 [20.04, 0.01]), and returned to baseline levels at 10, 30 and 60 min. There were no differences in SaO2, pO2, etCO2, or pCO2 over time and no evidence of abnormal hypoxemia or hypoventilation. Conclusions: In our study on human volunteers, VE, TV, and RR increased immediately following a standard Taser discharge, but returned to baseline within 10 minutes. There was no evidence of hypoxemia or hypoventilation in our study subjects.

Chan, T., C. Sloane, et al. (2007). The Impact of the Taser Weapon on Respiratory And Ventilatory Function in Human Subjects? . University of California San Diego.

Introduction: The Taser has gained widespread popularity with law enforcement as a less lethal weapon to subdue combative individuals. Because sudden deaths have been associated with their use, concern has arisen regarding the physiologic effects of these devices, including respiratory function. Objectives: We sought to determine the effect of the Taser on respiratory physiology, and hypothesized that the Taser would not cause significant decrement in pulmonary function, oxygenation or ventilation in human subjects. Methods: We conducted a randomized crossover, controlled trial in 28 human volunteers who underwent a standard 5 second Taser X26 discharge as part of law enforcement training. Subjects were monitored for tidal volume (TV), respiratory rate (RR), minute ventilation (VE), end-tidal CO2 (etCO2), and transcutaneous oximeter (SaO2) at baseline, during and 1, 10, 30 and 60

minutes after Taser discharge. Arterialized capillary samples for pH, pO2, and pCO2 were obtained at baseline, 1, 10, 30 and 60 minutes. Data were compared utilizing repeated measures ANOVA ($p < 0.05$) with differences and 95% confidence intervals [CI] reported (SPSS). Clinical significance was defined a priori as evidence of hypoxemia (SaO2 < 95%, pO2 < 85 mmHg) or hypoventilation (etCO2 or pCO2 > 45mmHg).Results: Mean VE, TV, and RR all increased at 1 min. after Taser discharge (increases of 12.8 L/m [8.5, 17.1], 0.5 L/breath [0.3, 0.7], and 3.8 breaths/min [1.6, 5.9], respectively), and returned to baseline levels at 10, 30 and 60 min. Mean pH decreased at 1 min. (20.02 [20.04, 0.01]), and returned to baseline levels at 10, 30 and 60 min. There were no differences in SaO2, pO2, etCO2, or pCO2 over time and no evidence of abnormal hypoxemia or hypoventilation. Conclusions: In our study on human volunteers, VE, TV, and RR increased immediately following a standard Taser discharge, but returned to baseline within 10 minutes. There was no evidence of hypoxemia or hypoventilation in our study subjects.

Chandler Arizona Police Department (2004). Advanced TASER Use of Force 2003 Annual Report April 1 – December 31. Chandler, AZ, Chandler Police Department**:** 12.

Charlotte-Mecklenburg Police Department (2004). TASER Project First Year-Full Deployment. Charlotte-Mecklenburg, Charlotte-Mecklenburg Police Department 12.

Chen, S. L., C. K. Richard, et al. (2006). "Perforating ocular injury by Taser." Clin Experiment Ophthalmol **34**(4): 378-80.

This report describes the features, treatment and outcome of globe perforation by a Taser dart electrode in a 21-year-old man. The Taser electrode caused mechanical iris, lens and retinal injury and consequent retinal detachment as result of proliferative vitreoretinopathy. The effect of electrical stimulation on ocular tissues is unknown. After the scleral and corneal wounds, traumatic cataract and retinal tear were repaired, the patient regained a visual acuity of 6/18. Nine months later a retinal detachment with proliferative vitreoretinopathy was discovered. The Taser may cause globe perforation and posterior segment injury. Understanding the barbed configuration of the dart electrode is important when extricating this device. Visual recovery is possible despite electric discharge of the Taser and suggests that the mechanism of ocular injury is largely mechanical.

Chief's Counsel (2005). Electronic Control weapons: Liability Issues. The Police Chief

Cincinnat Ohio Police Department, V., Douglas C. (2004). TASER. Cincinnati, City of Cincinnati Police Department**:** 1.

Cincinnati Police Department (2004). How Tasers Are Used by the Cincinnati PD, Cincinnati Police Department**:** 3.

City of Cincinnati (2005). Cincinnati Police Report to the Community TASER Devices. Cincinnati, City of Cincinnati 2.

City of Columbus (2005). 2005 TASER Study. Columbus, City Of Columbus 21.

City of Columbus, O. D. o. P. (2005). Six Month TASER Study. Columbus, OH, City of Columbus, Ohio Division of Police**:** 13.

Commissioner (2004). London Metropolitan Police Authority Review of TASER use, Metropolitan Police Authority.

Cooper, G. (2005). UK government's assessment of the medical risks of M26 and X26 TASERs, Defence Science and Technology Laboratory October 2005**:** 43.

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Dallas Police Department (2005). TASER Info at Lethal Force Level as of October 28, 2005. Dallas, TX**:** 2.

Davis, R. L. (2004). TASER Usage Study May 1 through October 31, 2004. San Jose, CA, San Jose, California Police Department**:** 9.

Davison N, L. N. (2006). Bradford Non-Lethal Weapons Research Project Centre for Conflict Resolution Department of Peace Studies.

Dawes, D. and J. Ho (2007). Excited Delirium, Police Physicians Section Track. 114th Anuual IACP Conference, International Association of Cheifs of Police.

Dawes, D., J. Ho, et al. (2008). The Effect of Cross Chest Electronic Control Device Exposure on Breathing. Hennipin County Medical Center, Australian College of Emergence Medicine Winter Symposium

Dawes, D., J. Ho, et al. (2008). The Effect of the eXtended Range Electronic Projectile (XREP) on Breathing. Hennipin County Medical Center, Australian College of Emergence Medicine Winter Symposium

Deaths in police custody can evoke strong reactions from the victims' families, the lay press, and the public. Police departments may be forced to prove that their actions (or inactions) did not contribute to these deaths. It is imperative for police chiefs and their staffs to have a good understanding of the history of this phenomenon, to understand the theories of causation in these sudden deaths, and to have a basic understanding of the current medical literature. In this workshop, these topics will be reviewed with a particular emphasis on conducted electrical weapons (CEW). The complex phenomenon of excited delirium will be reviewed as a theory of causation.

Dawes, D., J. Ho, et al. (2007). 15-SECOND CONDUCTED ELECTRICAL WEAPON EXPOSURE DOES NOT CAUSE CORE TEMPERATURE ELEVATION IN NON-ENVIRONMENTALLY STRESSED RESTING ADULTS Fourth Mediterranean Emergency Medicine Congress

Dawes, D., J. Ho, et al. (2007). THE NEUROENDOCRINE EFFECTS OF THE TASER X26 CONDUCTED ELECTRICAL WEAPON AS COMPARED TO OLEORESIN CAPSICUM

Dawes, D. M., J. Ho, et al. (2007). 15-SECOND CONDUCTED ELECTRICAL WEAPON EXPOSURE DOES NOT CAUSE CORE TEMPERATURE ELEVATION IN NON-ENVIRONMENTALLY STRESSED RESTING ADULTS Emergency Department, Lompoc District Hospital, Santa Barbara, CA, USA. Hennepin County Medical Center, Minneapolis, MN, USA. TASER International, Scottsdale, AZ, USA. , Fourth Mediterranean Emergency Medicine Congress (MEMC IV).

There has been speculation that exposure to the discharge of a CEW may cause an increase in core body temperature, presumably from muscle-tetany induced thermogenesis (rather than a direct current effect). In many cases of sudden in-custody death, especially in cases of the excited delirium syndrome or certain legal and illegal drug toxicities, the subjects are hyperthermic. Since in many hyperthermia phenomena (e.g., heat stroke, drug-induced hyperthermic syndromes), mortality is directly related to temperature and time at that temperature, it is speculated that worsening or prolonging the hyperthermia with a CEW discharge can lead to increased mortality. The objective of this study is to determine whether a CEW discharge causes an increase in core body temperature in non-environmentally stressed resting adults. METHODS: This was a prospective, un-blinded, observational study of adult human volunteers. Subjects swallowed a telemetric temperature recording capsule and had a data recording device attached to their waists in a fanny-pack pouch. The capsule sampled core body temperature every 15 seconds. After a waiting period of at least 30 minutes for equilibration, the subjects were exposed to a 15-second continuous discharge from the TASER X26® CEW. RESULTS: A total of 21 exposure subjects were enrolled in the study. There was no change in temperature from one minute before the exposure to one minute, 10 minutes, or 20 minutes after the exposure in the majority of patients. One patient had a 0.2 degree increase at 20 minutes, three patients had a 0.1 degree decrease in temperature at 10 minutes or 20 minutes. CONCLUSIONS: In summary, our results do not show that a 15-second conducted electrical weapon discharge significantly affects core body temperature in non-environmentally stressed resting adults. While additional studies are needed, our data suggests that theories about conducted electrical weapons contributing to hyperthermia are likely unfounded.

Dawes, D. M., J. Ho, et al. (2007). THE NEUROENDOCRINE EFFECTS OF THE TASER X26 CONDUCTED ELECTRICAL WEAPON AS COMPARED TO OLEORESIN CAPSICUM Lompoc District Hospital, Lompoc, CA, USA. Hennepin County Medical

Center, Minneapolis, MN, USA. TASER International, Scottsdale, AZ, USA, Fourth Mediterranean Emergency Medicine Congress (MEMC IV).

