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Intracardiac electrocardiographic assessment of precordial TASER shocks in human subjects: A pilot study

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ABSTRACT

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

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

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

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

1. Introduction

The Taser is a commonly used conducted electrical weapon (CEW) intended to allow police to subdue and apprehend violent or dangerous suspects. The device delivers a series of low current (2 mA), high voltage electrical pulses via two insulated wires attached to probes that are fired at suspects.[1] The probes are designed to lodge into the skin or clothing of the suspect, and the discharge pulses to produce compliance through a combination of pain and muscular incapacitation.

The overall safety of CEWs has been well demonstrated, with an estimated 4.9 million human exposures since modern Taser CEWs were introduced in 1999.[2] Serious or fatal injuries are rare and primarily due to falls. CEWs have been demonstrated to produce fewer significant injuries than other police force options such as hand to hand combat, hand held impact weapons, irritant sprays, canines, and firearms.[3] Their use has been associated with decreases in officer injuries, suspect injuries, and use of lethal force in numerous police agencies.[4,5] Numerous safety and physiology studies in humans have revealed no detrimental cardiac, respiratory, or metabolic effects within the range of typical CEW utilizations of 5–15 s.[6–8] However, one study demonstrated putative ventricular capture (240bpm) in one subject.9 The cardiac capture persisted throughout the duration of the discharge and resolved once the discharge stopped, with the subject experiencing no apparent ill effects. The Taser dart was located over the subject's right ventricle.[9]

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Therefore, concerns remain that CEW exposure could be related to rare cases of unexpected deaths after CEW use, specifically the possibility of cardiac rhythm disturbances due to the electrical discharge. Case reports of cardiac arrest, ventricular fibrillation, and ICD over sensing in temporal proximity to CEW exposure raise legitimate concerns about this as a rare possibility.[9–13] However, in a prospective review of 162 unexpected deaths in police custody, 70% of the deaths occurred in the absence of CEW use. The remaining 30% occurred after CEW use, though none displayed cardiovascular collapse immediately after CEW exposure, suggesting a possible direct dysrhythmic etiology of arrest.[14] A current estimate of the likelihood of sudden cardiac arrest directly due to CEW-induced dysrhythmia is one in 2.8 million uses.[15] This contentious topic has strong opinions on both sides.[9,16,17] Another related concern is possible damage to or interference with cardiac devices such as pacemakers (PM) or implantable cardioverter-defibrillators (ICD) due to CEW discharge.[16]

There have been calls for human research to definitively address these concerns, but these have been challenging due to both technical and ethical hurdles.[9,17,18] Surface EKG tracings are obscured by electrical noise during a CEW discharge, resulting in the need for intracardiac EKG monitoring to conclusively demonstrate electrical pacing or dysrhythmias during the CEW discharge cycle. While human volunteers are routinely exposed to CEW discharges for both training and research purposes, the ethics of placing an invasive intracardiac EKG for purely research purposes are problematic and human trials using this definitive level of monitoring have not yet been performed.

We sought to determine the feasibility of performing exactly this human research by recruiting patients with an intracardiac EKG sensing lead already in place, related to either a diagnostic electrophysiology study or to an implanted cardiac device such as a PM or ICD. In this pilot study we respectfully navigate the oversight and regulatory hurdles and demonstrate the intra-shock electrocardiographic effects of an intentional transcardiac CEW discharge using subcutaneous probes placed directly across the precordium.

2. Materials and methods

The study protocol was reviewed and approved by the Institutional Review Board. Approved informational fliers were placed in the Electrophysiology (EP) clinic and research staff approached potentially eligible subjects during pre-procedure office visits. Informed consent was completed prior to the start of the scheduled study or procedure.

Inclusion criteria included adult patients scheduled to undergo diagnostic EP studies or placement/replacement of an implanted cardiac device such as a PM or ICD in the EP laboratory of the participating medical center. Exclusion criteria included pregnancy, incarceration, inability to provide informed consent, known allergies to medications or cleansing materials used in the protocol, pacemaker dependence, or the discretion of the investigators or treating cardiologist. Patients with a history of osteopenia, vertebral fractures, or cancer were also excluded due to a known slight risk of bony injury due to muscle contraction.[19,20]

2.1. Study protocol

Patients were sedated for their clinical procedure at the discretion of the treating anesthetist, typically using midazolam and fentanyl or methohexitol, and remained so during the CEW exposure. The level of sedation was assessed before and after exposure using the Ramsey Sedation Scale, a widely used and validated scoring system that ranks sedation on a scale of 1 (agitated, anxious) to 6 (unresponsive to noxious stimuli).[21]

Skin sites at the right sternoclavicular junction and the left lower costal margin at the midclavicular line (Fig. 1) were cleansed using chlorhexidine or betadine and infiltrated with 2–3 cc of 1% lidocaine. Sterile 18 gauge needles were placed approximately 10 mm subcutaneously in a precordial/transcardiac position. A standard police issue TASER Model X26 CEW was attached to the subcutaneous electrodes and a 5 s discharge was delivered. Continuous surface and intracardiac EKG monitoring was performed before, during, and after the CEW discharge. Following completion of the CEW exposure the subcutaneous probes were removed and sterile dressings were applied to the probe sites as patient monitoring continued. ICDs/PMs were immediately interrogated and the recorded intracardiac rhythm strips were printed.

After completion of and recovery from their clinical procedure in the EP Lab, study subjects were interviewed and asked to report any localized tenderness or complications at probe sites, generalized muscle soreness, as well as any recollection of the Taser discharge. They received written post-study instructions regarding possible muscle soreness, care of the skin probe sites, and confirmation of investigator contact information.

2.2. Analysis

Primary outcomes included the incidence of ventricular capture/pacing, aberrantly conducted complexes, and ventricular dysrhythmias. Secondary outcomes included any interference with implanted devices, changes in vital signs, complications at probe sites, recall of the discharge, and muscle soreness.

Observed proportions of the primary events were reported, along with descriptive statistics. Numeric means of pre- and post-discharge vital signs were compared using nonparametric Wilcoxon Rank Sum testing. GraphPad InStat version 3.10 for Windows, GraphPad Software, San Diego California USA was used for analysis.

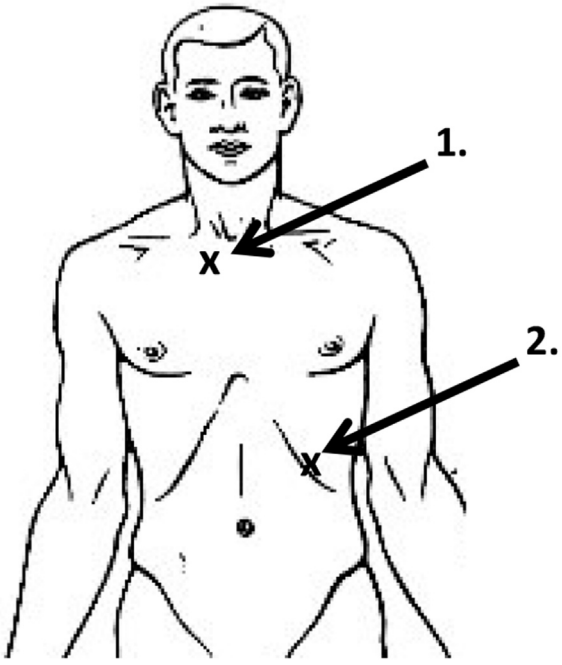

Fig. 1. Subcutaneous probe locations: 1) Right sternoclavicular junction; 2) Left lower costal margin at midclavicular line.