The Medical Effects of TASERS

By James R. Roberts, MD

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Learning Objectives: After reading this article, the physician should be able to:
1. Discuss the function of the TASER.
2. Describe the known cardiac effects from use of this device.
3. Summarize the pros and cons of the use of a TASER.

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Emergency physicians understand the need for rapid control of acutely delirious and agitated patients in the ED, and in past columns I have suggested various rationales and proposed interventions. It is intuitively obvious that patients must be able to cooperate, or at minimum, no longer flail around like a hooked barracuda in the bottom of a Florida flats boat for even a modicum of medical evaluation and treatment to begin. Prolonged agitation and struggling, especially against restraints, leads to a pathologic downward spiral, replete with metabolic acidosis, hyperthermia, rhabdomyolysis, coagulopathy, ARDS, and multisystem failure. Fatalities from uncontrolled or prolonged agitation are rare but well documented, often occurring precipitously, unexpectedly, and without warning. The physiology is usually one of PE/Abradycardia/asystole rather than ventricular fibrillation; however, once cardiac arrest occurs, it may be very difficult for resuscitation to be successful, even if medical personnel are on the scene.

Physical restraints and/or a bevy of burly security guards are often necessary to initially incapacitate a raving lunatic bent on hurting himself and everyone around him. Nonetheless, it appears prudent to expeditiously institute pharmacologic restraint with doses potent enough to get the job done. I had suggested that a combination of benzodiazepines and haloperidol is the time-honored first approach to the medically undifferentiated individual, and generally this combination is the safest and most effective regimen for agitated delirium. If there is predominantly underlying psychiatric disease, there is increasing support for using rapidly acting atypical parenteral antipsychotics, such as IM olanzapine (Zyprexa) or ziprasidone (Geodon). The exact pharmacologic cocktail that is prospectively best suited for each individual circumstance has not been identified, and there is likely little difference between regimens. The key is to provide rapid and effective tranquilization so that an organized medical evaluation can commence.

Law enforcement authorities face similar challenges in the field. They are often first on the scene, and must make important decisions with regard to their safety and the safety of everyone involved. The etiology of the delirium, the individual’s underlying medical problems or metabolic milieu, or the severe co-morbidity accompanying cocaine/amphetamines, not to mention the individual’s personal arsenal of dangerous weapons, simply cannot be determined before incarceration, cooperation, or submission are mandated. Many chronic stimulant users, for example, have clandestine cardiac disease, waiting to emerge as a lethal dysrhythmia when the milieu is right.

Chokeholds, hastily delivered gunshots, hogtying, and clubbing have been largely abandoned, and generally are believed to constitute unnecessary and unusual force. First responders who must quickly incapacitate a dangerous criminal have turned to the conducted electrical weapon, often called a stun gun but most commonly called a TASER, which, besides being its brand name, is the device studied in virtually all medical research because of its widespread use by law enforcement. (The TASER was designed in 1969 by Jack Cover, and was named after a fictional teenage adventurer and inventor, Thomas Swift [Thomas A. Swift’s Electric Rifle].)

Unfortunately, an altercation with police can occasionally lead to the death of an alleged perpetrator. Now a police action becomes a highly charged social, racial, and emotional conundrum, an event that can draft all involved, even the EP onto the 6 o’clock news or precipitate a neighborhood riot. The particularly unlucky ones garner instant, albeit unwanted and usually unwarranted, worldwide stardom on YouTube.com.

This month’s column will attempt to put the use of the TASER into medical perspective. The TASER is loved and embraced by police, hated and disdained by human rights groups and those who have been on the receiving end of its voltage, and likely misunderstood by most. I will attempt to cull out important medical issues, and eschew the omnipresent social and legal been implicated as a direct cause of death by some, this bad rap has not been medically proven to my analysis. Medical complications can occur, but well documented serious sequelae are actually few and far between. It is certainly difficult to differentiate direct TASER complications from many other complex confounding issues. In reality, there is surprisingly little medical information identifying exactly what true medical havoc a TASER discharge actually inflicts on a human recipient of the shock.

Cardiac Electrophysiological Consequences of Neuromuscular Incapacitating Device Discharges: Cardiovascular Consequences of Stun Gun Manthakumar K, et al J Am Coll Cardiol 2006;48:798

This article from the Canadian Institute of Health Research and the University of Toronto evaluated the cardiac consequences of neuromuscular incapacitation with a TASER discharge in an experimental animal model. The aim was to determine if large voltage electrical discharges posed risks for triggering lethal cardiac arrhythmias. Given the impossibility of performing this in humans, a pig model was used.