Conducted electrical weapons (CEW) induce neuromuscular incapacitation and pain by the application of an electrical current. There has been controversy with regard to the use of these weapons and in-custody death. There has been speculation that the discharge of a CEW may induce neuroendocrine effects that might predispose subjects to delayed cardiac arrhythmias and sudden death. The objective of this study is to compare the neuroendocrine effects of the TASER X26 CEW to oleoresin capsicum (O.C.), commonly called pepper spray. METHODS: Subjects were randomized to receive either a 5-second back exposure from the TASER X26® CEW or a 2-second spray of O.C. to the eyes. Subjects had salivary samples collected by passive drool through a straw 10-15 minutes before the exposure, and at 10, 20, and 60 minutes after the exposure. Salivary samples were analyzed for quantitative measures of alpha-amylase (surrogate for sympathetic-adrenal-medulla (SAM) axis stimulation, peak at 10 minutes) and cortisol (surrogate for hypothalamic-pituitary-adrenal (HPA) axis stimulation, peak at 20 minutes). RESULTS: 10 subjects were randomized to the O.C. exposure, and 5 subjects were randomized to the CEW exposure. There was a 173% (confidence interval 37.3-308.6) increase in alpha-amylase in the O.C. group at 10 minutes compared to an 8% (-33.0-31.3) decrease in the CEW group. Non-significant results included: 1) at one hour, alpha-amylase was 44% (11.8-75.6) over baseline in the O.C. group and 9% (-31.5-49.8) over baseline in the CEW group, 2) there was a 89% (41.9-135.3) increase in cortisol in the O.C. group at 20 minutes and a 90% (-61.3-242.0) increase in the CEW group, 3) at one hour, cortisol was 15% (-44.7-75.2)over baseline in the O.C. group and 68% (-114.4-242.0) over baseline in the CEW group. CONCLUSIONS: The results suggest a significant greater level of activation of the SAM cascade with O.C. compared to the CEW. Overlapping confidence intervals preclude a definitive statement about the other measurements, but do not suggest a greater activation of the stress cascade by the CEW than O.C.

Dawes, D. M., J. Ho, et al. (2007). BREATHING PARAMETERS, VENOUS GASES, AND CHEMISTRIES WITH EXPOSURE TO A NEW WIRELESS PROJECTILE CONDUCTED ELECTRICAL WEAPON. Lompoc District Hospital, Lompoc, CA, USA. Hennepin County Medical Center, Minneapolis, MN, USA. TASER International, Scottsdale, AZ, USA, Fourth Mediterranean Emergency Medicine Congress (MEMC IV).

The TASER X26 conducted electrical weapon (CEW) has a maximum range of 35 feet. TASER International has developed a new non-tethered CEW that is fired from a 12-gauge shotgun that has a longer range. A previous study showed that the TASER X26 had no significant effect on respiratory parameters. Here we examine the effects of this new CEW on respiration, venous blood gases, and certain blood chemistries. METHODS: Subjects had venipuncture prior to and immediately after the CEW exposure, and venous samples were analyzed to obtain venous pH, pCO2, HCO3, lactate, 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. In 27 subjects, the device was programmed for a 45-second exposure. The subjects could terminate the exposure 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. RESULTS: Fifty (50) subjects completed the study. In the self-terminating group, respiratory rate and minute ventilation increased significantly during the exposure. End-tidal CO2 decreased significantly during exposure. Venous pH decreased by 0.023, pO2 increased by 13.4, HCO3 decreased by 2.8, lactate increased by 2.4, and potassium decreased by 0.13. In the fixed 20-second exposure group, respiratory rate and minute ventilation increased significantly during the exposure. End-tidal CO2 decreased and end-tidal O2 increased significantly during exposure. Venous pH did not significantly change. pCO2 decreased by 4.0, pO2 increased by 16.3, HCO3 decreased by 3.4, and lactate increased by 2.7. Chemistries had no significant change. CONCLUSIONS: 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

Dearing, M. and T. J. Lewis (2005). "Foreign body lodged in distal phalanx of left index finger-taser dart." Emerg Radiol **11**(6): 364-5.

We report a case of a Taser dart presenting as a radio opaque foreign body to familiarize the Emergency Radiology community with the appearance of this non-lethal weapon which is being deployed in large numbers by police and security forces world wide.

Defence, U. S. D. o. (2004). Human Effectiveness and Risk Characterization of Electromuscular incapacitation Devices, Human Effects Center of Excellence.

Dennis, A. J., D. J. Valentino, et al. (2007). "Acute effects of TASER X26 discharges in a swine model." J Trauma **63**(3): 581-90.

BACKGROUND: Very little objective laboratory data are available describing the physiologic effects of stun guns or electromuscular incapacitation devices (EIDs). Unfortunately, there have been several hundred in-custody deaths, which have been temporally associated with the deployment of these devices. Most of the deaths have been attributed to specific cardiac and metabolic effects. We hypothesized that prolonged EID exposure in a model animal system would induce clinically significant metabolic acidosis and cardiovascular disturbances. METHODS: Using an Institutional Animal Care and Use Committee-approved protocol, 11 standard pigs (6 experimentals and 5 sham controls) were anesthetized with ketamine and xylazine. The experimentals were exposed to two 40-second discharges from an EID (TASER X26, TASER Intl., Scottsdale, AZ) across the torso. Electrocardiograms, blood pressure, troponin I, blood gases, and electrolyte levels were obtained pre-exposure and at 5, 15, 30, and 60 minutes and

24, 48, and 72 hours postdischarge. p values <0.05 were considered significant. RESULTS: Two deaths were observed immediately after TASER exposure from acute onset ventricular fibrillation (VF). In surviving animals, heart rate was significantly increased and significant hypotension was noted. Acid-base status was dramatically affected by the TASER discharge at the 5-minute time point and throughout the 60-minute monitoring period. Five minutes postdischarge, central venous blood pH (6.86 +/- 0.07) decreased from baseline (7.45 +/- 0.02; p = 0.0004). Pco2 (94.5 mm Hg +/- 14.8 mm Hg) was significantly increased from baseline (45.3 mm Hg +/- 2.6 mm Hg) and bicarbonate levels significantly decreased (15.7 mmol/L +/- 1.04 mmol/L) from baseline (30.4 mmol/L +/- 0.7 mmol/L). A large, significant increase in lactate occurred postdischarge (22.1 mmol/L +/- 1.5 mmol/L) from baseline (1.5 mmol/L +/- 0.3 mmol/L). All values returned to normal by 24 hours postdischarge in surviving animals. A minor, nonsignificant increase in troponin I was seen at 24 hours postdischarge (0.052 ng/mL +/- 0.030 ng/mL, mean +/- SEM). CONCLUSIONS: Immediately after the discharge, two deaths occurred because of ventricular fibrillation. In this model of prolonged EID exposure, clinically significant acid-base and cardiovascular disturbances were clearly seen. The severe metabolic and respiratory acidosis seen here suggests the involvement of a primary cardiovascular mechanism.

Denver Police Department (2003). Use of Force Reports for May and June 2003. Denver, CO, Denver Police Department.

Department of the Army (2005). The U.S. Army Center for Health Promotion and Preventive Medicine’s Position on whether TASER is safe to use on U.S. Army Military and Civilian Personnel during Training.

Dobrowolski, A. R. N. C. and S. M. S. N. R. N. C. C. E. N. C. Moore (2005). "Less Lethal Weapons and Their Impact on Patient Care." SO - Topics in Emergency Medicine January/March 2005;27(1):44-49.

Less lethal weapons are those used by law enforcement agencies to control behavior without causing significant injury or death. They include taser darts, pepper spray, tear gas, kinetic munitions, and light-sound diversion devices. Healthcare providers may be treating patients who have had these weapons deployed on them. Commonly, the effects of these weapons are minor; sometimes they can be deadly. This article reviews types of weapons, their anticipated and unanticipated effects, and how to treat patients who have sustained injuries resulting from their deployment., (C) 2005 Lippincott Williams & Wilkins, Inc.

Driscoll, P. (2003). Kinetic Impact Munitions and TASER Guns: Two Less Lethal Weapons Options for the Wayne County Airport Police Department, Wayne County Airport Police Department; Eastern Michigan University**:** 24.

E

Eichner, E. R. (1988). "Sudden death in racquet sports." Clinics in Sports Medicine **7**(2): 245-52.

The regular playing of racquet sports tends to confer general health and to protect the heart--to produce the athletic heart syndrome. Strenuous play, however, can provoke ventricular arrhythmias and can kill individuals with heart disease. The overall risk for an exercise death from racquet sport play seems to be as low as from distance running. Middle-aged men, however, especially those with known coronary disease or coronary risk factors, should approach racquet sports with caution, and might benefit from timely medical advice. [References: 15]

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Esquivel, A. O., E. J. Dawe, et al. (2007). "The physiologic effects of a conducted electrical weapon in swine." Ann Emerg Med **50**(5): 576-83.

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

F

Fales, W. (2003). Medical Considerations for TASER Operations Kalamazoo, MI, Kalamazoo County Medical Control Authority**:** 2.

Fandey, J. Z. e. a. (1976). TASER TF-1, CP76-5 U.S. Product Safety Commission, Letter Office of the Medical Director.

Fish, R. (1993). "Electric shock, Part III: Deliberately applied electric shocks and the treatment of electric injuries." J Emerg Med **11**(5): 599-603.

Earlier parts of this series have discussed the physics, pathophysiology, and nature of electric injury. This part will discuss deliberately applied electric shocks and the treatment of electric injuries. Electric shocks are deliberately applied to persons during electroshock therapy and with stun guns, shock batons, and electric cattle prods. Electric injuries, whether a complication of deliberate electric shock or due to accidental injury, should be treated to preserve cardiac and respiratory function and to prevent further tissue damage. Safe extrication at the scene, rapid triage, and emergency medical treatment are discussed.

Fish, R. M. and L. A. Geddes (2001). "Effects of stun guns and tasers." Lancet **358**(9283): 687-8.

Florida Gulf States University, O. C. S. s. O. (2004). TASER Deployments and Injuries: Analysis of Current and Emerging Trends. Orlando, FL, Florida Gulf States University.

This research attempts to break down violent law enforcement/citizen confrontations into a series of events, which will allow us to determine the effect of specific less lethal weapons in the final outcomes. We were also able to test the validity of some commonly held assumptions in law enforcement use of force and provide quantitative findings that law enforcement agencies can use to base policy decisions upon. Findings specific to this study are highlighted

Force Science Research Center (2005) FS News Readers Share Encounters With Naked Subjects. Force Science Research Center **Volume**, DOI:

Force Science Research Center (2005) Naked suspects: No Laughing Matter. Force Science News **Volume**, DOI:

Force Science Research Center Minnesota State University, M. (2004). Should Cops Stop Using TASER's? Force Science News**:** 4.

Frechette, A. and M. E. Rimsza (1992). "Stun gun injury: a new presentation of the battered child syndrome." Pediatrics **89**(5 Pt 1): 898-901.

