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A TASER conducted electrical weapon with cardiac biomonitoring capability: Proof of concept and initial human trial

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ABSTRACT

Introduction: Despite research demonstrating the overall safety of Conducted Electrical Weapons (CEWs), commonly known by the brand name TASER®, concerns remain regarding cardiac safety. The addition of cardiac biomonitoring capability to a CEW could prove useful and even lifesaving in the rare event of a medical crisis by detecting and analyzing cardiac rhythms during the period immediately after CEW discharge.

Objective: To combine an electrocardiogram (ECG) device with a CEW to detect and store ECG signals while still allowing the CEW to perform its primary function of delivering an incapacitating electrical discharge.

Methods: This work was performed in three phases. In Phase 1 standard law enforcement issue CEW cartridges were modified to demonstrate transmission of ECG signals. In Phase 2, a miniaturized ECG recorder was combined with a standard issue CEW and tested. In Phase 3, a prototype CEW with on-board cardiac biomonitoring was tested on human volunteers to assess its ability to perform its primary function of electrical incapacitation.

Results: Bench testing demonstrated that slightly modified CEW cartridge wires transmitted simulated ECG signals produced by an ECG rhythm generator and from a human volunteer. Ultimately, a modified CEW incorporating ECG monitoring successfully delivered incapacitating current to human volunteers and successfully recorded ECG signals from subcutaneous CEW probes after firing.

Conclusion: An ECG recording device was successfully incorporated into a standard issue CEW without impeding the functioning of the device. This serves as proof-of-concept that safety measures such as cardiac biomonitoring can be incorporated into CEWs and possibly other law enforcement devices.

1. Introduction

Conducted electrical weapons (CEWs), commonly known by the brand name TASER®, are commonly used by law enforcement officers to subdue and apprehend suspects who are actively resisting or threatening officers or others, but do not represent a lethal threat. Research has shown that serious injury or death is extremely rare after use of these less lethal devices.[1,2,14] However, isolated case reports of deaths occurring shortly after CEW use leave lingering questions of cardiac safety.[3–5] These unexpected deaths after exposure to a CEW discharge remain rare, and are often intertwined with other risk factors for sudden death including exertion, drug use, and pre-existing medical conditions.[6–8]

A CEW delivers a series of low current, high voltage electrical impulses via two insulated wires attached to probes, which are propelled through the air and imbed themselves in a subject's skin or clothing.[9] This combination of subcutaneous metal probes and insulated wires connected to an electronic device represents the basic components needed to obtain an electrocardiogram. This configuration makes it possible to detect and analyze the cardiac rate and rhythm of a suspect while the CEW remains attached. Such cardiac biomonitoring capability could prove useful and even lifesaving in the event of a medical crisis by detecting a suspect's cardiac rhythm during the period immediately after CEW

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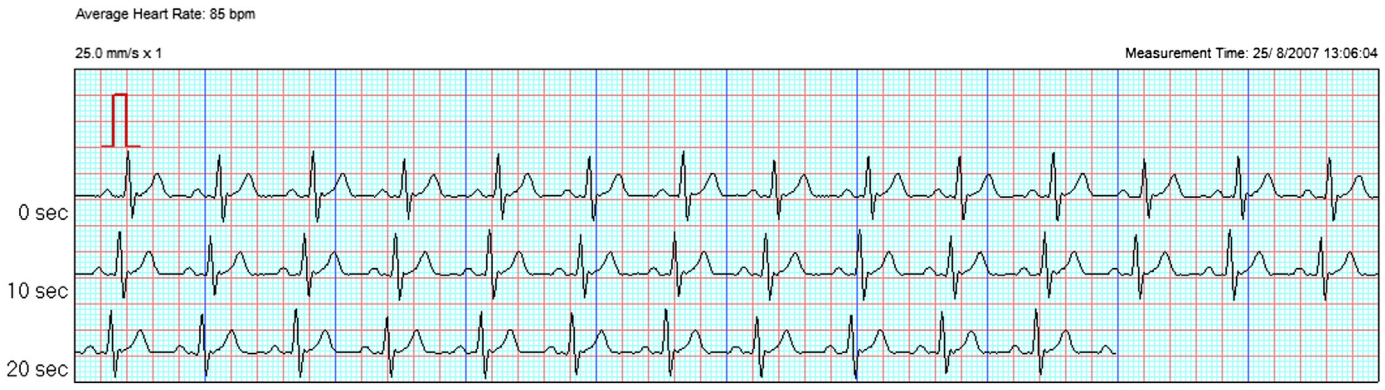

Fig. 1. Artificially generated ECG signal recorded after successful deployment of a modified CEW cartridge.

