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TASER SUBJECTS: Identification of High-Risk Individuals

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TASER SUBJECTS: Identification of High-Risk Individuals

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Dedication

I dedicate this body of work to my wonderful wife, Laura. Her encouragement, support, and understanding were instrumental and of the utmost importance.

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I would like to formally acknowledge all my capstone committee members for their assistance with this project. Special thanks to Dr. Laura Rudkin for all her time, direction, and advice.

TASER SUBJECTS: Identification of High-Risk Individuals

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Taser® devices are used by many police forces as a nonlethal means of subduing individuals. These devices use conducted electrical energy to cause neuromuscular incapacitation. Tasers have been associated with adverse clinical outcomes and death, and their use remains controversial. Current national level policing policies exhibit heterogeneity with respect to the clinical disposition of individuals subjected to Tasers. Critical review of the published medical literature concerning the human effects of Tasers suggests the delineation of certain groups potentially more vulnerable to adverse medical outcome and injurious clinical sequela. Policy changes mandating that these "high-risk" groups receive clinical evaluation post-incident may increase public safety with respect to Tasers.

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CHAPTER 1: INTRODUCTION

Policing and law enforcement agencies have long sought a reliable nonlethal means of subduing violent, uncooperative, or dangerous individuals prior to arrest and detainment. Some of these means have included various types of batons, incapacitating sprays like chemical mace, "beanbag" guns, canines, and others. One type of device widely employed today to serve this purpose is the Taser® (Taser International, Inc., Scottsdale, Arizona). A Taser is sometimes generically referred to as a conducted energy weapon (CEW) or conducted energy device (CED). According to the manufacturer, these devices are used to "quickly incapacitate dangerous, combative, or high-risk subjects who pose a risk to law enforcement officers, innocent citizens, or themselves" (Taser International, Inc., 2007).

A. SPECIFIC AIMS:

A detailed review of law enforcement policies with respect to the larger issue of nonlethal use of force is beyond the scope of this project, and no comment will be made regarding the initial decision of employment of the Taser device for field police work. Furthermore, it is beyond the purview of medical personnel to dictate police policy and procedures.

Tasers do possess the ability to harm, however, and there exists heterogeneity with respect to the clinical evaluation of Taser subjects once the device is used. If the current body of medical literature supports the delineation of a clinically "high-risk"

group(s), then policing agencies may wish to consider standard protocols for post-event evaluation of this group. This may increase public safety with respect to individuals subjected to Tasers.

I have three aims for this project:

1. Obtain a sampling of current Taser policies from national-level policing and law enforcement agencies. Review and summarize these with respect to guidance or directives for medical evaluation of the detainee following employment of the device.

2. Conduct a systematic medical literature review with respect to the clinical human effects of Tasers. Within the limits of the medical literature, determine which subject types are at high-risk for adverse clinical outcome.

3. If the medical literature supports, develop generic recommendations for policing and law enforcement agencies to consider with respect to the safe medical evaluation of Taser subjects. These recommendations may be useful to a governing or authoritative body concerning Taser policy protocols or algorithms.

B. BACKGROUND:

The term "Taser" is an acronym standing for "Thomas A. Swift's Electronic Rifle" (S. Tuttle of Taser International, Inc., personal communication, November 30, 2007). Tom Swift is the hero-protagonist in a long-standing series of adolescent adventure novels, and is particularly known for his ingenious adaptations of technology. The first book was published in 1910, written under the pseudonym Victor Appleton, and the series continues today with almost 100 books (Wikipedia, 2007).

While there are variants, the Taser is essentially a handgun-shaped device that employs compressed nitrogen gas to fire two metallic probes or darts. One barb fires straight along the sighting line, while the other is directed at an 8 degree downward angle. Once the barbs embed in the subject, rapid electrical pulses are transmitted to the probes through two insulated connecting wires that remain attached to the device. The electrical energy discharged to the individual via the probes is designed to adversely affect the peripheral nervous system in such a way as to render the individual incapacitated. The physiologic phenomenon has been deemed "neuromuscular incapacitation" (Taser International, Inc., 2007). This is a fundamental difference between Tasers and early generation CEW devices like "stun guns." Stun guns generally operate on forced compliance secondary to overwhelming pain, whereas Tasers truly render a subject incapacitated through involuntary muscular tetany (Jenkinson, et al., 2006; Lutes, 2006; Whitehead, 2005).

The barbs (essentially straight #8 fishhooks) are discharged at 170-180 feet per second, comparable to a recreational paintball gun which discharges projectiles at approximately 200 feet per second (Lutes, 2006). This is much slower than a handgun. The NATO standard 9 millimeter M-9 semiautomatic pistol, for example, has a muzzle velocity of 1,230 feet per second (US Army, 1988). Police model Tasers can shoot out to a maximum of 35 feet, but most engagements are between seven and twelve feet (S. Tuttle of Taser International, Inc., personal communication, November 30, 2007).

The two devices used in law enforcement are the M26 and X26 which are not available for sale to the general public. According to the technical specifications (Taser International, Inc., 2007), the M26 is larger and heavier (7.13" long, 19.2 oz. versus 6"

long and 7.2 oz. for the X26). The X26 has a more comprehensive data port download and is by far the more popular model in field use (S. Tuttle of Taser International, Inc., personal communication, November 30, 2007). Both operate on a five-second cycle delivering very short duration electrical pulses at a rate of 15-20 pulses per second. The M26 uses a blunt pulse, damped oscillation wave form with a peak 50,000V voltage and 3.6mA of average current. The X26 uses a more efficient complex shaped pulse with a peak 50,000V voltage and 2.1mA of average current. In its analysis of the Taser, the US military's Joint Non-Lethal Weapons Human Effects Center of Excellence (HECOE) determined the probability of achieving complete neuromuscular incapacitation to range from 52% to 74% depending on distance from the target and subsequent spread of the probes on the subject (2005).

Figure 1: Taser® X-26 (with permission, Taser International, Inc.)

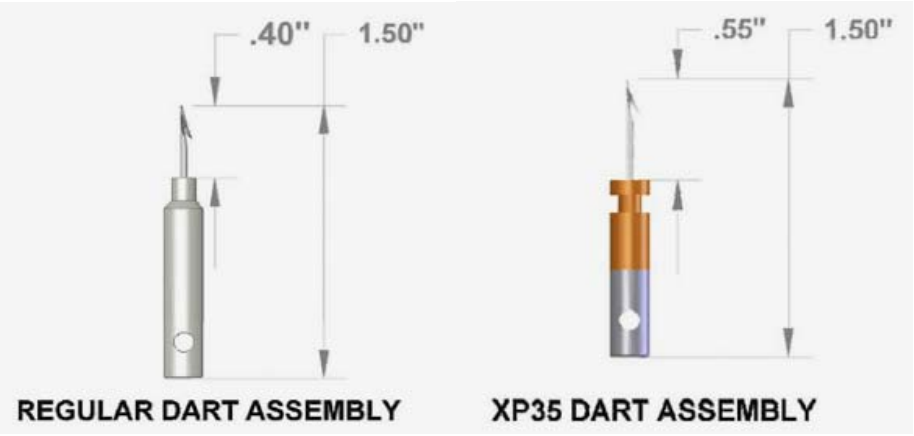

Figure 2: Taser® Darts (with permission, Taser International, Inc.)