Stun guns are self-protection devices that are increasingly available with few restrictions on their use and sale. We present a case of child abuse with a stun gun. The signs of such abuse are often subtle, and they may be underrecognized currently. The skin lesions that are often seen are hypopigmented circular macules, measuring approximately 0.5 cm in diameter. They may be raised slightly and erythematous if inflicted recently Most characteristic of stun gun assault is pairing of lesions approximately 5 cm apart. We discuss the design, operation, and effects of stun guns, and give an extensive differential of abusive and nonabusive circular lesions.

G

Givens, M. L., K. Ayotte, et al. (2004). "Needle thoracostomy: implications of computed tomography chest wall thickness." Acad Emerg Med **11**(2): 211-3.

OBJECTIVES: To determine the length of catheter required to perform a needle thoracostomy, as determined by chest wall thickness, to treat the majority of patients presenting to the emergency department (ED) with a potential tension pneumothorax. METHODS: A convenience sample of 111 computed tomography (CT) scans of the chest in trauma and medical resuscitation patients at a military Level 1 trauma center in San Antonio, Texas, was pooled, and the chest wall thickness was measured at the second intercostal space, midclavicular line, to the nearest 0.1 cm. RESULTS: The mean chest wall thickness in the patients studied averaged 4.24 cm (95% confidence interval [CI] = 3.97 to 4.52). Nearly one fourth (25) of the study patients had a chest wall thicker than 5 cm. Women, on average, have thicker chest walls than men (4.90 for women; 4.16 for men; p = 0.022). CONCLUSIONS: In this study, a catheter length of 5 cm would reliably penetrate the pleural space of only 75% of patients. A longer catheter should be considered, especially in women.

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Griffith, D. (2003). Would a TASER have Saved Nathaniel Jones? Police Magazine 2.

H

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Hamilton, A. (2002). "Stun guns for everyone." Time **159**(5): 50.

Harrison, R. G. (2000). ADVANCED TASER® M26 LESS LETHAL SYSTEM. TASER. Ottawa**:** 6.

Heck, J. J. (2003). Stun Guns The Medical Implications. EMS**:** 96-97.

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Ho, J. D., D. M. Dawes, et al. (2008). "Echocardiographic Evaluation of a TASER-X26 Application in the Ideal Human Cardiac Axis." Acad Emerg Med.

> 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.

Ho, J., D. Dawes, et al. (2008). Echocardiographic Determination of Cardiac Rhythm During Trans-Thoracic Wireless Conducted Electrical Weapon Exposure. Hennepin County Medical Center, Australian College of Emergence Medicine Winter Symposium

Ho, J., D. Dawes, et al. (2008). Cardiac and Diaphragm ECHO Evaluation during TASER Device Drive Stun, Australian College of Emergence Medicine Winter Symposium

Ho, J. (2008). Viewpoint: Rhetoric v. Reality. Emergency Medicine News.

Ho, J., D. Dawes, et al. (2007). "Physiologic Effects of Prolonged Conducted Electrical Weapon Discharge on Acidotic Adults." Acad Emerg Med **14**(5): 63.

> Conclusions: Markers of acidosis and cardiac injury were similar among acidotic subjects who underwent both sham and real prolonged CEW exposure. Prolonged CEW exposure in humans does not appear to have an effect with regard to worsening acidosis that is already present.

Ho, J., D. Dawes, et al. (2007). Physiologic Effects of Prolonged Conducted Electrical Weapon Discharge on Acidotic Adults. Hennepin County Medical Center.

> Conclusions: Markers of acidosis and cardiac injury
> were similar among acidotic subjects who underwent
> both sham and real prolonged CEW exposure. Prolonged

CEW exposure in humans does not appear to have an effect with regard to worsening acidosis that is already present.

Ho, J., D. Dawes, et al. (2007). "Absence of Electrocardiographic Change Following Prolonged Application of a Conducted Electrical Weapon in Physically Exhausted Adults." Acad Emerg Med **14**(5): 128-129.

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.

Ho, J., D. Dawes, et al. (2007). Absence of Electrocardiographic Change Following Prolonged Application of a Conducted Electrical Weapon in Physically Exhausted Adults. Hennepin County Medical Center.

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.

Ho, J., D. Dawes, et al. (2007). ABSENCE OF ELECTROCARDIOGRAPHIC CHANGE FOLLOWING PROLONGED APPLICATION OF A CONDUCTED ELECTRICAL WEAPON IN PHYSICALLY EXHAUSTED ADULTS Fourth Mediterranean Emergency Medicine Congress

Ho, J., D. Dawes, et al. (2006). Beneficial Impact of Conducted Electrical Weapons in the Mentally Ill Population. Hennepin County Medical Center, Minneapolis, MN.

Ho, J., A. Lapine, et al. (2008). "Confirmation of respiration during trapezoidal conducted electrical weapon application." Acad Emerg Med **15**(4): 398.

Ho, J., R. Reardon, et al. (2007). Ultrasound Measurement Of Cardiac Activity During Conducted Electrical Weapon Application In Exercising Adults. Fourth Mediterranean Emergency Medicine Congress

Ho, J., R. Reardon, et al. (2007). Ultrasound Measurement Of Cardiac Activity During Conducted Electrical Weapon Application In Exercising Adults, Fourth Mediterranean Emergency Medicine Congress (MEMC IV).

Ho, J. D., Miner, James R., Heegaard, William G., Reardon, Robert F. (2005). Deaths in American Police Custody: A 12 Month Surveillance Study. University of Minnesota Emergency Medicine Program.

Ho, J. D. (2005). Sudden In Custody Deaths. Police Magazine

Ho, J. D., Luceri, Richard , Lakireddy, Danunjaya R, Dawes, Donald M. (2006). Absence Of Electrocardiographic Effects Following Taser® Device Application In Human Volunteers. Hennepin County Medical Center, Minneapolis, MN, Holy Cross Hospital, Ft. Lauderdale, FL, Cleveland Clinic and Hospital, Cleveland, OH. Lompoc District Hospital, Lompoc, CA.

Objective: The TASER X26 device is a conducted electrical weapon. It is used by law enforcement for control of agitated subjects by causing pain and/or neuromuscular incapacitation. There has been significant recent scrutiny of the TASER and its potential role in the death of subjects who have died while in custody. While there are numerous cases every year of in-custody deaths when no TASER has been applied, criticism of this device has occurred and a questionable causal relationship has been hypothesized. One hypothesis is that the TASER may induce death from cardiac dysfunction, arrhythmia or delayed myocardial damage. We sought to determine if human exposure to a standard TASER device causes any detectable change in serial 12-lead electrocardiograms. Methods: 32 volunteer subjects agreed to participate in the study. IRB approval was received prior to starting the project. After obtaining informed consent, all subjects had a 5-second TASER application with deployed probes from a distance of approximately 7 feet using a standard TASER X26 device. Serial electrocardiograms were performed on all subjects immediately before and immediately after TASER exposure and again at 16 and 24 hours after exposure. The electrocardiograms were interpreted by a blinded cardiologist. Results were tabulated for review. Results: At baseline 30/32 EKGs were interpreted as normal. The two abnormal EKGs (one was left ventricular hypertrophy and one was a sinus pause) remained unchanged at all four time points. No other EKG abnormalities were noted and no changes from baseline were detected. Conclusions: A 5-second TASER X26 application did not cause a detectable change in the 12-lead electrocardiograms of this sampled population. Theories of TASER induced dysrhythmic death or myocardial damage are not supported by our findings.

Ho, J. D., D. Dawes, et al. (2007). The State of Current Human Research and Electronic Control Devices (ECDs). 4th European Symposium on Non-Lethal Weapons. Stadthalle Ettlingen, Germany, 4th European Symposium on Non-Lethal Weapons.

There appears to be increasing interest in ECD use in society from law enforcement, military and personal defense perspectives. Along with increasing use of these devices, there is also a heightened awareness of perceived association with SD events. This perception may be stimulated by media inaccuracy and sensationalism at times. It may also be the product of misapplied logic. There have been numerous human studies investigating the possible association between ECD application and SD events. To date, no clear

association has been demonstrated when examining the currently recognized etiologies of sudden death such as cardiogenic, pulmonary, metabolic or thermoregulatory causes. Additionally, data exists to show that ECD use has the potential to save human lives within certain populations. We believe that further study of ECDs is recommended to validate our findings.

Ho, J. D., D. M. Dawes, et al. (2007). "Respiratory effect of prolonged electrical weapon application on human volunteers." Acad Emerg Med **14**(3): 197-201.

BACKGROUND: Conducted electrical weapons (CEWs) are used by law enforcement to subdue combative subjects. Occasionally, subjects will die after a CEW has been used on them. It is theorized that CEWs may contribute to these deaths by impairing respiration. OBJECTIVES: To examine the respiratory effects of CEWs. METHODS: Human volunteers received a 15-second application of electrical current from a CEW while wearing a respiratory measurement device. Common respiratory parameters were collected before, during, and after exposure. Health histories and demographic information were also collected. RESULTS: Fifty-two subjects were analyzed. Thirty-four underwent a 15-second continuous exposure, and 18 underwent three 5-second burst exposures. In the continuous application group, the baseline mean tidal volume of 1.1 L increased to 1.8 L during application, the baseline end-tidal CO2 level went from 40.5 mm Hg to 37.3 mm Hg after exposure, the baseline end-tidal oxygen level went from 118.7 mm Hg to 121.3 mm Hg after exposure, and the baseline respiratory rate went from 15.9 breaths/min to 16.4 breaths/min after exposure. In the 5-second burst group, the baseline mean tidal volume increased to 1.85 L during application, the baseline end-tidal CO2 level went from 40.9 mm Hg to 39.1 mm Hg after exposure, the baseline end-tidal oxygen level went from 123.1 mm Hg to 127.0 mm Hg after exposure, and the baseline respiratory rate went from 13.8 breaths/min to 14.6 breaths/min after exposure. CONCLUSIONS: Prolonged CEW application did not impair respiratory parameters in this population of volunteers. Further study is recommended to validate these findings in other populations.

Ho, J. D., D. M. Dawes, et al. (2007). "Impact of conducted electrical weapons in a mentally ill population: a brief report." Am J Emerg Med **25**(7): 780-5.