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The TASER was designed in 1969 by Jack Cover, and the TASER was named after a fictional teenage adventurer and inventor, Thomas Swift (Thomas A. Swift’s Electric Rifle). The devices are used worldwide by about 12,000 law enforcement agencies, and an estimated 600,000 people have been shocked. The devices are used mostly by law enforcement officers worldwide. They have often replaced the 9 mm police handgun as the intervention of choice when other measures have failed. The device is said to deliver 50,000 volts of electricity, arching between two propelled metal barbed darts, hence the name “stun gun.”

- The TASER is commonly used in the United States and has been used by police, military, and security professionals around the world.
- It uses a pulse of electricity to disrupt the heart’s normal rhythm, typically causing ventricular fibrillation.
- The device is designed to be used in critical situations where other options may not be feasible, such as when a person is in immediate danger of harming themselves or others.
- The device is safe for use in most situations, but there are some precautions that should be taken, such as avoiding the use of the device on individuals with medical conditions that could be exacerbated by the electrical shock.

**Effective Cocaine Intoxication on Threshold for Stun Gun Induction of Ventricular Fibrillation**

Lakkireddy D, et al
J Am Coll Cardiol 2006;48(4):805

This manufacturer-sponsored study sought to evaluate the effect of cocaine on TASER-induced VF threshold in a pig model. Because violent subjects who are restrained or controlled by police are often intoxicated with cocaine or other drugs, the interaction of cocaine with a TASER, particularly with the production of VF, would be an important parameter to study. Again, the adult pig model was used.

A custom device (not an actual TASER) was attached to five locations on the animal's body, and standard discharges associated with the commercial TASER were applied. No ventricular fibrillation was seen in any of the locations before or after cocaine infusion. The electrical discharges were then escalated above the level possible with the TASER until VF was induced. The VF threshold increased as the distance of the electrodes from the heart increased.

Interestingly, cocaine increased the required strength of the electrical discharge that was required to produce ventricular capture. The study demonstrated that cocaine actually increased the safety margin by one-and-a-half to two times from baseline. The authors conclude that the use of cocaine increases the safety margin (raises the VF threshold) by 50 percent to 100 percent above baseline with regard to potential vulnerability of the pig heart to VF from the TASER discharges.

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Anesthetized pigs were monitored with intracardiac catheters and blood pressure transducers prior to the application of TASER discharges. Two commercially available models were used, and discharges were of 5 and 15 seconds duration. The devices delivered pulses of 50,000 V. 11 us to 50 us in duration, at a rate of 16 to 20 pulses per second. Per the author's introduction, this short duration of stimulation has been expected to have only a small chance of stimulating the myocardium, but will capture and stimulate nerves and skeletal muscle. The discharging wires were placed to provide two different vectors of electrical discharge, one being thoracic and parallel to the long access of the heart, and the other non-thoracic, being away from the heart (over the abdomen). In addition, an intravenous infusion of epinephrine was instituted to simulate the adrenergic storm produced by a struggling, delirious, or uncontrolled individual.

A total of 150 discharges were delivered. None of the nonthoracic discharges stimulated the heart, but about 80 percent of the over-the-heart discharges did produce electrical capture of the myocardium. When the electrical device was discharging, mechanical capture produced heart rates in the 300 beats per minute range. Only one of the discharges produced VT and one produced VF, both occurring during the epinephrine infusion. The VT spontaneously converted. It is unclear whether the epinephrine infusion or the electricity produced the ventricular arrhythmias. The authors theorized that structural heart disease could predispose to catastrophic ventricular arrhythmias when a rapid ventricular stimulation is produced by the device. They concluded that electrical TASER discharge across the chest of their experimental animal can capture the myocardium and could produce ventricular fibrillation. The intracardiac catheters may have found abnormalities not reported in other studies where surface EKGs were disrupted by the electrical discharges. The authors were careful to avoid postulating that VF could be precipitated in humans. They caution that their model only describes the worst-case scenario in which the discharge is vectored across the heart, and they believe that their model rules out arrhythmias as a cause of death when the vectors are not across the heart or when death occurs after the discharges. Importantly, this study demonstrated that the discharges across the chest caused electrical and mechanical capture of the myocardium in this model. In their conclusion, the authors state that their experimental model suggests that electrical discharges across the chest can produce cardiac stimulation at high rates, possibly suggesting cardiac risk in humans. Importantly, they do not conclude that the device can cause ventricular fibrillation in humans.

**Comment:** TASERs are being increasingly used by law enforcement officers worldwide. They have often replaced the...
scientific studies, either on volunteers or animals, are not the same as the real issue at hand. Autopsy reports often assume that the TASER is “related” to the death just because it was used pre-mortem and because no specific cause of death can be found (not uncommon in many deaths). In the past, medical examiners have related deaths to the TASER. Most quote reports from the 1990s before any true electrical data were available (see Forensic Sci 1991;36:434; J Forensic Sci 1992;37:956.) It should be noted that although studies on this device are very incomplete, there is no credible proof that the TASER induces cardiac arrest when used by law enforcement officials in a prescribed manner. In fact, the voltage required to induce VF has been calculated to be 15 to 42 times the charge possible to be delivered from the TASER. (Pacing Clin Electrophys 2005;28(Suppl 1):S284.) It has been stated that there have been no documented cases of VF directly caused by the device in more than 600,000 police uses. (J Am Coll Cardiol 2007;49[6]:732.)