At the federal level, the Bureau of Alcohol, Tobacco, Firearms, and Explosives does not classify the Taser as a firearm (18 U.S.C. § 921), because it expels the probes by means of compressed gas cartridges as opposed to an explosive (GAO Publication No. GAO-05-464, 2005). State and local law, however, can vary. For example, in the state of Indiana, they are subject to the same legal applicability of handgun provisions (Ind. Code Ann. § 35-47-8-4).

C. SIGNIFICANCE:

Taser use is common, yet controversial. According to the manufacturer, more than 11,000 law enforcement, correctional, and military agencies in 44 countries deploy Tasers with a history of over 83,000 field usages (Taser International, Inc., 2007). Unfortunately, many dissatisfactory clinical outcomes have resulted in individuals subjected to the Taser, including death. For example, one relatively recent case that has received widespread media attention involved a 40 year-old Polish immigrant who died shortly after being subjected to Taser discharge by the Royal Canadian Mounted Police at the airport in Vancouver (Austen, 2007).

This has led many to question the safety of their use. For example, in its position paper on Tasers, the University of Illinois' Police Training Institute (PTI) cited numerous articles questioning Taser safety in major national newspapers including the Arizona Republic, New York Times, and Chicago Daily Herald (Stearns, et al., 2004). Prior to the purchase and deployment of Tasers by the San Francisco Police Department, the American Civil Liberties Union (ACLU) of Northern California requested that they "only allow tasers to be used as an alternative to deadly force…" citing concerns about safety and instances of proximate death (ACLU, 2004). Furthermore, because of these safety questions, Amnesty International USA (2006) issued recommendations to "Suspend all transfers and use of tasers and other electro-shock weapons pending a rigorous, independent and impartial inquiry into their use and effects. p28"

It is interesting, given the ballistic nature of the barb discharge and high voltage electrical energy conducted, that law enforcement Taser policies can vary considerably with respect to post-incident medical care for the subject prior to detainment. Some agencies do require the subject to undergo a medical evaluation, but this is not universal. In some municipalities the evaluation can be conducted by Emergency Medical Services (EMS, i.e. a paramedic) while in certain instances other policies may direct that the officer proceeds to an emergency department for physician evaluation. Some policies leave the decision of professional medical evaluation solely to the on-scene officer's discretion, even allowing barb removal and wound care to be completed by the officer. In such cases, an individual subjected to a Taser discharge might not receive any clinical evaluation. The manufacturer does not endorse mandatory clinical evaluation guidelines,

and recommends leaving the decision to the on-scene officer's discretion (S. Tuttle of Taser International, Inc., personal communication, November 30, 2007).

This naturally begets the question as to which Taser subjects, if any, should be evaluated by a physician? Certainly, because of the high-energy nature of the device and electrical discharge to the individual, one can conceive that some types of individuals could be a higher risk for death, adverse outcome, or other dissatisfactory clinical sequela following employment of the Taser. Does the current body of medical literature identify who is "high risk," and should policies mandate that these individuals be evaluated by a physician? Would such recommendations increase public safety with respect to Tasers?

This report will assess the disparity in national police policies regarding the post-incident disposition of Taser subjects. It will also systematically review the existing published medical literature concerning the human effects of Tasers in order to discern the delineation of subjects at risk for adverse outcome. Policy changes that recognize the delineation of "high-risk" groups and facilitate post-incident clinical evaluation for them may increase public safety with respect to Tasers.

CHAPTER 2: DATA AND METHODS

There was no primary data collected for this project, and no individual was subjected to the discharge of a Taser. To address the first aim, there are no centralized "Medline-equivalent" databases in which to systematically search for law enforcement Taser policies. Standard web searches were conducted using the "Google Advanced Search" search engine for English language websites using keyword combinations and permutations with the intent of obtaining multiple Taser policies from national level police and law enforcement organizations When possible, policies reviewed online were often followed up for clarification with personal communication. In most instances, local police forces and municipalities adopt and use these national recommendations to develop their own policies and protocols.

Guidelines and polices were obtained from the United States, and two other western countries, Canada and the United Kingdom, to serve as comparisons. Specifically, the manner and degree of freedom afforded officers to adjudge which individuals, if any, must undergo a formal clinical evaluation after Taser employment to determine physical safety was determined.

For the second aim, a National Library of Medicine Medline database search was conducted from years 1950 to August 2007 restricted to English-only language articles. In the absence of a specific subject heading for this topic (and at the advice of research librarians consulted), multiple keyword searches were conducted with the ".MP" field designator addition for title, original title, abstract, name of substance word, and subject

word heading. These searches were conducted using the keywords “Taser” (using TASER$), “conducted energy weapons” (using CONDUCT$ adj ENERGY adj WEAPON$), “nonlethal force” (using NONLETHAL adj FORCE$), and “neuromuscular incapacitating device/weapon (using NEUROMUSCULAR adj INCAPACITAT$ adj (weapon or device)). This search yielded a total of 31 articles. In some cases, further literature was obtained and reviewed from the references listed in the aforementioned original articles obtained. A complete list of all medical articles, technical reports, and scientific assembly presentations can be found in the reference section.

The third aim entailed the development of clinically based guidelines for policy development. This necessitated the synthesis of the published medical literature into generic recommendations for the development of policy or algorithms for the safe clinical evaluation of “high-risk” individuals subjected to Tasers.

CHAPTER 3: RESULTS

A. LAW ENFORCEMENT POLICY AND GUIDELINES:

With increased interest in "less-than-lethal" weapons by law enforcement agencies and increased Taser use, the US Government Accountability Office (GAO) issued a 2005 report on Taser weapons (GAO Publication No. GAO-05-464). This report reviewed seven Taser-related state and major metropolitan law enforcement agency policies and procedures. These agencies were selected because they were identified as agencies that had purchased the largest number of Tasers and had employed them in field conditions for the longest period of time as compared to their contemporaries. They included Austin, Texas, Police Department; Ohio Highway Patrol; Orange County, Florida, Sheriff's Department; Phoenix, Arizona, Police Department; Sacramento, California, Police Department; Sacramento, California, Sheriff's Department; and the San Jose, California, Police Department.

Included in the protocols under review were post-incident procedures for officers. Not one of the agencies surveyed required an emergency room visit post-incident, unless the probe impacts the subject's face or neck (Orange County Sheriff's Department also requires for any female shot in breast or groin). Furthermore, barb removal was at the officer's discretion in six of the seven agencies meaning that it could be accomplished by the officer in the field without the subject being seen by a physician or even a paramedic. According to these policies, an individual could be subject to a Taser discharge, and

never given the opportunity to receive any medical evaluation per the on-scene officer's discretion.