INTRODUCTION: Conducted electrical weapons (CEWs) are used by some law enforcement agencies to subdue mentally ill subjects who are combative, violent, or suicidal. The use of CEWs in this population is controversial. Proponents advocate CEW use to avoid other forms of escalated force. Opponents advocate against CEW use because of the potential for abuse. What is lacking in the medical literature is documentation of the impact on outcome that this technology may have when used in this population. This project represents an initial report in this area. METHODS: A database of CEW use has been maintained since 1999 to which law enforcement agencies voluntarily report. This database was reviewed for occurrences of CEW use on mentally ill and suicidal subjects. Situation outcome and potential for law enforcement use of deadly force as an alternative

were recorded. Data analysis was performed using descriptive statistics. RESULTS: There were 10,608 reports of CEW use over a 72-month period. Of these, there were 2452 uses on mentally ill subjects; and of these, 1111 (45.3%) were in situations where lethal force by the law enforcement agency would have been justified or where the subject represented an imminent life threat to himself. 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.

Ho, J. D., D. M. Dawes, et al. (2008). PROLONGED TASER® “DRIVE STUN” EXPOSURE IN HUMANS DOES NOT CAUSE WORRISOME BIOMARKER CHANGES Hennepin County Medical Center, National Association of EMS Physicians.

Ho, J. D., D. M. Dawes, et al. (2008). Echocardiographic Evaluation of Human Transcutaneous TASER® Application Along the Cardiac Axis. Hennepin County Medical Center, Minneapolis, MN, Lompoc District Hospital, Lompoc, CA, Heart Rythm Society.

Ho, J. D., J. R. Miner, et al. (2005). Deaths in police custody: An 8 month surveillance study. University of Minnesota Medical School Emergency Medicine Program, Hennepin County Medical Center.

Ho, J. D., J. R. Miner, et al. (2006). "Cardiovascular and physiologic effects of conducted electrical weapon discharge in resting adults." Acad Emerg Med **13**(6): 589-95.

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

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

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

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Ideker, R. E. and D. J. Dosdall (2007). "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 **28**(3): 195-201.

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

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> Stun guns are electric shock devices that are used by a number of law enforcement agencies to subdue violent offenders, but sometimes are discharged into human bodies as offensive weapons. We autopsied a 22-year-old woman who was strangled and had many stun-gun injuries on her head, chest, abdomen, arms, and legs. The stun-gun injuries consisted of many pairs of round erythemas

with or without central paleness, some of which were accompanied by circumferential abrasions. To determine whether the electric shocks were administered before or after her death, we studied stun-gun injuries on pigs before and after death and found that the shocks after death did not mark the animal skin. Based on this experiment, all of the stun-gun injuries on the victim's body were concluded to have been inflicted before her death.

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Jauchem, J. (2004). Effectiveness & Health Effects of Electro-Muscular Incapacitating Devices, Air Force Research Laboratory

Jauchem, J. R. (2007). Reply to Letter to the Editor Re: Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of Sus scrofa following repeatedTASER exposures, Forensic Science International.

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> In a previous study, 18 repeated exposures of anaesthetized swine to an electro-muscular incapacitating device (TASER International's ADVANCED TASER((R)) X26 electronic control device) resulted in acidosis and increases in blood electrolytes. In the current study, experiments were performed to investigate effects of a more typical scenario of repeated exposures of the device on muscle contraction and changes in blood factors. Ten swine were exposed for 5s, followed by a 5-s period of no exposure, three times. Selected blood factors were monitored for 3h following exposure. Transient increases in blood glucose, lactate, sodium, potassium, calcium, and pCO(2) were consistent with previous reports in the literature dealing with studies of muscle stimulation or exercise. Blood pH was decreased immediately following exposure, but subsequently returned toward a normal level. Oxygen saturation (measured by pulse oximetry) was not changed significantly. In conclusion, three repeated TASER device exposures had only transient effects on blood factors, which all returned to pre-exposure levels, with the exception of hematocrit (which remained elevated after 3h). Since the increase in this factor was less than that which may occur after short periods of exercise, it is unlikely that this would be an indicator of any serious harm.

Jauchem, J. R., C. J. Sherry, et al. (2006). "Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of Sus scrofa following repeated TASER

exposures." Forensic Sci Int **161**(1): 20-30.

Repeated exposure to electro-muscular incapacitating devices could result in repetitive, sustained muscle contraction, with little or no muscle recovery period. Therefore, rhabdomyolysis and other physiological responses, including acidosis, hyperkalaemia, and altered levels of muscle enzymes in the blood, would be likely to occur. Experiments were performed to investigate effects of repeated exposures of TASER International's Advanced TASER X26 on muscle contraction and resultant changes in blood factors in an anaesthetized swine model. A total of 10 animals were used. Six swine were exposed for 5 s, followed by a 5-s period of no exposure, repeatedly for 3 min. (In five of the animals, after a 1-h delay, a second 3-min exposure period was added.) The remaining four animals were used for an additional pilot study. All four limbs of each animal exhibited contraction even though the electrodes were positioned in areas at some distances from the limbs. The degree of muscle contraction generated during the second exposure period was significantly lower than that in the first exposure series. This finding was consistent with previous studies showing that prolonged activity in skeletal muscle will eventually result in a decline of force production. There were some similarities in blood sample changes in the current experiments with previous studies of muscular exercise. Thus problems concerning biological effects of repeated TASER exposures may be related, not directly to the "electric output" per se, but rather to the resulting contraction of muscles (and related interruption of respiration) and subsequent sequelae. Transient increases in hematocrit, potassium, and sodium were consistent with previous reports in the literature dealing with studies of muscle stimulation or exercise. It is doubtful that these short-term elevations would have any serious health consequences in a healthy individual. Blood pH was significantly decreased for 1h following exposure, but subsequently returned toward a normal level. Leg muscle contractions and decreases in respiration each appeared to contribute to the acidosis. Lactate was highly elevated, with a slow return (time course greater than 1 h) to baseline. Other investigators have reported profound metabolic acidosis during restraint-associated cardiac arrest. Since restraint often occurs immediately after TASER exposure, this issue should be considered in further development of deployment concepts. On the basis of the results of the current studies, the repeated use of electro-muscular incapacitating devices in a short period of time is, at least, feasible, with the caveat that some medical monitoring of subjects may be required (to observe factors such as lactate and acidosis).

Jeanette Michael (1975). Jurisdiction over the TASER Public Defender, U.S. Product Safety Commission, U.S. Government Memorandum.

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An electronic weapon, the Taser M26, has recently entered the use-of-force

continuum for police officers in England and Wales and is currently licensed for use by authorised firearms officers only. The aim of this report was to assess the relative risk of injury to officers and subjects of police use-of-force options and to evaluate whether the current positioning of the M26 in the use-of-force hierarchy is appropriate. We analysed use-of-force data from Northamptonshire Police Force and M26 field use data from TASER International. 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.

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Summary: The purpose of this report is to review the evidence that physical inactivity and excess adiposity are related to an increased risk of all-cause mortality, and to better identify the independent contributions of each to all-cause mortality rates. A variance-based method of meta-analysis was used to summarize the relationships from available studies. The summary relative risk of all-cause mortality for physical activity from the 55 analyses (31 studies) that included an index of adiposity as a covariate was 0.80 [95% confidence interval (CI) 0.78-0.82], whereas it was 0.82 [95% CI 0.80-0.84] for the 44 analyses (26 studies) that did not include an index of adiposity. Thus, physically active individuals have a lower risk of mortality by comparison to physically inactive peers, independent of level of adiposity. The summary relative risk of all-cause mortality for an elevated body mass index (BMI) from the 25 analyses (13 studies) that included physical activity as a covariate was 1.23 [95% CI 1.18-1.29], and it was 1.24 [95% CI 1.21-1.28] for the 81 analyses (36 studies) that did not include physical activity as a covariate. Studies that used a measure of adiposity other than the BMI show similar relationships with mortality, and stratified analyses indicate that both physical inactivity and adiposity are important determinants of mortality risk., (C) 2003 Blackwell Science Ltd.

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> Less lethal is a technology ubiquitous to law enforcement. It capitalizes on the use of technology to subdue, confuse, and control with less force than traditional firearms present. Injuries can and do occur with these tools, and understanding their uses, patterns of injury, and treatment is important not only for the law enforcer but the medical provider as well. The article discusses compressed air technology, conducted energy weapons, extended range impact projectiles, noise flash diversion devices, and chemical agents., (C) 2003 Lippincott Williams & Wilkins, Inc.

Kim, P. J. and W. H. Franklin (2005). "Ventricular fibrillation after stun-gun discharge." N Engl J Med **353**(9): 958-9.

Knight, D. (2003). "Trade in the tools of torture. The U.S. government OKs the export of shackles and stun guns." US News World Rep **135**(18): 30-1.

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> Sixteen deaths associated with the use of the Taser were examined. All involved young males who had a history of abuse of controlled substances; all but three were under the influence of cocaine, phencyclidine [phenylcyclohexylpiperidine (PCP)], or amphetamine. All were behaving in a bizarre or unusual fashion which necessitated calling the police. The cause of death was an overdose of drugs in eleven, gunshot wounds in three, heart disease and Taser shock in one, and an undetermined cause in one. All were considered to be under the influence of PCP by the police at the time of the incident. All were unarmed, which was the reason a Taser was used instead of a more lethal weapon. The conclusion reached after evaluation of these cases is that the Taser in and of itself does not cause death, although it may have contributed to death in one case.

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> The Taser is an electrical law enforcement and self-defense weapon that is being used with increasing frequency. The weapon is described and its effects and ballistic and electrical considerations are reviewed. Clinical aspects of Taser

injury, including weapon-fired barb injury, barb removal methods, injury secondary to electrical current, ventricular fibrillation, possible interactions with implanted pacemakers, and injuries secondary to weapon-induced falls, are discussed. Taser injuries are a new and increasingly frequent emergency medicine problem.

Koscove, E. M. (1987). "Taser dart ingestion." J Emerg Med **5**(6): 493-8.

The Taser is a relatively new electronic self-defense and immobilization weapon used by the public and by law enforcement agencies. Taser victims characteristically have an altered mental status due to drug ingestion or primary psychiatric illness. An unexpected case of Taser-associated morbidity, that of voluntary Taser dart ingestion in a patient with paranoid delusions, is reported. Near mismanagement due to unfamiliarity with the Taser occurred. Recommendations for diagnosis and management are discussed. The emergency physician should be aware of the potential of this unusual ingestion.

