



C18 Weight Adjusted Meta-Analysis of Fibrillation Risk From Taser® Conducted Electrical Weapons

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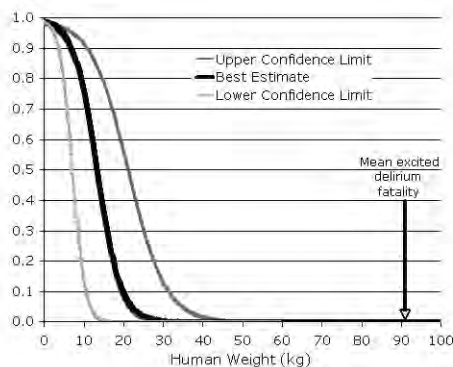
After attending this presentation, attendees will understand the risk of CEW fibrillation for human beings of various body weights.

This presentation will impact the forensic community by demonstrating how a forensic investigator will be able to estimate the risk of CEW-induced fibrillation with an arrest-related death.

Background: Some have raised the concern that the rapid pulses from the TASER® X26 Conducted Electrical Weapon (CEW) might induce ventricular fibrillation (VF) from an exposure to the chest. This concern has received some support from occasional reports of the induction of VF in swine with the TASER X26. The TASER M26 has not been suggested as causing VF.⁽¹⁾ The electrical current threshold for VF is approximately proportional to the body weight for both utility power and CEW pulses.⁽²⁻⁴⁾ This has raised the issue of the scalability of these results to heavier humans as the mean weight of excited delirium deaths is 91 kg.⁽⁵⁾

Methods: Published peer-reviewed papers studying the application of chest exposures of the TASER X26 to swine were researched — in which the heart was in the current path between the barbs. If individual weights were not given reported ranges to build an appropriate distribution were used. Swine weights were scaled using a moderate correction (human weight = 0.72 * swine weight) from the classic Dalziel data⁽²⁾ even though more recent evidence suggests that swine are even more sensitive to the induction of VF.⁽⁶⁻⁸⁾ The cases of reported VF induction were then entered along with the exposures not inducing VF into a logistic regression dose-response model. Acute epinephrine effects were scaled using the published 28% VF threshold reduction.⁽⁹⁾

Results: Eight papers were found meeting the criteria.^(1, 4, 10-15) These studies covered 117 chest exposures in 81 swine weighing between 22-117 kg. There were three inductions of VF in 56 tests with swine of ≤ 37 kg for a probability of .05. There were no VF inductions in swine of > 37 kg. These data were well fit ($r^2 = .81$ by U test) to a logistic regression model ($p = .0003$ by Wald chi-square test) as shown in the figure. The human weight at which VF induction is likely ($p > 0.5$) is predicted to be 13.3 kg (confidence limits: 7.1, 21.2 kg). These estimates are conservative as the majority of chest exposures do not include the heart in the current path. The predicted probability of VF in a 91 kg human is 3.4×10^{-12} (confidence limits: 4.5×10^{-23} , 3.2×10^{-7}).



Conclusions: Consistent with historical and recent literature, the susceptibility to VF is strongly and negatively correlated with body weight. For human weights < 20 kg VF induction may be possible for successful chest exposures which include the heart between the barbs. The probability of VF with a chest application of a CEW is essentially zero for the weight of the typical excited delirium fatality case. The theoretical possibility of CEW induced VF does not appear to be a plausible explanation for arrest-related deaths.

References:

1. Nanthakumar K, Billingsley IM, Masse S, Dorian P, Cameron D, Chauhan VS, Downar E, Sevaptisid E. Cardiac electrophysiological consequences of neuromuscular incapacitating device discharges. *J Am Coll Cardiol* 2006;48:798-804.



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- ² Dalziel CF, Lee WR. Reevaluation of lethal electric currents. *IEEE Transactions on Industry and General Applications* 1968;IGA- 4:467-476.
- ³ Geddes LA, Cabler P, Moore AG, Rosborough J, Tacker WA. Threshold 60-Hz current required for ventricular fibrillation in subjects of various body weights. *IEEE Trans Biomed Eng* 1973;20:465-8.
- ⁴ McDaniel WC, Stratbucker RA, Nerheim M, Brewer JE. Cardiac safety of neuromuscular incapacitating defensive devices. *Pacing Clin Electrophysiol* 2005;28 Suppl 1:S284-7.
- ⁵ Stratton SJ, Rogers C, Brickett K, Gruzinski G. Factors associated with sudden death of individuals requiring restraint for excited delirium. *Am J Emerg Med* 2001;19:187-91.
- ⁶ Allison JS, Qin H, Dossdall DJ, Huang J, Newton JC, Allred JD, Smith WM, Ideker RE. The transmural activation sequence in porcine and canine left ventricle is markedly different during long- duration ventricular fibrillation. *J Cardiovasc Electrophysiol* 2007;18:1306-12.
- ⁷ Li GR, Du XL, Siow YL, O K, Tse HF, Lau CP. Calcium-activated transient outward chloride current and phase 1 repolarization of swine ventricular action potential. *Cardiovasc Res* 2003;58:89-98.
- ⁸ Pak HN, Kim YH, Lim HE, Chou CC, Miyauchi Y, Fang YH, Sun K, Hwang C, Chen PS. Role of the posterior papillary muscle and purkinje potentials in the mechanism of ventricular fibrillation in open chest dogs and Swine: effects of catheter ablation. *J Cardiovasc Electrophysiol* 2006;17:777-83.
- ⁹ Han J, Garcia-dejalón P, Moe GK. Adrenergic Effects on Ventricular Vulnerability. *Circ Res* 1964;14:516-24.
- ¹⁰ Dennis AJ, Valentino DJ, Walter RJ, Nagy KK, Winners J, Bokhari F, Wiley DE, Joseph KT, Roberts RR. Acute effects of TASER X26 discharges in a swine model. *J Trauma* 2007;63:581-90.
- ¹¹ Jauchem JR, Cook MC, Beason CW. Blood factors of *Sus scrofa* following a series of three TASER((R)) electronic control device exposures. *Forensic Sci Int* 2007.
- ¹² Jauchem JR, Sherry CJ, Fines DA, Cook MC. Acidosis, lactate, electrolytes, muscle enzymes, and other factors in the blood of *Sus scrofa* following repeated TASER exposures. *Forensic Sci Int* 2006;161:20-30.
- ¹³ Lakkireddy D, Wallick D, Verma A, Ryschon K, Kowalewski W, Wazni O, Butany J, Martin D, Tchou PJ. Cardiac effects of electrical stun guns: does position of barbs contact make a difference? *Pacing Clin Electrophysiol* 2008;31:398-408.
- ¹⁴ Walter RJ, Dennis AJ, Valentino DJ, Margeta B, Nagy KK, Bokhari F, Wiley DE, Joseph KT, Roberts RR. TASER X26 discharges in swine produce potentially fatal ventricular arrhythmias. *Acad Emerg Med* 2008;15:66-73.
- ¹⁵ Wu JY, Sun H, O'Rourke AP, Huebner S, Rahko PS, Will JA, Webster JG. Taser dart-to-heart distance that causes ventricular fibrillation in pigs. *IEEE Trans Biomed Eng* 2007;54:503-8.

Taser®, Fibrillation, Conducted Electrical Weapon