In 2006, the U.S. Department of Justice Office of Community Oriented Policing Services (COPS Office) sponsored a study conducted by the Police Executive Research Forum (PERF) on conducted energy devices with focus on the creation of national policy and training guidelines (Cronin, et al., 2006). The PERF is a national organization of police executives from large state, city, and county police agencies that focuses on "improving policing and advancing professionalism through research and involvement in public policy debate." (PERF, 2007). Their Conducted Energy Device (CED) Guidelines for Consideration included the following with respect to post-incident medical care (Cronin, et al., 2006, p23):

> "When possible, emergency medical personnel should be notified when officers respond to calls for service in which it is anticipated that a CED may be activated against a person."
>
> "All persons who have been exposed to a CED activation should receive a medical evaluation. Agencies shall consult with local medical personnel to develop appropriate police-medical protocols."
>
> "All persons who have been subjected to a CED activation should be monitored regularly while in police custody, even if they received medical care."

These guidelines seem to mandate, at minimum, EMS involvement when Taser use is anticipated. In suggesting that all subjects receive a "medical evaluation," there is no directive as to who can provide this evaluation (officer versus paramedic versus physician) or detail on exactly what it should comprise (officer's basic first aid evaluation

versus physician's detailed clinical exam). The national policy, in this case, defers to locally developed protocols.

The United Kingdom, by contrast, is more comprehensive with respect to the clinical evaluation of Taser subjects. Graham Smith of the Home Office Scientific Development Branch (HOSDB) notes that "persons subjected to TASER are seen by a Force Medical Examiner at the very least." (personal communication, November 20, 2007). A Force Medical Examiner, also known as a Forensic Medical Examiner, is a physician (usually a general practitioner) attending at the police station. The HOSDB has sponsored Taser-related studies and collects information and maintains records with respect to Taser injuries and adverse medical outcomes.

Police forces in the UK employ Tasers according to joint policy and operational guidance from the Association of Chief Police Officers (ACPO) based on HOSDB recommendations. ACPO is an independent strategic body that "leads and coordinates the direction and development of the police service in England, Wales and Northern Ireland" (ACPO, 2007a). Overseeing and working in partnership with policing organizations, ACPO issued operational guidance in its "Operational Use of Taser by Authorised Firearms Officers" stating "appropriate post incident procedures will be implemented depending on the nature of the injury or harm occasioned." (ACPO, 2007b). ACPO mandates clinical evaluation and care as follows (ACPO, 2007b, p16-17):

> "Unless there is an operational necessity no attempt should be made by officers to remove the barbs which have penetrated the skin. This should only be done by a medical professional…" (Section 11.3)
>
> "Where officers are informed or come to believe that a person to whom the Taser had been applied has a cardiac

> pacemaker or other implanted device in place, immediate referral should be made to the hospital. Similarly, if the subject is found to have any other pre-existing medical condition that might lead to increased medical risk immediate referral to a hospital should be considered." (Section 11.6)
>
> "All arrested persons who have been subjected to the discharge of a Taser, must be examined by a Forensic Medical Examiner as soon as practicable." (Section 11.7)
>
> "Close monitoring of a subject throughout the period following application of the Taser is of utmost importance." (Section 11.8)

With respect to Canada, there is no national policy or consensus regarding paramedic or physician evaluation following employment of the Taser according to Dr. John Butt, a forensic pathologist (personal communication, November 28, 2007). Dr. Butt was a member of the medical review panel reviewing conducted energy weapons on behalf of British Columbia's Office of the Police Complaints Commissioner (Battershill, et al., 2005). As an example of a Canadian policy that is widely prevalent, Dr. Butt suggested reviewing that of the Royal Canadian Mounted Police (RCMP), a national agency of the Ministry of Public Safety with a significant number of local policing contracts throughout the country (RCMP, 2007). The RCMP Conducted Energy Weapon (CEW) policy defers to on-scene officer discretion with respect to post-incident clinical evaluation for Taser subjects (Inspector T. Lightfoot and B. Zanin of the RCMP, personal communication, December 20, 2007):

> "Ensure the individual receives medical attention if any unusual reactions occur or if you think that he or she is in distress." (Section 5.2)
>
> "If the CEW was used…, a member currently certified in first aid may remove the probes. It is not necessary to have a medically trained person examine the individual, unless a

> probe is lodged in a sensitive part of the body, such as the eye or the groin, or the individual's physical condition warrants medical attention." (Section 5.3)

As a result of deaths and growing public concern associated with Taser use, the Canadian Association of Chiefs of Police (CACP) solicited the Canadian Police Research Centre (CPRC) for a comprehensive review of safety. The review culminated in a technical report outlined with respect to medical safety, police policy considerations, and a special section addressing "excited delirium," a special medical state thought to be a significant factor in Taser deaths (Manojlovic, et al., 2005). The policy section does speak to medical considerations with respect to decisions to employ the device, but does not address post-incident clinical evaluation.

Excited delirium is not a specific diagnosis, but a clinical state of many potential etiologies characterized by agitation, altered consciousness, and loss of cognition and perception according to the CPRC report. In this section, under "interventions to potentially lessen the risk of death," is the following recommendation (Manojlovic, et al., 2005, p43):

> "…after successful physical restraint of an individual in the field is the best time to involve prehospital care practitioners in an attempt to mitigate subject risk. Police officers should be trained to recognize that acutely agitated persons are suffering from a medical emergency, and that EMS involvement is warranted as early as possible in the restraint process. Notification of EMS for dispatch prior to actual physical engagement with the subject may be the most rational policy."

As of November of 2007, the CACP has again solicited the CPRC to undertake a "comprehensive review of, and conduct additional research on, the use of Conducted

Energy Devices (CEDs)—more commonly known as Tasers—to provide a national perspective on the safety and use of the devices." (CACP, 2007). Along with many other objectives, this study by the CPRC will be reviewing the range and disparities of Taser-related policies across the country (S. Palmer of CPRC, personal communication, December 15, 2007).

In summary, there is heterogeneity with respect to the post-incident clinical evaluation of Taser subjects. The United Kingdom adopts the most conservative position mandating that all subjects, at a minimum, be evaluated by a physician, and even specifying certain medical conditions that warrant immediate hospital evaluation. Canada does not have a national policy, but does acknowledge concerns with respect to medical safety and policy disparity across the country. It is currently engaged in policy review at its national police research center, the CPRC. The United States recommends a "medical evaluation," but is not specific as to the professional expertise qualified to perform this deferring to locally developed police-medical protocols. Only the UK delineates subgroups which may warrant special clinical attention (e.g. cardiac pacemakers), and mandates that these individuals are handled differently with respect to post-incident care.

B. HUMAN EFFECTS:

Incontrovertibly, Tasers possess the ability to harm, and the clinical effects and physical injuries can vary considerably. Early in their use, Koscove (1985) and Ordog, et al. (1987) began to prepare the medical community about the untoward effects of Tasers citing multiple possible clinical considerations including ballistic output and dart penetration, cardiac arrhythmias, respiratory arrest, burns, rhabdomyolysis, and others.

Other case reports citing the untoward effects of Tasers have included a case of miscarriage (Mehl, 1992) and even testicular torsion (Ordog, et al., 1987). In one bizarre case of Taser-associated morbidity, the subject actually purposefully ingested a dart immediately following the police confrontation (Koscove, 1987). Fearing death, his stated motive was to "prove" on autopsy that it was the police that killed him. He uneventfully passed the dart on day four of hospital observation.