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Sudden, in-custody death (SICD) events are alarming phenomena that occur numerous
times per year in this country. With increasing usage of electronic control devices (ECD), such as TASER® brand devices by law enforcement, the number of SICD events that are temporally related to ECD applications is growing. The autopsy in such a case presents a diagnostic challenge to the medical examiner as there are no postmortem tests available to detect past electrical applications.
We believe that because ECD technology is relatively new, medical examiners may not be fully aware of what these devices are and are not capable of and may, therefore, be making errors in diagnostic judgment. We analyzed the probable error rate in assigned causes of death based on a convenience sample population.

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Lakkireddy, D., A. Khasnis, et al. (2007). "Do electrical stun guns (TASER-X26) affect the functional integrity of implantable pacemakers and defibrillators?" Europace **9**(7): 551-6.

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

Lakkireddy, D., D. Wallick, et al. (2006). "Effects of cocaine intoxication on the threshold

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

Lakkireddy, D., D. Wallick, et al. (2008). "Cardiac effects of electrical stun guns: does position of barbs contact make a difference?" Pacing Clin Electrophysiol **31**(4): 398-408.

BACKGROUND: The use of electrical stun guns has been rising among law enforcement authorities for subduing violent subjects. Multiple reports have raised concerns over their safety. The cardiovascular safety profile of these devices in relationship to the position of delivery on the torso has not been well studied. METHODS: We tested 13 adult pigs using a custom device built to deliver neuromuscular incapacitating (NMI) discharge of increasing intensity that matched the waveform of a commercially available stun gun (TASER(R) X-26, TASER International, Scottsdale, AZ, USA). Discharges with increasing multiples of output capacitances were applied in a step-up and step-down fashion, using two-tethered barbs at five locations: (1) Sternal notch to cardiac apex (position-1), (2) sternal notch to supraumbilical area (position-2), (3) sternal notch to infraumbilical area (position-3), (4) side to side on the chest (position-4), and (5) upper to lower mid-posterior torso (position-5). Endpoints included determination of maximum safe multiple (MaxSM), ventricular fibrillation threshold (VFT), and minimum ventricular fibrillation induction multiple (MinVFIM). RESULTS: Standard TASER discharges repeated three times did not cause ventricular fibrillation (VF) at any of the five locations. When the barbs were applied in the axis of the heart (position-1),

MaxSM and MinVFIM were significantly lower than when applied away from the heart, on the dorsum (position-5) (4.31 +/- 1.11 vs 40.77 +/- 9.54, P< 0.001 and 8.31 +/- 2.69 vs 50.77 +/- 9.54, P< 0.001, respectively). The values of these endpoints at position-2, position-3, and position-4 were progressively higher and ranged in between those of position-1 and position-5. Presence of ventricular capture at a 2:1 ratio to the delivered TASER impulses correlated with induction of VF. No significant metabolic changes were seen after standard NMI TASER discharge. There was no evidence of myocardial damage based on serum cardiac markers, electrocardiography, echocardiography, and histopathologic findings confirming the absence of significant cardiac effects. CONCLUSIONS: Standard TASER discharges did not cause VF at any of the positions. Induction of VF at higher output multiples appear to be sensitive to electrode distance from the heart, giving highest ventricular fibrillation safety margin when the electrodes are placed on the dorsum. Rapid ventricular capture appears to be a likely mechanism of VF induction by higher output TASER discharges.

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Levine, S. D., Sloane, Christian, Chan, Theodore, Vilke, Gary, Dunford,James (2005). "Cardiac Monitoring of Subjects Exposed to the TASER." Academic Emergency Medicine **12**(5 Supplement 1).

The Taser is a weapon that delivers high-voltage electricity and is used by approximately one third of U.S. law enforcement agencies. Although generally regarded as safe, little research exists in the literature despite reported sudden deaths. To our knowledge, no prospective human studies on the Taser exist. Objectives: To evaluate for cardiac changes utilizing monitoring during deployment of the Taser on healthy volunteers. Methods: This prospective, interventional pilot study was performed with police officers receiving training on the Taser X-26. The officers, all of whom had already volunteered to be "tasered," had continuous 3-lead electrocardiographic (ECG) monitoring immediately before, during, and after firing of the Taser. The mean duration of ECG tracing after shock was 16.3 seconds. Primary endpoints included development of changes in cardiac rate and rhythm, morphology, and intervals. Investigators individually analyzed the tracings. Comparative statistical analysis utilized paired Student's t-test and 95% confidence intervals (CIs). Results: Data were collected on 20 subjects. The mean shock duration was 2.4 seconds (range 1.2–5 s). Other than sinus tachycardia, no dysrhythmias were identified after the taserings. There was no change in morphology, QRS duration (range 40–80 msec), or QT interval (range 200–400 msec) between the before- and after-Taser groups. After the tasering, there was a 12-msec decrease (95% CI 6 to 18, $p < 0.001$) in the mean PR interval from 132 to 120 msec. The mean heart rates before and after being tasered were, respectively, 127 (range 80–160) and 142 (range 108–175). The mean increase in heart rate was 15 beats/min (95% CI 7 to 22; $p < 0.001$). Conclusions: In this pilot study we found no significant cardiac dysrhythmias in healthy human subjects immediately after receiving a Taser shock. In addition, there were no morphologic, rhythm, or interval changes other than a small decrease in PR interval and an increase in heart rate.

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SUBJECTS EXPOSED TO THE TASER." The Journal of Emergency Medicine **doi:10.1016/j.jemermed.2007.02.018**.

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

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Neuromuscular incapacitation (NMI) devices discharge a pulsed dose of electrical energy to cause muscle contraction and pain. Field data suggest electrical NMI devices present an extremely low risk of injury. One risk of delivering electricity to a human is the induction of ventricular fibrillation (VF). We hypothesized that inducing VF would require a significantly greater NMI discharge than a discharge output by fielded devices. The cardiac safety of NMI discharges was studied in nine pigs weighing 60 +/- 28 kg. The minimum fibrillating level was defined as the lowest discharge that induced VF at least once, the maximum safe level was defined as the highest discharge which could be applied five times without VF induction, and the VF threshold was defined as their average. A safety index was defined as the ratio of the VF threshold to the standard discharge level output by fielded NMI devices. A VF induction protocol was applied to each pig to estimate the VF threshold and safety index. The safety index for stored charge ranged from

15X to 42X as weight increased from 30 to 117 kg (P < 0.001). Discharge levels above standard discharge and weight were independently significant for predicting VF inducibility. 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.

McManus, J., et al (2004). A Retrospective Case Series Describing the Injury Pattern of the Advanced TASER M26 in Multnomah County Oregon. Society of Academic Emergency Medicine. **Volume 11**.

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Mehl, L. E. (1992). "Electrical injury from Tasering and miscarriage." Acta Obstet Gynecol Scand **71**(2): 118-23.

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 currettage 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.

Mesloh, Wolf, et al. (2008). Less Lethal Weapons for Law Enforcement: A Performance-Based Analysis.

Mesloh, C. (2005). TASER and Less Lethal Weapons: An Exploratory Analysis of Deployment and Effectiveness, Law Enforcement Executive Forum 2005.

Meyer, G. (1991). Non-Lethal Weapons Versus Conventional Police Tactics: The Los Angeles Police Department Experience. Political Science. Los Angeles, California Sate University**:** 80.

Miami-Dade County Grand Jury (2005). Mental Illness and the Criminal Justice System: A Recipe for Disaster/A Prescription for Improvement. Miami**:** 51.

Michigan Municipal Risk Management Authority Law Enforcement Advisory Committee (2005). Less Lethal Weapons-Model Policy and Procedures for Public Safety Officers, Michigan Municipal Risk Managment Authority.

Mobile Police Department (2005). Police Use TASER for Last Minute Rescues. Mobile, AL, Mobile Police Department**:** 1.

Moscati, R., J. Ho, et al. (2007). "Physiologic Effects of Prolonged Conducted Electrical Weapon Discharge on Intoxicated Adults." Acad Emerg Med **14**(5): 63-64.
.

> Conclusions: Intoxicated adults with prolonged CEW exposure demonstrate small transient increases in measures of acidosis and no change in markers of cardiac injury. The increased acidosis was not clinically significant and self corrected.

Munetz, M. R., A. Fitzgerald, et al. (2006). "Police use of the taser with people with mental illness in crisis." Psychiatr Serv **57**(6): 883.

N

Nanthakumar, K., I. M. Billingsley, et al. (2006). "Cardiac electrophysiological consequences of neuromuscular incapacitating device discharges." J Am Coll Cardiol **48**(4): 798-804.

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

Nanthakumar, K., S. Masse, et al. (2008). "Cardiac stimulation with high voltage discharge from stun guns." Cmaj.

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

Ng, W. and M. Chehade (2005). "Taser penetrating ocular injury." Am J Ophthalmol **139**(4): 713-5.

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

Northern Ireland Office, A. o. C. P. O. (2002). A Research Programme into Alternative Policing Approaches Towards the Management of Conflict, Northern Ireland Office, Association of Chief Police Officers**:** 7.

O

O'Brien, D. J. (1991). "Electronic weaponry--a question of safety." Ann Emerg Med **20**(5): 583-7.

> Electronic weapons represent a new class of weapon available to law enforcement and the lay public. Although these weapons have been available for several years, there is inadequate research to document their safety or efficacy. Two of the most common, the TASER and the stun gun, are reviewed. The electronic weapon was initially and still is approved by the US Consumer Product Safety Commission; its approval was based on theoretical calculations of the physical effects of damped sinusoidal pulses, not on the basis of animal or human studies. These devices are widely available and heavily promoted, despite limited research into their safety or efficiency and despite recent animal studies documenting their potential for lethality.

Office of the Police Complaint Commissioner (2005). TASER Technology Review Final Report Victoria, British Columbia.

Office of Justice Programs (2008). Study of Deaths Following Electro Muscular Disruption: Interim Report, US Dept of Justice.

Ogden, D., et al (2005). TASER Final Report Orange County Sheriff's Office Florida**:** 41.

Orange County Sheriff's Office Florida (2004). TASER Task Force Medical Findings Transcripts Orange County Sheriff's Office Florida**:** 14.

Ordog, G. J., J. Wasserberger, et al. (1987). "Electronic gun (Taser) injuries." Ann Emerg Med **16**(1): 73-8.