Contrast this with lay press headlines that the TASER kills many people. (“167 Cases of Death Following Stun-Gun Use,” Arizona Republic, February 5, 2006.) If one reads the UpToDate database, the 2007 version states that the TASER is “capable of inducing fatal arrhythmias and other injuries.” My analysis: We simply don’t know for sure, but many self-proclaimed authorities come down on both sides of the debate, many have a personal, financial, or social bias, and many simply don’t read the literature.

Other injuries claimed to be associat- ed with the TASER include burns, lacerations, testicular torsion, and miscarriage. Although the concepts may be believable, these are often anecdotal and poorly characterized reports. A miscarriage two weeks after a TASER application is hardly a scientific cause-effect. Thoracic spine compression fractures from the TASER in a volunteer who did not fall but experienced severe muscle contraction has recently been reported. (Ann Emerg Med 2007;50[5]:584.) Fracture and dislocation from electrical shock are well documented. All articles that claim the TASER can cause VF reference a short letter to the editor by Kim and Franklin (New Engl J Med 2005;353:958) stating “Ventricular Fibrillation after Stun Gun Discharge.” If one actually reads this sketchy report, it is hardly proof of the article’s title. This is clearly only a worrisome observation and certainly not quite science based on my read. Specifically, a violently agitated subject was subdued with a TASER. Later he had VF but was resusci- tated to normal with ACLS interventions. No drug screen or medical history was reported.

Kroll claims that this particular case was “misreported with serious omis- sions.” His version (personal communica- tion: “Obtained from police records”) was that following submission of a violently agitated man with a TASER, paramedics found a normal pulse and respirations. Twenty some minutes after this episode, the subject experienced a cardiorespira- tory collapse. It is my understanding that no ventricular fibrillation was document- ed until many minutes after TASER use, and after interventions including multiple medic-delivered cardiac shocks, atropine and epinephrine were administered. As stated, most agitated patients die via bradycardia. I am leery of this supposed documentation of VF after TASER dis- charge, yet it is universally quoted. So far, I have received no response from the author to my email query. A theoretical discussion by Ideker et al. (Am J Forensic Med Pathol 2007; 28[3]:190) states that fundamental laws of electrical stimulation predicted the TASER pulse will not stimulate an ectopic beat in a large majority of nor- mal adults. It is unlikely, at least from a theoretical stance, that a TASER can ini- tiate ventricular fibrillation. It’s a nice theoretical discussion but hardly firm clinical evidence.

Ho et al recently reported on respira- tory effects of prolonged electrical weapon application to human volun- teers. (Acad Emerg Med 2007;14:107.) Human volunteers received a 15-second application of electrical current while wearing respiratory measurement devices. These were certainly brave vol- unteers. Respiratory parameters were collected during and after exposure. The aim of the article was to see if the TASER contributed to death by impair- ing respirations. In this study, respira- tory measurements were taken pre-expo- sure, during electrical weapon exposure, and during the first and second minute after exposure. No respiratory impair- ment was demonstrated either during prolonged continuous or prolonged intermittent TASER discharge. There was no decrease in tidal volume nor was there hypercapnia, hypoxia, or apnea associated in this volunteer model.

Other work has failed to demonstrate any significant changes in cardiac serum markers, hyperkalemia, or acidosis fol- lowing TASER application. Transient

Even More Compressions in Cardiac Resuscitation

Giving more chest compressions and fewer breaths than the current American Heart Association CPR guidelines mandate greatly increases the likelihood of survival for a person in cardiac arrest in a non-health care setting, according to a study recently presented at an American Heart Association conference.

Alex G. Garza, MD, MPH, currently a Washington Hospital Center physician in Washington, D.C., instituted new CPR guidelines while he was the medical director of Emergency Medical Services in Kansas City, MO. Medicos were instructed to give 50 compressions, followed by two rescue breaths (50:2). The AHA’s current guidelines, which were altered only last year, recommend giving 30 compressions, followed by two rescue breaths (30:2). Previously, the AHA’s CPR guid- elines recommended giving 15 compressions, followed by two rescue breaths (15:2). Dr. Garza instructed Kansas City Medics to perform compressions before defibrillation and limit compression inter- ruptions, such as pulse checks and IV line starts.

The study, conducted between April 2006 and March 2007, showed a dra- matic increase in survival rates for patients in cardiac arrest, from 21 per- cent under the 15:2 guidelines to 44 per- cent under the 50:2 guidelines.