Actually, many police policies regarding Tasers recognize a delineation of certain vulnerable populations, recommending that the device not even be employed in such instances (e.g. Cronin, et al., 2006 and Manojlovic, et al., 2005). These include young children, pregnant women, elderly persons, the visibly frail, those immersed in flammable substances, and those at risk from falls from height after incapacitation. The medical literature on human effects is far from complete (e.g. 31 articles from a National Library of Medicine Medline database search), but can generally be sorted into the following three major clinical categories: ballistic injury and secondary falls, cardiovascular and respiratory effects, and metabolic effects.

1. Ballistic Injury and Secondary Falls:

The implement itself is a ballistic discharge device, and naturally injury can result from direct trauma via the projectile probes or secondary falls after incapacitation. With respect to ballistic output, the relatively low discharge velocity (170-180 feet per second) and small dart mass makes the kinetic energy departed (mass x velocity^2) rather small, especially compared to firearms. Many have labeled the device a ballistically low-energy weapon (e.g. Koscove, 1985). In contrast to this low-energy assessment, however, Rehman and Yonas (2007) did report a case of a 16 year-old who presented with a Taser

dart impacted deeply into the forehead. This was subsequently found to have violated the cranial vault and penetrated the dura into the brain requiring neurosurgery. Attempted barb retrieval on behalf of an officer in the field could have been disastrous in this case as the authors noted.

Yet, even given a low kinetic energy rating, some body areas still remain vulnerable to low-energy missiles (especially sharp and barbed), and penetrating injuries have occurred with Tasers (e.g. Dearing, et al., 2005). Historically, significant proportions (65%) of field use discharges have, indeed, penetrated the skin (Nanthakumar, et al., 2006). Conceivably, areas with thin skin and little subcutaneous fat with critical underlying structures (e.g. vital neurovascular structures in the neck) may remain vulnerable. In looking at stab wounds, for example, Bleetman, et al. (2000) studied 25 volunteers looking at minimum skin-to-organ distances (kidney, spleen, liver, pericardium, and pleura) finding the most accessible organs lie only 1cm (0.39in) beneath the skin in the thinnest individuals in erect position; the XP35 dart can penetrate 0.55in. Bozeman, et al. (2007) performed a large, multicenter cohort study of 962 Taser cases over a two-year period characterizing injuries associated with their use. Cases, although uncommon, of hemo-pneumothorax and hepatic and splenic laceration were recorded. In 2.5% of cases, the barb impacted the head, face, neck, or genitalia.

Another obvious concern includes the eye, and perforating ocular injuries have been reported (Chen, et al., 2006 and Ng, et al., 2005). Chen also notes that the long-term affects of high-voltage application to the globe remains unknown. In its analysis of the Taser, the US military's Joint Non-Lethal Weapons Human Effects Center of

Excellence (HECOE, 2005) determined the probability estimates for eye strikes to be quite low at 0.04% depending on distance from the target.

The very nature of the device's intended physiologic response, neuromuscular incapacitation through skeletal muscle tetany, presents the possibility of unprotected falls. In the Bozeman, et al. study (2007), contusions (10%), soft tissue injury (0.5%), fractures (0.5%), and a case of severe head injury were reported, though it is unclear if these were the direct result of fall versus another mechanism. In reviewing a law enforcement database, the US military's Joint Non-Lethal Weapons Human Effects Center of Excellence (HECOE, 2005), reported a fall injury rate of only 0.2%, but these were not stratified by clinical significance.

2. Cardiovascular and Respiratory Effects:

A natural concern regarding the human effects of Tasers is that of cardiac vulnerability, particularly to the physiologic electrical pathways, and respiratory embarrassment or arrest. Furthermore, it is certainly plausible that individuals with preexisting cardiovascular comorbid conditions might be at a higher risk for poor outcome status post Taser employment given the high electrical voltage discharged to incapacitate the subject. In his extensive review of medical management of civil unrest trauma, Ballantyne (2006) points out that Tasers should not be considered safe for use against individuals with cardiac disease, especially those prone to arrhythmias. Likewise, it also seems plausible that if an individual is under the influence of cardiotoxic drugs (e.g., cocaine, phenylcyclohexylpiperidine (PCP), amphetamines), this may result in higher likelihood of death or adverse sequela.

Autopsy studies have been suggestive of an adverse association with cardiac disease and cardio-toxic drugs. One case series study of 37 autopsy reports in Taser-related deaths found cardiovascular disease in 54.1% and illegal substance toxicology screens in 78.4% of cases (Strote and Hutson, 2006). The authors note that the rates of cardiovascular disease were significantly higher than that of the general population, and especially for this cohort with a mean age of 35.6 years. Kornblum and Reddy's (1991) review of 16 Taser-related deaths showed all but three were under the influence of sympathomimetic drugs (specifically cocaine, PCP, and/or amphetamine).

Autopsy studies, however, cannot demonstrate causation, only a temporal relationship. Furthermore, Allen (1992) notes that such studies are often lacking specifics that would prove helpful in more completely assessing this association including location of the Taser strikes, number and duration of shocks, actual drug concentrations, immediate versus delayed resuscitation, other comorbid conditions, etc.

Ordog, et al. (1987) conducted a prospective descriptive case series comparing Taser and gunshot wound patients presenting to a large city medical center. Of 218 Taser patients, the majority of these patients had a PCP toxicological profile including 86% reporting same day use and 70% with positive serum levels. There were three deaths—all with high levels of PCP and one with a history of cardiac disease. All three presented in delayed asystole beginning 5, 15, and 25 minutes following the Taser event, respectively. Almost half of the subjects were dispositioned into the hospital system (medical, psychiatric, and coroner) rather than to home or police custody, though the author notes the majority of medical issues resulted from preexisting disease and/or violence and intoxication associated with the conditions that led to the police involvement. In

commenting on this study, Fish and Geddes (2001) note that it is unlikely in the three deaths, given the delay between employment of the Taser and cardiac arrest, that immediate induction of a dysrhythmia from the Taser occurred. Still, they call for examination of methods for stratifying those at risk for respiratory or cardiac arrest with Tasers.

Despite the early results of Ordog, et al. (1987) showing a delay from Taser use to asystole, direct induction of malignant dysrhythmias secondary to electrical discharge has remained a concern. There have been some studies to further determine this plausibility. While the device can generate 50,000V, current is a function of both voltage and resistance. O'Brian (1991) notes that dry skin resistance varies between 100,000 and 300,000 Ohms, and the manufacturer reports an average current imparted of 3.6 mAmps for the M26 and 2.1 mAmps for the X26 (Taser International, Inc., 2007). The threshold for ventricular fibrillation is thought to be on the order of 50-100 mAmps (Lutes, 2006).

McDaniel, et al. (2005) furthered this argument on nine anesthetized (isoflurane) porcine models (average weight of 60 kg) with a device mimicking the wave-form output of the Taser X26, but capable of delivering escalating electrical output. External barbs were placed at the sternal notch and anterolateral thorax for maximal transthoracic flow. In this study, fibrillation was not induced until a minimum of 15 times the standard discharge of the Taser device was applied. This threshold was found to be weight dependent (lower weight requiring less energy) and ranged from 15 to 42 times that of the police X26 model Taser as weight of subjects increased from 30 to 117 kg.