The Taser is an electrical weapon used for immobilization. Two hundred eighteen patients who were shot by police with a Taser for violent or criminal behavior were compared to 22 similar patients shot by police with .38 Specials. The long-term morbidity rate was significantly different for "tasered" victims (0%) and for those with bullet wounds (50%) (P less than .05). The mortality rate was also significantly different between "tasered" victims (1.4%), and gunshot wound victims (50%) (P less than .05). Possible complications associated with Taser wounds included contusions, abrasions, and lacerations (38%); mild rhabdomyolysis (1%); and testicular torsion (0.5%). Although 48% of "tasered" patients required hospitalization, all but one was for a preexisting injury or toxic or psychiatric problem. We conclude that Tasers are relatively safe when compared to shooting with more conventional weapons.

P

Panescu, D. (2008). Estimation of TASER Current Flow and Effects on Human Body. Braidwood Commision Vancouver British Columbia.

Panescu, D. (2007). Numerical Estimation of TASER CEW Current Flow and Effects on Human Body. Bioelectromagnetics Society 29th Annual Meeting Kanazawa, Japan, St. Jude Medical.

Panescu, D., M. W. Kroll, et al. (2006). Finite Element Modeling of Electric Field Effects of TASER Devices on Nerve and Muscle. Engineering in Medicine and Biology Society, 2006. EMBS '06. 28th Annual International Conference of the IEEE, St. Jude Medical.

TASERs deliver electrical pulses that can temporarily incapacitate subjects. The goal of this paper is to analyze the distribution of currents in muscle layers and understand the electro-muscular incapacitation safety and efficacy of TASERs. The analyses describe skeletal muscle and motor nerve activation, cell electroporation and current and electric field distributions through skin, fat and muscle layers, under worst-case assumptions for TASER electrode penetration and separation. For the muscle layer, the analysis predicts worst-case current-density and field-strength values of 94 mA/cm2 and 47 V/cm. Both values are higher than thresholds required for neuromuscular activation but significantly lower than levels needed for permanent cellular electroporation or tissue damage. The results indicate that TASERs are safe and effective in producing temporary subject incapacitation

Panescu, D., M. W. Kroll, et al. (2006). "Finite Element Modeling of Electric Field Effects of TASER Devices on Nerve and Muscle." Conf Proc IEEE Eng Med Biol Soc **1**: 1277-9.

TASERs deliver electrical pulses that can temporarily incapacitate subjects. The goal of this paper is to analyze the distribution of currents in muscle layers and understand the electro-muscular incapacitation safety and efficacy of TASERs. The analyses describe skeletal muscle and motor nerve activation, cell electroporation and current and electric field distributions through skin, fat and muscle layers, under worst-case assumptions for TASER electrode penetration and separation. For the muscle layer, the analysis predicts worst-case current-density and field-strength values of 94 mA/cm² and 47 V/cm. Both values are higher than thresholds required for neuromuscular activation but significantly lower than levels needed for permanent cellular electroporation or tissue damage. The results indicate that TASERs are safe and effective in producing temporary subject incapacitation.

Panescu, D., M. W. Kroll, et al. (2006). "Finite element modeling of electric field effects of TASER devices on nerve and muscle." Conf Proc IEEE Eng Med Biol Soc **1**: 1277-9.

TASERs deliver electrical pulses that can temporarily incapacitate subjects. The goal of this paper is to analyze the distribution of currents in muscle layers and understand the electro-muscular incapacitation safety and efficacy of TASERs. The analyses describe skeletal muscle and motor nerve activation, cell electroporation and current and electric field distributions through skin, fat and muscle layers, under worst-case assumptions for TASER electrode penetration and separation. For the muscle layer, the analysis predicts worst-case current-density and field-strength values of 94 mA/cm(2) and 47 V/cm. Both values are higher than thresholds required for neuromuscular activation but significantly lower than levels needed for permanent cellular electroporation or tissue damage. The results indicate that TASERs are safe and effective in producing temporary subject incapacitation.

Patel, F. (1993). "Homicidal manual strangulation and multiple stun gun injuries." Am J Forensic Med Pathol **14**(3): 271.

Peters, J. G. (2006). Sudden Death, “Excited” Delirium, and Issues of Force. Police and Security News **22**.

Phoenix Police Department, C. o. P. P. D. M. R. D. (2004). Police Involved Shootings Lowest in 14 Years, Phoenix Police Department City of Phoenix Police Department Media Relations Detail**:** 3.

Pudiak, C. M. and M. A. Bozarth (1994). "Cocaine fatalities increased by restraint stress." Life Sci **55**(19): PL379-82.

Laboratory rats injected daily with a moderate dose of cocaine hydrochloride (30 mg/kg, i.p.) showed increased fatalities when cocaine injections were followed by 30 min of restraint stress. The 5-day mortality rate was 58% for the cocaine-plus-stress group, while 17% of the animals receiving cocaine without

restraint stress died. This finding suggests that stress can augment the toxic effect of cocaine and that minimizing stress may be an important consideration in the clinical management of cocaine overdose.

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Rostker, B. D., L. M. Hanser, et al. (2008). Evaluation of the New York City Police Department Firearm Training and Firearm-Discharge Review Process, RAND Center on Quality Policing.

R.A., S., M. W. Kroll, et al. (2006). Cardiac Current Density Distribution by Electrical Pulses from TASER devices. Engineering in Medicine and Biology Society, 2006. EMBS '06. 28th Annual International Conference of the IEEE.

TASERs deliver electrical pulses that can temporarily incapacitate subjects. The goal of this paper is to analyze the distribution of TASER currents in the heart and understand their chances of triggering cardiac arrhythmias. The models analyzed herein describe strength-duration thresholds for myocyte excitation and ventricular fibrillation induction. Finite element modeling is used to compute current density in the heart for worst-case TASER electrode placement. The model predicts a maximum TASER current density of 0.27 mA/cm2 in the heart. It is conclude that the 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.

Racht, E., Pat Cocker. Personal correspondence (2005). TASER Clinical Risk Review. Austin, City of Austin/Travis County Emergency Medical Service System**:** 3.

Reisner, A. D. (2003). "The electroconvulsive therapy controversy: evidence and ethics." Neuropsychol Rev **13**(4): 199-219.

The author reviews literature pertaining to the efficacy and safety of electroconvulsive therapy (ECT), with emphasis on the controversy concerning whether ECT causes brain damage. ECT does appear to be effective in the treatment of severe depression and possibly mania. The types of memory problems caused by ECT are discussed, and evidence suggests that most of these deficits are transitory. Although most evidence points toward modern ECT not causing brain damage, there are still some findings that raise questions about safety. Ethical issues involving this treatment's use, its availability to the public, and informed consent procedures are discussed.

Roberts, J. R. (2008). InFocus: The Medical Effects of TASERs. Emergency Medicine News.

Rose, J. (2004). Navigating the Learning Curve, Cincinnati Police Department**:** 17.

Ross, V. G., Colorado Police Department) (2004). Use of Force Success S. Tuttle. Glendale, CO**:** 1.

Roy, O. Z. and A. S. Podgorski (1989). "Tests on a shocking device--the stun gun." Med Biol Eng Comput **27**(4): 445-8.

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Salem Police Department (2004). Salem Police Department TASER Use Summary Jan 2004–Dec 2004. Salem, Salem Police Department**:** 2.

San Bernardino County Sheriffs Department (2004). Program Evaluation of a pilot study of the TASER X26. San Bernardino, San Bernardino County Sheriffs Department

San Jose Police Department. Davis, C. R. L. D. (2005). TASER Usage Update. San Jose, San Jose Police Department**:** 2.

Savage, S. S. (2005). After the Zap: TASER Injuries and How to Treat Them. National Commission on Correctional Health Care- Correct Care. **19**.

Schmiederer, B., A. Du Chesne, et al. (2005). "Specific traces in stun gun deployment." Int J Legal Med **119**(4): 207-12.

Stun guns are electric shocking devices that can be deployed as defensive or offensive weapons. The aim of this study was the identification of several types of trace evidence for corroborating deployment and providing clues to the weapon

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

Seattle Police Department (2002). Update on TASER Usage as of 14 November 2002, Seattle Police Department**:** 7.

Seattle Police Department (2005). The M26 TASER: Two Years' Experience. Seattle, Washington, Seattle, Washington Police Department**:** 14.

Sloane, C. (2008). UCSD CED Related Studies. Braidwood Commission Vancouver British Columbia.

Sloane, C., G. Vilke, et al. (2007). "Serum Troponin I Measurement of Subjects Exposed to the Taser X-26." Acad Emerg Med **14**(5): 103-104.

Conclusions: Though limited by short shock duration, human volunteers exposed to a single shock from the Taser did not develop an abnormal serum troponin I level 6 hours after shock, suggesting that there was no myocardial necrosis.

Sloane, C. M., T. C. Chan, et al. (2008). "Thoracic Spine Compression Fracture after TASER Activation." J Emerg Med.

The TASER is a less lethal weapon seeing increased use by police jurisdictions across the country. As a result, subjects of TASER use are being seen with increasing frequency in emergency departments across the country. The potential injury patterns of the device are important for emergency physicians to understand. This report describes the case of an officer who complained of back pain after a single 5-s TASER discharge during a routine training exercise. Subsequent evaluation led to the diagnosis of an acute thoracic vertebral compression fracture. We discuss the potential mechanisms of injury in this case. Because we were unable to find any cases like this in our review of TASER-related

injuries, we liken it to compression fractures that have been documented after seizures. We recommend that physicians consider obtaining back radiographs to rule out a vertebral compression fracture in any individual who has sustained a TASER discharge and has ongoing or persistent back pain.

Stephens, B. G. M. D., J. M. M. D. Jentzen, et al. (2004). "Criteria for the Interpretation of Cocaine Levels in Human Biological Samples and Their Relation to the Cause of Death." American Journal of Forensic Medicine & Pathology **25**(1): 1-10.