AHA Expands eLearning Program

The American Heart Association recently expanded its Emergency Cardiovascular Care (ECC) eLearning program. The updated eLearning program offers stand-alone courses, which do not require hands-on training and can be completed online, and blended courses, which incorporate online teaching and hands-on training, and must be scheduled with an authorized AHA Training Center.

Current stand-alone courses include instruction on heart rhythms and stroke risk factors, diagnosis, and assessment. Blended course options cover cardiopulmonary resuscitation, automated external defibrillator, and other first aid procedures. Though current eLearning courses are tailored for health care professionals who want to keep their skills up-to-date, the AHA said it will provide courses for the general public in the near future.

Medicaid Reimbursement Lower Than Uninsured

Payments for emergency department ser- vices declined for all patients over an eight-year period, with the sharpest drops being observed in Medicaid reimburse- ments, according to a new study pub- lished in the November issue of Annals of Emergency Medicine.

Researchers from the University of California at San Francisco led by Renee Hisoa, MD, analyzed charges and pay- ments for 43,128 emergency depart- ment visits from 1996 to 2004. They found that the overall proportion of emergency department charges paid for outpatient emergency department visits declined from 57 percent to 42 percent. The share of charges paid was consis- tently the highest among patients cov- ered by private insurers, and the share of charges paid was consistently the low- est among Medicaid and uninsured patients.

Emergency departments were reim- bursed less for Medicaid than all other groups, however, including those the uninsured. In 2004, 35 percent of charges for uninsured visits were paid, but only 33 percent of Medicaid visits were.

The authors also note that emergency departments are often “core safety net providers” and that declining reimburse- ment rates threaten both providers of emergency care as well as patients seek- ing emergency care.
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mild increases in CKP and lactate were observed, likely due to muscle contraction. (Acad Emerg Med 2006;13:589.) Shocking does not cause hyperthermia (Forensic Sci Int November 2007, abstract only), and minimal testing has shown no disruption of pacemakers, ICDs, or their leads when exposed to TASERs. (European 2007;9[7]:551.)

Conclusions
It may be difficult to convince family members that the death of their loved one following a TASER episode by police was not related to the use of this device. After all, lightning and the electric chair kill, and he was shocked and then died, and so likely was “electrocuted.” However, it is difficult to find any credible medical evidence that such is the case or even possible. These scenarios are always multifactorial, and frequently clouded by underlying unknown heart disease, drug overdose, massive stimulant use, alcohol withdrawal, or other unknown variables. Specifically, to my analysis, ventricular fibrillation has not been demonstrated as a direct result of TASER use in humans.

Certainly the TASER dart can cause physical damage, and I have had to dig out a few during my ED shifts; a dart in the eye would be potentially blinding. (Am J Ophthalmol 2005;139:713.) Injuries from falls during muscle incapacitation can be expected, so the emergency physician needs to be aware of occult injuries, particularly cervical spine injuries. Fractures and dislocations may occur secondary to intense muscular contractions.

Many police departments have protocols mandating that all subjects who have had TASER applied be brought to the ED for medical clearance. It has not been my experience that the police politely escort the suspect into the ED wearing a cervical collar, so C-spine precautions should be high on the list of priorities for the clinician.

When I took an informal poll of my colleagues and our residents, it was the common belief, almost unanimous, that the TASER can cause death and rather common belief, almost unanimous, that the TASER is a rather remarkable device. After all, lightning and the electric chair are illegal in Philadelphia, nor would I ever like to be a police officer called to the scene of a raving lunatic with lethal weapons who is capable of gantutan physical acts. A civilian TASER is now available (about $400 and requiring a background check performed by the company). These devices are illegal in Philadelphia, but my wife wants one.

Finally, Boseman (Ann Emerg Med 2005;46[3]:300) has likened the TASER to the now federally mandated automobile airbags: They may harm a small subset of individuals but save the lives of countless others. Is this a reasonable tradeoff? Importantly, research into the full adverse effects of the TASER is nascent, to say the least, so the bottom line is never say never until more data are available.

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Questions:
1. The TASER has been demonstrated to directly cause ventricular fibrillation in humans following recommended use. [ ] True [ ] False
2. Cardiac arrest of a deliberate patient physically subdued is usually a bradycardic, asystolic death, as opposed to ventricular fibrillation. [ ] True [ ] False
3. The TASER discharge will capture the myocardium as it is discharging, but does cause an elevation in cardiac enzymes. [ ] True [ ] False
4. Human volunteers undergoing shocks from the TASER do not demonstrate clinically significant adverse effects on respiratory function, vital signs, venous pH, or electrolytes. [ ] True [ ] False
5. The TASER incapacitates an individual by causing a momentary loss of consciousness secondary to electrical effects on the brain. [ ] True [ ] False

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