Sztajnkrycer (2005a) noted several issues, however, with respect to how generalizable the results of this study might be. Concerns included the appropriateness of

a swine model to predict human cardiac physiology, the issue of a "custom device" instead of using an actual Taser model, and finally that the pigs were maintained under general anesthesia which likely blunted sympathetic response to the shocks. One interesting correlation demonstrated, though, was the relationship of energy to the test subject's weight with smaller weights requiring less energy to induce fibrillation.

A later study (Nanthakumar, et al., 2006) found discordant results. It also studied the risk of dysrhythmias in porcine models (45-55 kg), but with the actual Taser device (both M26 and X26 models). Six anesthetized (ketamine and isoflurane) pigs were subjected to Taser shocks in both transthoracic and non-transthoracic vectors, but the cardiac consequences in this case were measured using shielded intracardiac catheters (right ventricle and coronary sinus) rather than surface EKG leads. In 94 transthoracic discharges, 74 resulted in myocardial stimulation with capture (324 +/- 66 beats/min) while none of the non-transthoracic discharges resulted in stimulation. The authors also simulated "adrenergic stress" by means of introducing epinephrine (to achieve 50% increase in heart rate) in 16 additional transthoracic discharges (13 stimulated the myocardium) with one resulting in ventricular fibrillation and one resulting in ventricular tachycardia (postulating an R-on-T phenomenon with discharges occurring during the vulnerable T-wave).

In this study, electrical and mechanical capture of the heart ensued in a majority of transthoracic flow discharges, while those vectored away from the chest did not. The authors suggest the possibility of serious dysrhythmias during catecholamine stress and noted that the risk of arrhythmia would be greater for those with structural heart disease,

especially electrophysiological. They also noted that central sympathetic response in the test animals was likely blunted due to use of anesthesia.

However, the adverse effects of cardiotoxic drugs with respect to Taser application have not been universally demonstrated. Lakkireddy, et al. (2006) also used a porcine model to study the effects of cocaine intoxication with respect to ventricular fibrillation thresholds secondary to Taser discharge. Using a custom built device matching the electrical output and waveform discharge of the Taser X26, five adult anesthetized (ketamine, isoflurane, and nitrous oxide) pigs (25.3-42.7 kg) were tested at five different body locations before and after cocaine infusion (8 mg/kg). Interestingly, cocaine was actually found to have a protective effect requiring a 50 to 100% increase above baseline in the threshold required to produce fibrillation suggesting decreased cardiac vulnerability. Consistent with other studies, they found transthoracic flow to require the lowest fibrillary thresholds with increased distance from the heart requiring higher thresholds.

While the manufacturer reports more than 610,000 human volunteers subjected to Taser discharge to date (S. Tuttle of Taser International, Inc., personal communication, December 17, 2007), large numbers of controlled human studies are lacking. Taser, International uses this human volunteer data to support its safety, though certainly selection bias (Gordis, 2004) must be considered. These individuals are likely healthy (most were active police officers), presumably without significant heart disease, and without acute illicit drug intoxication or prior prolonged physical struggle.

Levine, et al., (2007) studied 105 police subjects voluntarily subjected to the X26 Taser. Subjects had continual EKG monitoring before, during, and after exposure with

mean shock duration of 3.0 sec. (range 0.9-5 sec.). Subjects were noted to develop increased heart rate (mean increase 15 beats/min) with no subsequent cardiac dysrhythmias or morphologic changes noted. Measurements of cardiac cycle intervals (PR, QRS, and QTc) were unavailable due to artifact obscuring waveforms and significant intra-observer variability.

The authors acknowledge limitations of small cohort, single-lead EKG data only, lack of monitoring of late events, and that the cohort was probably not representative of the population with whom Tasers are likely employed in field usage. The mean shock duration was less than the 5 second cycle of a field use and the darts were directed at the subjects' back, unlike a face-to-face field confrontation. Nanthakumar, et al., (2006) also notes that such surface electrical measurements are unlikely to capture true cardiac stimulation (as in their porcine model study) during the event due to electromagnetic interference.

In another prospective human volunteer study, Ho, et al. (2006) monitored 66 subjects for a 24-hour period following a full 5-second X26 model Taser application. The study included serum analysis for electrolytes, blood urea nitrogen (BUN) to creatinine level (as a marker of renal function), lactate, creatine kinase (CK), myoglobin, and troponin levels (as markers of skeletal and cardiac muscle injury). Levels were measured at baseline, immediately following, and at 16 and 24 hours post-incident. A subset of 32 also included a 12-lead EKG at each of the four study points.

This study found no significant change from baseline in electrolyte levels or BUN/creatinine ratio. Increases above baseline were noted for the following: CK at 16 and 24 hours (23.9% and 32.2% respectively), lactate immediately following (66.9%),

and myoglobin immediately and at 16 and 24 hours (34.1%, 36.3%, and 64.0% respectively). Thirty of 32 EKGs were normal; the two interpreted as abnormal were the same at baseline (one with left ventricular hypertrophy and the other with occasional sinus pause). Troponin values all remained normal with the exception of a single subject at 24 hours (who reported a vigorous aerobic workout three hours prior to the exposure). This was subsequently extensively evaluated with a hospital cardiologist including repeat normal levels and normal treadmill and profusion studies. There was no evidence of myocardial infarction, and the authors posit explanations of spurious lab value, delayed clearance related to baseline physiology, or idiopathic etiology.

The authors purport advantages over other controlled prospective human studies reporting that the cohort received a full 5-second application and was more 'representative' of the general population (reporting heterogeneity of the subjects' medical histories including obesity, hypertension, hypercholesterolemia, type II diabetes, and even three subjects with histories of previous myocardial infarction, congestive heart failure, and a history of transient ischemic attack). The device was applied to the back unlike a field frontal application, and metabolic changes were, indeed, noted. The authors reported no induced dysrhythmias, but subjects were not continuously monitored throughout the study.

In a separate study on human volunteers, Ho, et al. (2007), assessed respiratory function following application of the X26 model. Fifty-two subjects underwent successive Taser applications: 34 received a 15-second application while 18 received three 5-second. applications with electrodes positioned for transdiaphragmatic flow. Measurements were taken for tidal volume, respiratory rate, and end-tidal oxygen and

carbon dioxide. The authors documented small mean increases in respiratory rate, tidal volume, and end-tidal oxygen with decreases in carbon dioxide during the exposure window, but determined these to be statistically and clinically insignificant stating that the application did not impair respiratory parameters in the conclusions. As with other human studies, the author notes limitations of a non-representative cohort of presumably healthy police officers in a non-representative scenario absent of drug intoxication, physical exertion, etc.

No studies were found assessing Taser safety with respect to cardiac pacemakers. Haegeli, et al., (2006) does present a case report of a 51 year-old, 75 kg female subjected to an M26 Taser model due to violent behavior with dart impact to the sternum. She presented for regular follow up two months after the incident, and interrogation of the pacemaker device revealed that it had interpreted the electrical activity of the Taser as ventricular fibrillation. The device charged for shock, but the energy was diverted with no shock ultimately delivered. In this case, the reconfirm function no longer sensed the fibrillation electrical activity, presumably due to cessation of the Taser, and the shock was aborted. Furthermore, investigation failed to show any damage or detrimental alteration to the device, leads, or circuitry.