The determination that cocaine is directly responsible for the immediate cause of death should be considered only when there is a reasonably complete understanding of the circumstances or facts surrounding the death. Another, more obvious and immediate cause of death must be absent, or, at least cocaine must be shown to be a significant contributing factor in the chain of medical findings that lead directly to the immediate cause of death. Not all death investigation requires the sequential steps described in this paper, but these steps must be considered early on in the investigation whenever there is scene, investigational, medical or a historical basis to believe that cocaine is directly related to the cause of death. A relatively high profile death when cocaine is known to be involved, or a death involving unusual behavior on the part of the deceased with police involvement are examples where these considerations may well apply. Information needs to be obtained as soon as possible to have the highest chance of successfully documenting the toxicologic basis for the diagnosis. These facts would include, but would not necessarily be limited to, a scene investigation (whenever possible), a careful review of the investigative reports from all involved agencies, the initial core temperature of the body as well as that of the environment at the time of the collapse or death, the past medical history of the individual, and the results of a complete forensic autopsy and toxicologic studies. Knowledge of and an understanding of the current relevant forensic literature on this subject should be available to the reviewer prior to any interpretation of the significance of cocaine upon a specific death., (C) 2004 Lippincott Williams & Wilkins, Inc.

Stratbucker, R. (1993). Safety Technical Evaluation of the Model XR 5000 Electronic Stun Gun. Omaha, Univeristy of Nebraska Medical Center.

Stratbucker, R. (1996). Air TASER Model 34000 Safety Study. Omaha, Stratbucker and Associates.

Stratbucker, R. A., M. W. Kroll, et al. (2006). "Cardiac Current Density Distribution by Electrical Pulses from TASER devices." Conf Proc IEEE Eng Med Biol Soc **1**: 6305-7.

TASERs deliver electrical pulses that can temporarily incapacitate subjects. The goal of this paper is to analyze the distribution of TASER currents in the heart and understand their chances of triggering cardiac arrhythmias. The models analyzed herein describe strength-duration thresholds for myocyte excitation and ventricular fibrillation induction. Finite element modeling is used to compute current density in

the heart for worst-case TASER electrode placement. The model predicts a maximum TASER current density of 0.27 mA/cm² in the heart. It is conclude that the 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.

Stratton, S. J. M. M., C. M. Rogers, et al. (2001). "Factors Associated With Sudden Death of Individuals Requiring Restraint for Excited Delirium." American Journal of Emergency Medicine **19**(3): 187-191.

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. (Am J Emerg Med 2001;19:187-191. Copyright (C) 2001 by W.B. Saunders Company), (C) 2001 W.B. Saunders Company, a Harcourt Health Sciences Company

Strote, J., Shane Hamman, Rich Campbell, John Pease,H. Range Hutson (2005). "The Role of TASERs in Police Restraint-Related Death.".

Strote, J. and H. Range Hutson (2006). "Taser use in restraint-related deaths." Prehosp Emerg Care **10**(4): 447-50.

OBJECTIVE: The Taser is an electric weapon capable of releasing significant amounts of electricity in rapid pulses, causing uncontrollable muscle contraction. Use of this weapon has dramatically increased over the past decade, and it is now commonly used by law enforcement officers nationwide. Emergency medical services providers are, likewise, seeing more patients who have recently been subjected to application of a Taser. We examined the autopsy reports of patients who died after application of a Taser in an attempt to identify high-risk interactions. METHODS: This is a case series of Taser-related deaths. Fatalities occurring over four years beginning in January 2001 were identified through an Internet search,

and autopsy reports were requested. Reports were analyzed for patient demographics, preexisting cardiac disease, toxicology, evidence of excited delirium, restraint techniques used, and listed cause of death. RESULTS: Of 75 cases identified, 37 (49.3%) had autopsy reports available for review. All cases involved men, with ages ranging from 18 to 50 years. Cardiovascular disease was found in 54.1%. Illegal substance use was found on toxicology screening for 78.4%; within that group, 86.2% were found to have been using stimulants. A diagnosis of excited delirium was given for 75.7% of the cases. Use of a Taser was considered a potential or contributory cause of death in 27%. CONCLUSIONS: This is the largest review of Taser-related fatalities reported in the medical literature. The findings are consistent with prior studies, suggesting a high frequency of restraint-related and excited delirium-related fatalities.

Strote, J. H., Range Hutson (2006). TASER use in Restraint Related Deaths. Prehostpital Emergency Care **10**.

Stuart, B. and C. Lawrence (2007). Report on Conducted Energy Weapons and Excited Delirium Syndrome, Royal Canadian Mounted Police.

Sun, H., J.-Y. W. R. Abdallah, et al. (2006). Electromuscular Incapacitating Device Safety. Madison, WI, University of Wisconsin-Madison/Department of Electrical and Computer Engineering.

Swerdlow, C. (2008). Presenting Rhythm in Sudden Deaths After Use of TASER® Conducted Energy Devices. Braidwood Commission Vancouver British Columbia.

Swerdlow, C., M. W. Kroll, et al. (2008). Presenting Rhythm in Sudden Custodial Deaths After Use of TASER® Electronic Control Device. Heart Rythm Society, Cedars-Sinai Medical Center, Los Angeles, CA, University of Minnesota, Minneapolis, MN San Marcos Police Department, San Marcos, TX University of Kansas Medical Center, Kansas City, KS, Cleveland Clinic, Cleveland, OH.

Synyshyn, S. (2008). A Briefing Note on the State of Tasers in Canada: A Select Review of Medical and Policy Review Literature, The Canadian Association of Police Boards.

Conclusion: It is hoped that this report will contribute to the development of Canadian Association of Police Boards (CAPB) on matters relating to tasers. After reviewing only a small portion of the amounts of literature available it appears that tasers are a more effective and less dangerous option in circumstances that would otherwise call for more lethal or injury-prone uses of force. The primary advantage, incapacitation of subjects from a distance, is significant. Proper training and constant reassessment of the quality of techniques and concepts for evaluating situations prior to the use of any force are crucial. Nevertheless, for reasons stated earlier in this paper, controversy surrounding their use in law enforcement will undoubtedly continue. Therefore it is crucial that those bodies charged with fulfilling oversight functions inform themselves as much as possible and insist that

their agencies have at the ready accurate and sufficient answers and policies to reassure the public these devices are being deployed in situations that appropriately warrant their use.

Sztajnkrycer, M. D. (2005). Cardiovascular Risk and the TASER: A Review of the Recent Literature. Tactical Emergency Medicine **2**.

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The Alfred Hospital (2003). Advanced TASER M-26 Safety Analysis The Alfred Hospital**:** 26.

The Alfred Hospital (2003). Advanced TASER X-26 Safety Analysis 28.

The Florida Senate (2005). Dart firing stun guns, The Florida Senate.

Tilton, D. S. S. B. C. S. D. (2005). TASER Survey. San Bernardino, San Bernardino County Sheriffs Department**:** 98.

Tintinalli, J. E., G. D. Kelen, et al. (2005). "Emergency Medicine A Comprehensive Study Guide (6th edition)."

Tisdale, J. E., H. Shimoyama, et al. (1996). "The effect of cocaine on Ventricular fibrillation threshold in the normal canine heart." Pharmacotherapy **16**(3): 429-37.

We determined the effect of cocaine on ventricular vulnerability to fibrillation, as measured by ventricular fibrillation threshold (VFT), and cardiac electrophysiology in 20 anesthetized dogs with normal hearts. Animals were randomized in blinded fashion to receive a continuous 3-hour infusion of cocaine 0.11 mg/kg/minute (total

dose 20 mg/kg) or placebo (lactose dissolved in normal saline). The VFT, systolic and diastolic blood pressures, ventricular effective refractory period (ERP), and electrocardiographic intervals were measured at baseline and every 30 minutes during infusion. Baseline mean +/- SE VFT in cocaine and placebo groups was 57.0 +/- 7.8 and 51.8 +/- 7.6 mA, respectively (p = 0.64). Cocaine did not significantly decrease VFT, but actually increased it (i.e., reduced ventricular vulnerability to fibrillation) compared with placebo (84.6 +/- 10.4 vs 55.8 +/- 7.2 mA, respectively, at 150 minutes, p = 0.04). Cocaine prolonged ERP and PR, QRS, QT, QTc, JT, and JTc intervals. Cocaine does not increase ventricular vulnerability to fibrillation in anesthetized dogs with normal intact hearts. Its electrophysiologic effects are similar to those of class I antiarrhythmic agents in this model.

Tisdale, J. E. e. a. (1996). "Electrophysiological and Electrocardiographic Pharmacodynamics of Cocaine." Pharmacotherapy **16** (3): 438-445.

Titusville Police Department (2005). Description of Incidents.

Toxicolgy Excellence for Risk Assesment (TERA), A. M., Patricia Nance, LINEA INC., General Dynamics, Clifford J Sherry, Metatec Associates, J Patrick Reily, Dr B JOn Klauenberg, Jonathan T Drummond LT Col USAF (2005). Human Effectiveness and Risk Characterization of the Electromuscular Incapacitation Device – A Limited Analysis of the TASER Part I –Technical Report, The Joint Non-Lethal Weapons Human Effects Center of Excellence**:** 76.

Transcript (2005). TASER Hearing Open Meeting. State of Wisconsin TASER Hearing.

Turner, M. S. and M. L. Jumbelic (2003). "Stun gun injuries in the abuse and death of a seven-month-old infant." J Forensic Sci **48**(1): 180-2.

The author autopsied a seven-month-old infant who was shocked repeatedly with a stun gun by his foster mother, in an attempt by the foster mother to get the infant to stop crying. The stun gun injuries were round, well-circumscribed, erythematous macular lesions, which were found in pairs. The lesions were 2 in. apart, and were found to match the distance between the electrodes of the stun gun found in the foster mother's purse. Based on the electrical output of the stun gun, the small size of the infant, location of stun gun discharge, and the decreased resistance of the infant's skin, it can be concluded that the stun gun injury is responsible for the infant's death.

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Underwriters' Laboratories, I. (1939; 1955). Electric Shock as it Pertains to the Electric Fence, National Board of Fire Underwriters Bulletin of Research**:** 55.

United Kingdom Defence Scientific Advisory Council (2004). DSAC Sub-Committee on the Medical Implications of Less-lethal Weapons United Kingdom Defence Scientific Advisory Council.

United States Government Accountability Office (2005). TASER WEAPONS: Use Of Tasers by Selected Law Enforcement Agencies Washington, D.C, U.S. Government Printing Office**:** 25.