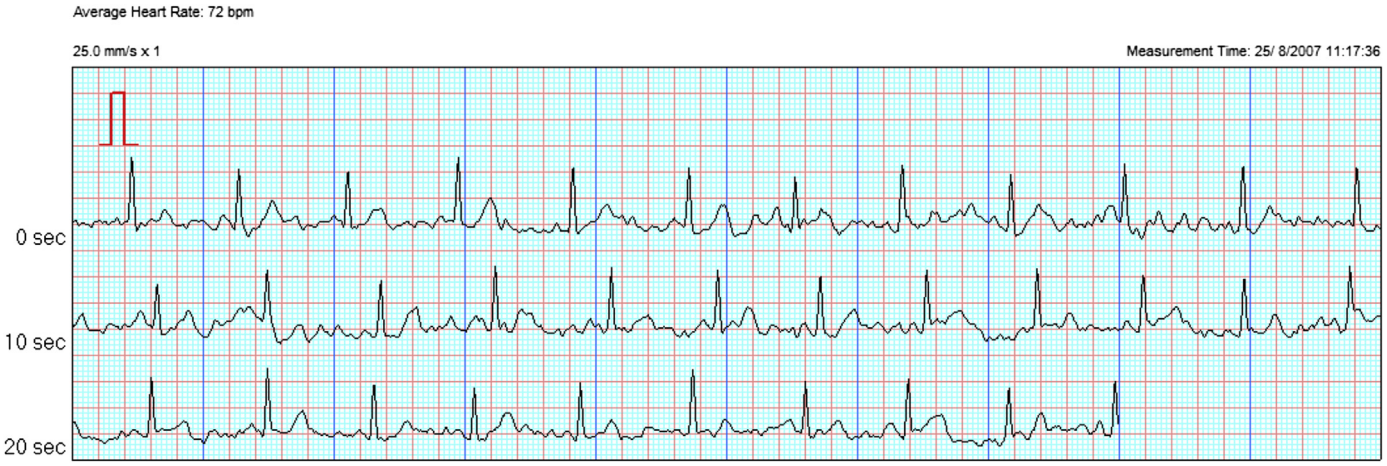

Fig. 2. Surface ECG recorded from skin electrodes after successful deployment of a modified CEW cartridge.

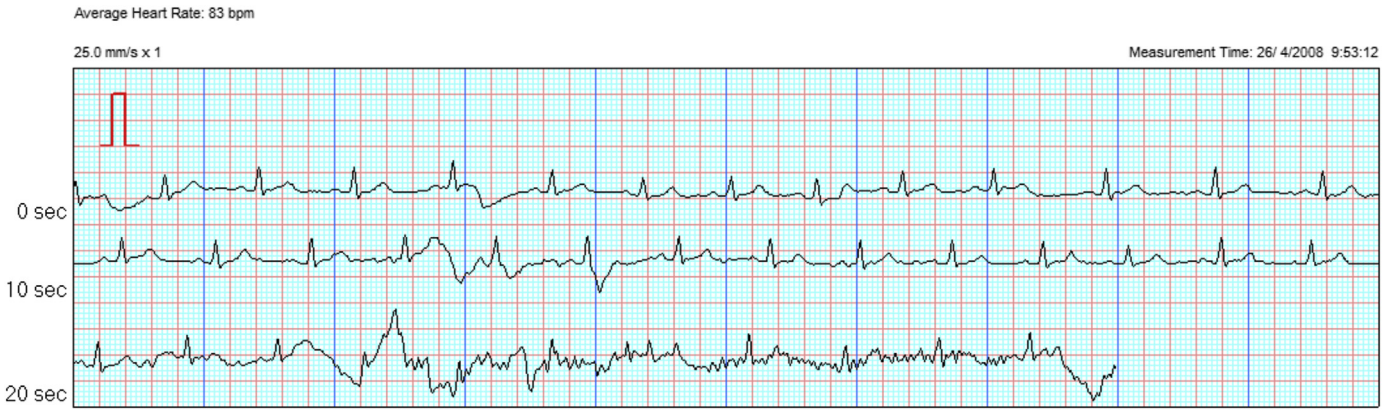

Fig. 3. ECG tracing recorded from weapon-fired subcutaneous CEW probes at the posterior torso after successful discharge and function of a modified CEW cartridge.

discharge. Incorporation of real time analysis capability, which already exists in implanted cardiac devices, combined with a notification system could prompt nonmedical CEW users (law enforcement personnel) to obtain immediate medical assistance or apply an automatic external defibrillator (AED) if dangerous cardiac rhythms are detected. This could enhance subject safety whether the dangerous rhythm is related to the CEW discharge, a coexisting medical condition, or to another process such as drug overdose or Excited Delirium Syndrome.[1,10–12] Further, a recording of the cardiac rhythm at the time of collapse and death would be invaluable when investigating and determining the cause of rare in-custody deaths.

We hypothesized that a combination of existing technologies would allow us to obtain interpretable electrocardiogram (ECG) tracings through minor modifications to a standard police issue CEW and cartridge. Our primary objective was to provide proof of this concept and then to combine a miniaturized ECG device with a standard CEW in order to test detection and storage of ECG signals