3. Metabolic Effects:

High voltage application to the body with intense, sustained tetany-like skeletal muscle contraction can certainly have untoward metabolic effects on the body. Fish, et al. (2001) posits that the Taser may affect acid-base balance through rapid skeletal muscle contraction contributing to acidosis, and this could certainly prove to be subsequently pro-arrhythmogenic, especially in a PCP or cocaine toxic individual.

One porcine model study demonstrated significant blood metabolic acidosis and electrolyte disturbances following repeated applications of the Taser X26 (Jauchem, et al., 2006). Using anesthetized (propofol) pigs (49.5-58.0 kg), the authors used 5-second Taser X26 exposures in succession (5-second on, 5-second rest) for three minutes with transthoracic flow with measurements at time zero, 30 minutes, and 60 minutes. They reported small but significant rises in potassium, but noted that these were comparable with studies involving vigorous exercise, and deemed this of unlikely clinical relevance. Lactate was consistently significantly elevated and pH showed consistently significant acidosis at all points in time (nadir of 7.0) post Taser applications. No ventricular fibrillation was observed via external monitoring, though the author does concede that acidosis is known to lower fibrillation thresholds.

In commenting on this study, Miller (2007) notes that the findings of lactic acidosis and hyperkalemia shown in resting, anesthetized pigs would likely be additive and potentially of even greater clinical significance in a true field application. He notes that Taser subjects are often engaged in prolonged violent struggle and considerable physical exertion immediately prior to use of the device. This activity alone can cause similar metabolic derangements, and these are likely to be compounded by effects of application of the Taser.

In the Ho, et al. (2007) study mentioned previously, the authors did note metabolic changes including increases in CK, lactate, and myoglobin, but there was no evidence of electrolyte abnormality (including hyperkalemia), BUN/creatinine ratio, or acidosis (bicarbonate remained largely unchanged). While they reported no adverse sequela in the test subjects, the authors do note limitations that the subjects were at rest

(no prolonged physical struggle), there were no multiple applications of shocks (as is sometimes the case in field use), the subjects were without psychiatric history or psychotropic medication, and no one was acutely sympathomimetic toxic from drugs. Such circumstances or comorbid conditions could potentially cause the metabolic changes noted in the test subjects to be of significant clinical consequence and contribute to adverse outcomes.

The subject of "excited delirium" has been the topic of much concern regarding Taser-related deaths. Excited delirium does not constitute a specific diagnosis, but rather a clinical state or spectrum of many possible etiologies. Hallmarks of this state include cognitive dysfunction with agitation, tachycardia, hyperthermia, and metabolic acidosis (Lutes, 2006). It is often associated with acute drug toxicity (especially PCP and cocaine), and is clinically similar to neuroleptic malignant syndrome with derangement of dopamine receptors (Ross, 1998; Wetli, et al., 1996).

Unfortunately, individuals in varying degrees of this state are often the very ones subjected to Tasers as a means to physical restraint as they are often acting in a bizarre fashion, exhibiting agitation, aggression, and severe cognitive impairment (Manojlovic, et al., 2005). For example, in Kornblum and Reddy's (1991) Taser related autopsy series, subjects in every case had been behaving in a bizarre fashion necessitating police involvement. Strote and Hutson's (2006) autopsy case series of Taser-related deaths noted that 75.7% of cases were specifically given a diagnosis of excited delirium by the medical examiner. The Ordog, et al. (1987) case series showed 76% were subjected to the Taser secondary to bizarre and uncontrollable behavior.

The concept of excited delirium and its relationship to sudden, unexpected death is not new and is not solely related to Taser phenomenon. It was first described in 1849 with respect to psychiatric patients who developed hyperthermia, agitation, mania, and sudden death after collapse (Sztajnkrycer, et al., 2005b). It was also known as Bell's mania, lethal catatonia, and acute exhaustive mania (Ross, 1998). It has since been discussed within the context of cocaine and other illicit drug intoxication, physical restraint, and deaths in-custody (e.g. Sztajnkrycer, et al., 2005b; Stratton, et al., 2001; Ross, 1998; Wetli, et al., 1996).

In reviewing 18 cases of excited delirium-related sudden deaths (five Taser related), Stratton, et al. (2001) notes common themes of acute stimulant drug toxicity (78%) and existing heart disease (61%) with every case involving observed struggle against force (with high potential for metabolic acidosis). Ross (1998) likewise reviewed 61 cases of excited delirium decedents. Again, every case was associated with physical struggle, and the majority was associated with acute cocaine toxicity.

Wetli, et al. (1996) and Ross (1998) note that identification of the actual "cause" of death is extremely difficult in these cases with, almost invariably, multiple contributing factors involved. These do, however, generally follow a predictable course involving hyperthermia and agitation followed by cognitive dysfunction/psychosis and varying degrees of violence with very high pain thresholds. This is generally when police forces become involved whereby a physical, violent struggle often ensues. The final stages are marked by acidosis and metabolic derangement with high adrenergic tone and catecholamines, respiratory embarrassment/arrest (often with positional restraint), and sudden death.

Certainly, one could imagine that such individuals exhibiting signs of excited delirium would potentially be subjected to a Taser as a means of incapacitation. In these cases, the Taser use may be proximate, but death may have been the inevitable result regardless of its use. Or, the physiologic affects of the Taser—even minor—may have been synergistic or contributory enough in an already precarious clinical condition ultimately leading to death. One could say the same for police intervention in other cases of excited delirium including a protracted physical struggle or positional restraint. What is clear is that such persons with excited delirium require medical intervention and aggressive supportive care including volume support, cardiac and respiratory monitoring, correction of electrolyte imbalances, adequate cooling, and benzodiazepines (Lutes, 2006).

4. Existing Clinical Post-Incident Recommendations:

Review of the clinical literature clearly suggests that the safety profile of Tasers is not unassailable. The fact that some authors and clinicians have called for a uniform approach to clinical evaluation, is juxtaposed to the policing community which allows, in some cases, wide officer discretion in medical disposition. As an example, Koscove (1988) recommends performing an EKG on all Taser patients, and admission for monitoring if dysrhythmias are present. Lutes (2006) recommends a thorough physical examination looking for signs of injury noting that Taser-persons invariably fall, and often are not in a state to break or mitigate their fall. He posits routine EKGs are not necessary, provided patients exhibit no signs of excited delirium. For cases of excited delirium, treatment is outlined as previously mentioned.

Bleetman, et al. (2004) recommends consideration to important points of medical history including cardiac disease, implantable defibrillator, pregnancy, drug intoxication, bizarre behavior at time of incident, and history of psychiatric disease. Physicians should pay particular attention to barb locations and signs of secondary trauma, and perform EKGs for chest pain, palpitations, or cardiac history.