United States. Government Accountability Office. and United States. Congress. House. Committee on Government Reform. Subcommittee on National Security Emerging Threats and International Relations. (2005). Taser weapons : use of Tasers by selected law enforcement agencies : report to the chairman, Subcommittee on National Security, Emerging Threats and International Relations, Committee on Government Reform, House of Representatives. Washington, D.C., U.S. Government Accountability Office.

V

Valentino, D., R. Walter, et al. (2007). "TASER Discharges Capture Cardiac Rhythm in a Swine Model." Acad Emerg Med **14**(5): 104.

> Conclusions: Given the possibility of cardiac capture with TASER discharges, cardiac monitoring should be performed on exposed subjects.

Valentino, D. J., R. J. Walter, et al. (2007). "Neuromuscular effects of stun device discharges." J Surg Res **143**(1): 78-87.

> CONCLUSIONS: There was no evidence of acute arrhythmia from MK63 discharges. No clinically significant changes were seen in any of the physiological parameters measured here at any time point. Neuromuscular function was not significantly altered by the MK63 discharge. In this animal model, even lengthy MK63 discharges did not induce muscle or nerve injury as seen using EMG, blood chemistry, or histology.

Victoria Police Service (2005). TASER Technology Review Final Report, Office of the Police Complaint Comissioner Victoria Police Service British Columbia**:** 44.

Vilke, G. and T. Chan (2007). Less Lethal Technology: medical issues. San Diego,

University of California**:** 3.

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

Vilke, G., C. Sloane, et al. (2007). "Cardiovascular and Metabolic Effects of the Taser on Human Subjects." Acad Emerg Med **14**(5): 104-105.

Conclusions: There were no clinically significant or lasting statistically significant changes in cardiovascular, electrolyte, lactate or pH levels in human subjects after a 5 second Taser activation

Vilke, G., C. Sloane, et al. (2007). "Cardiovascular and Metabolic Effects of the Taser on Human Subjects."

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

Conclusions: There were no cardiac dysrhythmia, interval or morphology changes in human subjects who received a Taser shock on evaluation of a 12 lead ECG performed immediately before and after Taser activation.

Vilke, G., C. Sloane, et al. (2007). Does the Taser Cause Electrical Changes in Twelve Lead ECG Monitoring of Human Subjects.

> Conclusions: There were no cardiac dysrhythmia, interval or morphology changes in human subjects who received a Taser shock on evaluation of a 12 lead ECG performed immediately before and after Taser activation.

Vilke, G. M., C. Sloane, et al. (2008). "Twelve-lead electrocardiogram monitoring of subjects before and after voluntary exposure to the Taser X26." Am J Emerg Med **26**(1): 1-4.

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

Vilke, G. M., C. M. Sloane, et al. (2007). "Physiological Effects of a Conducted Electrical Weapon on Human Subjects." Ann Emerg Med.

> STUDY OBJECTIVE: Sudden death after a conducted electrical weapon exposure has not been well studied. We examine the effects of a single Taser exposure on markers of physiologic stress in healthy humans. METHODS: This is a prospective trial investigating the effects of a single Taser exposure. As part of their police training, 32 healthy law enforcement officers received a 5-second Taser electrical discharge. Measures before and for 60 minutes after an exposure included minute ventilation; tidal volume; respiratory rate (RR); end-tidal PCO(2); oxygen saturation, pulse rate; blood pressure (systolic blood pressure/diastolic blood pressure); arterialized blood for pH, PO(2), PCO(2), and lactate; and venous blood

for bicarbonate and electrolytes. Troponin I was measured at 6 hours. Data were analyzed using a repeated-measures ANOVA and paired t tests. RESULTS: At 1 minute postexposure, minute ventilation increased from a mean of 16 to 29 L/minute, tidal volume increased from 0.9 to 1.4 L, and RR increased from 19 to 23 breaths/min, all returning to baseline at 10 min. Pulse rate of 102 beats/min and systolic blood pressure of 139 mm Hg were higher before Taser exposure than at anytime afterward. Blood lactate increased from 1.4 mmol/L at baseline to 2.8 mmol/L at 1 minute, returning to baseline at 30 minutes. pH And bicarbonate decreased, respectively, by 0.03 and 1.2 mEq/L at 1 minute, returning to baseline at 30 minutes. All troponin I values were normal and there were no EKG changes. Ventilation was not interrupted, and there was no hypoxemia or hypercarbia. CONCLUSION: A 5-second exposure of a Taser X-26 to healthy law enforcement personnel does not result in clinically significant changes of physiologic stress.

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Walter, R. J., A. J. Dennis, et al. (2008). "TASER X26 discharges in swine produce potentially fatal ventricular arrhythmias." Acad Emerg Med **15**(1): 66-73.

OBJECTIVES: Data from the authors and others suggest that TASER X26 stun devices can acutely alter cardiac function in swine. The authors hypothesized that TASER discharges degrade cardiac performance through a mechanism not involving concurrent acidosis. METHODS: Using an Institutional Animal Care and Use Committee (IACUC)-approved protocol, Yorkshire pigs (25-71 kg) were anesthetized, paralyzed with succinylcholine (SCh; 2 mg/kg), and then exposed to two 40-second discharges from a TASER X26 with a transcardiac vector. Vital signs, blood chemistry, and electrolyte levels were obtained before exposure and periodically for 48 hours postdischarge. Electrocardiograms and echocardiography (echo) were performed before, during, and after the discharges. p-Values < 0.05 were considered significant. RESULTS: Electrocardiograms were unreadable during the discharges due to electrical interference, but echo images showed unmistakably that cardiac rhythm was captured immediately at a rate of 301 +/- 18 beats/min (n = 8) in all animals tested. Capture continued for the duration of the discharge and in one animal degenerated into fatal ventricular fibrillation (VF). In the remaining animals, ventricular tachycardia (VT) occurred postdischarge for 1-17 seconds, whereupon sinus rhythm was regained spontaneously. Blood chemistry values and vital signs were minimally altered postdischarge and no significant acidosis was seen. CONCLUSIONS: Extreme acid-base disturbances usually seen after lengthy TASER discharges were absent

with SCh, but TASER X26 discharges immediately and invariably produced myocardial capture. This usually reverted spontaneously to sinus rhythm postdischarge, but fatal VF was seen in one animal. Thus, in the absence of systemic acidosis, lengthy transcardiac TASER X26 discharges (2 x 40 seconds) captured myocardial rhythm, potentially resulting in VT or VF in swine.

Webster, J., Will JA, Sun, H, Wu J-Y, O'rourke, AP, Huebner, SM Rahko, PS (2006). Can Tasers® directly cause ventricular fibrillation? Madison, WI, University of Wisconsin/Dept. Biomedical Engineering.

Tasers are battery powered electrical devicesused by law enforcement personnel to temporarily incapacitatea suspect. This study is a portion of a larger study to determine the probability of a Taser (X26 and M26) causing ventricular fibrillation (VF) in humans. We determined the distance between a Taser dart and the ventricle (dart-to-heart distance) necessary to trigger VF in an in-vivo porcine model, using 10 anesthetized pigs. All experiments were approved by the appropriate IUCUC and adhere to all applicable laws and standards of the NIH and USDA as well as the policies of the APS. To more accurately represent the dart-to-heart distances found in a human, we reflected the skin, subcutaneous fat and
muscle over the sternum and placed a thoracic dart into the third intercostal space over the right ventricle. Current flowed to a second dart 15 to 54 cm away on the abdomen. We determined that the distance between the darts makes no significant difference in the current. We directly measured the dart-toheart distance and confirmed it post mortem. The dart-to-heart distance that causes VF is 17 mm ± 6.48 (SD) for the first VF event and 13.7 mm ± 6.79 (SD) for the average of the successive VF events. We will combine these data with echocardiographic human anatomic data, police-provided dart landing distribution data, and a finite element method (FEM) model of current density in the human torso to yield a probability of a Taser causing VF in a human.

Webster, J. G. (2006). Electromuscular Incapacitating Devices. Madison, WI, University of Wisconsin-Madison.

White, M. and J. Ready (2008). The Impact of the TASER on Suspect Effectiveness. Crime Delinquency Onlinefirst, http://cad.sagepub.com.

Despite the Taser's increasing popularity among police agencies, questions have been raised concerning the weapon's use and effectiveness as well as its potential to cause serious injury or death. This article examines all Taser deployments by the New York City Police Department from 2002 to 2005 (N = 375) and uses two multivariate approaches—logistic regression and chi-square automatic interaction detection—to identify predictors of Tasereffectiveness, measured as continued suspect resistance and officer satisfaction. Findings indicate that several factors are associated with reduced effectiveness, including suspect body weight (more than 200 pounds), drug and alcohol use, physical violence, and close distance (3 feet or less) between the officer and the suspect. Although this study represents a

preliminary effort at identifying predictors of Taser effectiveness, there are clear training and policy implications for police departments.

Whitehead, S. (2005). "A rational response to Taser strikes." Jems **30**(5): 56-66.

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Will J, W. J.-Y., O'Rourke A, Huebner S, Webster G (2006). CAN TASERS® DIRECTLY CAUSE VENTRICULAR FIBRILLATION? . University of Wisconsin-Madison.

Williams, H. E. (2008). TASER ELECTRONIC CONTROL DEVICES AND SUDDEN IN-CUSTODY DEATH: Separating Evidence from Conjecture C C Thomas

Winslow, J. E., W. P. Bozeman, et al. (2007). "Thoracic compression fractures as a result of shock from a conducted energy weapon: a case report." Ann Emerg Med **50**(5): 584-6.
The Taser is an electrical conducted energy weapon used by law enforcement officers throughout the United States and the world. Though generally regarded as safe, conducted energy weapons can produce injuries. In this case report we describe for the first time thoracic spine compression fractures resulting from a conducted energy weapon discharge. Physicians who may care for patients who have been exposed to a conducted energy weapon discharge should be aware of this as a possible complication.

Wisconsin Department of Justice Law Enforcement Standards Board, A. C. R. f. T. f. E. o. a. E. C. D. D. o. J. L. E. S. B. (2005). Advisory Committee Recommendations for Training for Employment of an Electronic Control Device Wisconsin Department of Justice Law Enforcement Standards Board – Advisory Committee Recommendations for Training for Employment of an Electronic Control Device Department of Justice Law Enforcement Standards Board**:** 9.

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Zylich, N. P. (1976). TASER Evaluation and Analysis U.S. Product Safety Commission.