In developing a systematic step-wise approach to Taser patients for EMS personnel, Whitehead (2005) readily admits, "Most of the tased individuals you evaluate will need to be transported to the emergency department (ED)." He also advocates the importance of medical and incident history in determining medical disposition. He calls for transport in all cases with evidence of excited delirium, abnormal vital signs, findings consistent with drug use, cardiac history, altered consciousness or aggressive behavior, hyperthermia, and subjective complaints of chest pain, shortness of breath, nausea, or headaches. He further recommends continual cardiac monitoring and supplemental oxygen for all Taser transports.

C. SUMMARY OF HUMAN EFFECTS:

Tasers do possess the ability to harm. The human effects of such devices, as published in the medical literature, can generally be categorized into three related divisions: ballistic injury and secondary falls, cardiovascular and respiratory effects, and metabolic effects. Studies are summarized in Appendix A minus articles with sole content of commentary, discourse, or exposition.

Although of relatively low kinetic energy, the discharged barbs can cause harm. Literature is restricted to isolated case reports for ocular penetration, and cases of damage

to underlying organs or vital structures shallow to the skin are likewise scarce. Neuromuscular incapacitation can result in unprotected falls, though the clinically significant injury rate is relatively low.

The cardiovascular and respiratory effects of Tasers remain unclear, and studies have yielded inconsistent results. One concern is that of direct induction of malignant dysrhythmias. One porcine model study demonstrated this possibility with electro-mechanical cardiac capture using invasive monitoring techniques. However, most authors have argued against this with another porcine study and two human studies in healthy populations demonstrating a lack of causation. Furthermore, the manufacturer reports well over one-half million human volunteers safely subjected to Taser discharge. Of more concern is the possibility of death or adverse outcome in individuals with a pre-existing pro-arrhythmogenic state including cardiovascular disease, drug toxicity, and acidosis. Autopsy studies have shown a high association with cardiovascular disease and positive toxicology screens, but a porcine model study failed to demonstrate this.

Metabolic derangements have been demonstrated in both human and porcine model studies, but the clinical significance of these is uncertain. Many have posited that these may be of particular concern in the context of excited delirium, a complex clinical state characterized by significant metabolic derangement in and of itself. This is plausible in light of the shortcomings of controlled human studies and large number of volunteer applications—they are not representative of the excited delirium cohort likely to be the actual recipients of a Taser discharge in the field.

CHAPTER 4: CONCLUSIONS

A. CLINICAL LINK TO POLICY:

It has been purported by many that the Taser has many operational benefits including successfully de-escalating violent situations, reducing the risk of harm to officers and individuals, and providing a safer alternative to firearms (e.g. Bozeman, et al., 2007; Jenkinson, et al., 2006; Lutes, 2006). This study does not address the suitability of employment of the device, and assessments of the efficacy of Tasers with respect to other nonlethal police means has been examined elsewhere (e.g. Jenkinson, et al., 2006; ACPO, 2004). The intent of this project is to determine if the clinical literature supports the delineation of "high-risk" individuals with the inference that public safety may be increased if policies mandated post-incident clinical evaluation for such individuals.

Since it is universally accepted that Tasers do possess the ability to harm, the most conservative policy approach would be for all subjects to receive, at least, a comprehensive clinical evaluation from a medical professional. This has been successfully argued in other contexts of risk threshold. For example, in some trauma center catchment areas, protocols mandate that any persons involved a high-speed vehicle accident will be transported to an emergency department for evaluation. Such a disposition protocol is based on a threshold risk of injury patterns (overt or occult) regardless of accident circumstances (e.g. rollover, head-on, etc.), patient complaint, demographics, etc. It is universally applied simply due to injury potential given such a high-energy collision. There is, indeed, injury potential for an individual subjected to

the discharge of Taser. This position has been adapted by the U.K. with respect to Tasers, and is understandable given the paucity of scientific literature and comprehensive understanding of the true human effects of such devices. It is also, perhaps, the most ethically sound position—*primum non nocere*. If risk of harm exists, then these individuals deserve a clinical evaluation to exclude or treat injury.

Others may argue that such a sweeping approach unnecessarily consumes time and resources. It should be noted that we, as a society, already leave many critical decisions regarding a whole host of disposition issues to capable and well-trained field police officers. Proponents of this position may argue that efforts should focus on a more specific or stratified risk-analysis with respect to which subject receives a post-incident physician evaluation. It is within this context of identifying individuals that are "high-risk" for adverse sequela and poor clinical outcome that the following recommendations are made based on the existing scientific literature. Realize, however, that there are flaws in the existing research and major gaps in knowledge about the effects of Tasers. Subsequently, all recommendations based on this existing body of knowledge must be interpreted with caution.

There is not a significant body of medical literature published with respect to ballistic injury and secondary falls. This may or may not represent low incidence. There does, however, remain possibility and plausibility for significant injury, with certain areas especially vulnerable (e.g. thin skin with little subcutaneous fat and critical underlying structures). The likelihood of an event may be low (e.g. 2.5% cases barb impacted head, face, neck, or genitalia in one study). Yet, in the context of 83,000 field deployments, this can represent a significant number. It is prudent, as many local municipalities have

already adopted, to have all cases of barb impact in such areas (face, neck, and groin) be evaluated by a physician for examination and assessment of potentially consequential barb impact.

In the case of secondary falls, it is understandable that the possibility of unprotected falls may occur in light of the intended effects of neuromuscular incapacitation. However, there is no reason in this instance to supersede the on-scene officer's discretion with respect to disposition and clinical evaluation in these cases. This is not to say that these injuries are few or of no clinical significance, but that there is no reason to believe that these would present in an unusual or occult manner other than similar fall-type injuries encountered during other types of police field work.

The cardiovascular effects of Tasers represent the majority of the existing literature on human effects, though there has been some discordance with respect to these findings. The bulk of studies and field data seem to support that Tasers do not cause direct, immediate malignant dysrhythmias. And, even if such a case did occur, police would certainly initiate means to definitive medical care as the patient would present with clinical features obviously in need of such. The literature is not universal, however, in declaration of cardiac safety, especially in cases of comorbid conditions and pro-arrhythmogenic states like cardiovascular disease and acute drug toxicity. As such, it would be sensible that cases of known or suspected drug toxicity or cardiac disease should receive a post-incident medical evaluation. Clearly, some field conditions do not facilitate the completion of a cardiac medical history, and the mandate for physician evaluation should be extended to any subject with complaints of chest pain, palpitations, dyspnea or physical signs of altered consciousness, pallor, diaphoresis, syncope, etc.

These clinical signs and symptoms are representative of a tenuous cardiac state are usually not difficult to recognize. Indeed, they are taught at the very basic levels of first aid. These cases would clearly signify the need for physician evaluation.

Perhaps the area of greatest concern is that of excited delirium. It can be argued that individuals in this state—hyperthermic, acidotic, hypovolemic, and psychotic—are already at high-risk to suffer a poor clinical outcome regardless of Taser use, and this alone may explain many cases of proximate death. Yet, the requirement for medical attention and supportive care in such cases—Taser use or not—is clearly necessitated. Law enforcement officers should be trained in the recognition of such symptoms, and policies should mandate physician evaluation.

In summary, post-incident physician evaluation of Taser subjects should be considered for mandate in the following cases:

- Any individual with barb impact to the face, neck, or groin.
- Any individual with known or suspected acute drug toxicity.
- Any individual complaining of symptoms or exhibiting signs consistent with an acute cardiac condition.
- Any individual presenting with signs suggestive of excited delirium.
- Any other cases requiring medical attention given the assessment, good judgment, and discretion of the on-scene officer.

It is appropriate to say that there is still more to be learned with respect to the human effects of Tasers. The gaps and inconsistencies in the published medical literature regarding the human effects of Tasers clearly call for more research and data collection.

A recurring theme in controlled studies, both animal model and human, is that they do not mimic field conditions or represent the true cohort of individuals likely to be subjected to the device. Yet, Taser deployment and use is widespread—this is the very data that should be collected and reviewed.

There is no official standardized or statutory national or international database for recording the human effects or clinical sequela following Taser use. Some data is maintained at local municipalities or by the manufacturer, but this is not standardized, verifiable, or legally mandated. The best source of data for future study of human effects and subsequent policy development remains a collective, standardized, systematic database for all field applications.

B. LIMITATIONS:

The fact that there have been sudden or unexpected deaths in individuals following the use of a Taser device does not necessarily demonstrate causality or even a contributory critical role. Autopsy and prospective case studies can only demonstrate proximal association with a Taser discharge. Certainly, the unfortunate death or adverse outcome may have been secondary to other confounders (drug toxicity, extreme physical exertion with acidosis, positional restraint with respiratory embarrassment, etc.) and may have occurred regardless of use of the Taser. Comprehensive, controlled, large-scale studies of the human physiologic effects of Taser application are lacking, especially within the context and the cohort population likely to receive a Taser discharge in the field. At this stage of study, there are only small demonstrations of relative safety in

healthy volunteer cohorts and some suggestion of untoward human effects based on surrogate animal models.

There is literature supporting the porcine model as a good surrogate with comparable physiological parameters (Hannon, et al., 1990) and heart-body ratios and cardiac anatomy similar to humans (Howe, et al., 1968). Pippin (2007), however, argues that they make poor surrogates for human cardiac physiologic responses. He further notes confounders in such studies as use of anesthesia, controlled laboratory conditions, smaller body masses than humans, and inability to interview subjects about symptoms—all limiting their contributions to understanding the true human effects. He notes that the most useful information to date is from studies human tests subjects.

The limited human studies, however, are not without issues, as well. Electrical interference with surface EKG monitoring may preclude a more true understanding of myocardial capture and cardiac effects (Nanthakumar, et al., 2006) as more invasive monitoring techniques might further elucidate. Furthermore, human volunteer studies are probably a poor representative cohort of those likely to be subjected to a Taser limited by selection bias. No human studies have accounted for multiple shocks, acute cardiotoxic drug intoxication states, the possibility of acute psychiatric conditions and psychotropic medications, or a prolonged pre-incident struggle or intense physical activity.

Finally, many of the studies presented were directly associated with or supported by the device manufacturer (e.g. Ho, et al., 2007; Ho, et al., 2006; Lakkireddy, et al., 2006; McDaniel, et al., 2005). Yet even with incomplete data and less than perfect studies, policy decisions still need to be made. Tasers remain in widespread use, and

policy should reflect the best available data and information available with regular institutional review and updates as more complete information is brought forth.

APPENDIX A

Summary Table: Effects of Tasers

Author	Year	Study Design	Subjects	Sample	Factors	Major Results
Koscove, E.	1985	Case observations	Human	n/a	n/a	Observations with summary comments preparing medical community for increased Taser-related cases and clinical considerations.
Koscove, E.	1987	Case report	Human	1	Dart morbidity	Voluntary dart ingestion.
Ordog, et al.	1987	Case series	Human	218	Toxicology profile, morbidity, mortality	86% reporting same-day drug use, 70% with positive toxicology screens. 3 deaths; contusions, abrasions, lacerations, rhabdomyolysis, testicular torsion. 48% required hospitalization.
Ross, D.	1998	Case series	Human	61	Excited delirium-associated sudden death	77% died in police custody; 57% acutely drug-toxic.
Kornblum, et al.	1991	Case series	Human	16	Autopsy	All with bizarre behavior; 81% with positive toxicology screen.
Mehl, L.	1992	Case report	Human	1	Fetal outcome	Miscarriage.
Bleetman, et al.	2000	Experimental	Human	25	Major organ susceptibility	Organs lie 1cm below skin in thin subjects in erect position.
Stratton, et al.	2001	Case series	Human	18	Excited delirium-associated sudden death	Stimulant drug toxicity (78%); heart disease (61%)
Dearing, et al.	2005	Case report	Human	1	Dart morbidity	Dart embedded in distal phalanx.
McDaniel, et al.	2005	Experimental	Porcine model	9	Cardiac vulnerability	Minimum 15x standard electrical discharge to induce fibrillation. Threshold weight dependent.

Ng, et al.	2005	Case report	Human	1	Dart morbidity	Ocular penetration.
Chen, et al.	2006	Case report	Human	1	Dart morbidity	Ocular penetration.
Haegeli, et al.	2006	Case report	Human	1	Cardiac vulnerability	No damage or detrimental effect to implantable cardioverter defibrillator.
Ho, et al.	2006	Experimental	Human	66	Cardiac vulnerability; metabolic effects	No change in EKG, electrolyte, or BUN/Cr ratio. Increases noted for CK, lactate, myoglobin. One subject with increased troponin.
Jauchem, et al.	2006	Experimental	Porcine model	10	Cardiac vulnerability; metabolic effects	Elevations in potassium and lactate; acidosis; no fibrillation observed.
Lakkireddy, et al.	2006	Experimental	Porcine model	5	Cardiac vulnerability	Cocaine increased threshold baseline for fibrillation by 50-100%; transthoracic flow required lowest energy.
Nanthakumar, et al.	2006	Experimental	Porcine model	6	Cardiac vulnerability	79% of transthoracic discharges stimulated myocardium (measured by intracardiac catheters); case of V-fib & V-tach with catecholamines.
Strote, et al.	2006	Case series	Human	37	Autopsy	78% with positive toxicology screen; 76% with excited delirium, 54% with cardiovascular disease.
Bozeman, et al.	2007	Cohort	Human	962	Morbid injury	22.5% with “mild injury” (e.g. contusions, lacerations, soft tissue injury, fracture). Cases of significant organ injury reported (rare).
Ho, et al.	2007	Experimental	Human	52	Respiratory embarrassment	No impairment of respiratory parameters.
Levine, et al.	2007	Experimental	Human	105	Cardiac vulnerability	Subjects with increased heart rate; no ectopy or dysrhythmias.
Rehman, et al.	2007	Case report	Human	1	Morbidity	Intracranial dart penetration.

APPENDIX B

Summary Recommendations: Post-incident Physician Evaluation of Taser Subjects

- Any individual with barb impact to the face, neck, or groin.
- Any individual with known or suspected acute drug toxicity.
- Any individual complaining of symptoms or exhibiting signs consistent with an acute cardiac condition.
- Any individual presenting with signs suggestive of excited delirium.
- Any other cases requiring medical attention given the assessment, good judgment, and discretion of the on-scene officer.

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VITA

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