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Brief Reports

PHYSIOLOGIC EFFECTS OF A NEW-GENERATION CONDUCTED ELECTRICAL WEAPON ON HUMAN VOLUNTEERS

Jeffrey D. Ho, MD,*† Donald M. Dawes, MD,‡§ Richard J. Chang, MD,‖ Rebecca S. Nelson, BS,* and James R. Miner, MD*

*Department of Emergency Medicine, Hennepin County Medical Center, Minneapolis, Minnesota, †Meeker County Sheriff's Office, Litchfield, Minnesota, ‡Department of Emergency Medicine, Lompoc Valley Medical Center, Lompoc, California, §Santa Barbara Police Department, Santa Barbara, California, and ‖Department of Emergency Medicine, Providence Regional Medical Center, Everett, Washington
Reprint Address: Jeffrey D. Ho, MD, Department of Emergency Medicine, Hennepin County Medical Center, 701 Park Avenue South, Minneapolis, MN 55415

☐ **Abstract—Background: Conducted electrical weapons (CEWs) are used by law enforcement to restrain or repel potentially violent persons. The TASER X2 CEW is a next-generation device with new technology, including new electrical waveform and output specifications. It has not previously been studied in humans. Objective: The objective of this study was to evaluate the human physiologic effect of a new-generation CEW. Methods: This was a prospective, observational human study. Volunteers received a 10-s exposure via deployed probes from an X2 CEW in the abdomen and upper thigh. Measured data included vital signs; 12-lead electrocardiograms; and blood serum biomarkers before, immediately after, and 24 h post exposure. Biomarkers measured included pH, lactate, potassium, creatine kinase (CK), and troponin-I. Real-time spirometry and echocardiography were performed before, during, and after the exposure. Results: Ten volunteers completed the study. There were no important changes in vital signs or potassium. Median increase in lactate as a consequence of the exposure was 1.2 mg/dL (range 0.6–2.8 mg/dL). Median change in pH was −0.031 (range −0.011 to −0.067). No subject had a positive troponin. Median change in CK at 24 h was 313 ng/mL (range −40 to 3418 ng/mL). There was no evidence of respiratory impairment. Baseline median minute ventilation was 14.2 L/min, increased to 21.6 L/min intra-exposure ($p = 0.05$), and remained elevated at 21.6 L/min post exposure ($p = 0.01$). Conclusions: There was no evidence of dangerous physiology found in the measured parameters. The physiologic effects of the X2 CEW are similar to older-generation CEWs. We encourage further study to validate these results.** © **2014 Elsevier Inc.**

☐ **Keywords—TASER; electronic control device; conducted electrical weapon; human physiology**

INTRODUCTION

Conducted electrical weapons (CEWs) are used by law-enforcement officers (LEOs) as intermediate weapons, defined as items that generally can induce subject compliance due to pain or incapacitation and are a level above empty-hand control techniques but less than deadly force. They have filled a gap left by other law-enforcement devices, tactics, or tools and have been shown to reduce LEO and suspect injuries (1–3). CEWs deliver electrical charge from a capacitor system in discrete pulses at fast rates (19 pulses per second in most models) leading to the depolarization of peripheral motor neurons within a "zone of capture." This results in subsequent involuntary

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subtetanic muscle contraction. The devices also depolarize afferent sensory neurons leading to pain.

The TASER X26 CEW (Figure 1) is currently the most prevalent CEW in use in the world and has been in service since 2003. It is considered to be older-generation technology and is based on electrical waveform characteristics developed more than a decade ago. Its operational limitations include the ability to fire a single cartridge only without reloading. This can present a distinct disadvantage during scenarios with unsuccessful current delivery (such as missing probe contact with the intended target), if the probe spread distance is too close to be effective, or there are multiple subjects to engage. There have been numerous human physiology studies performed using the older-technology X26 CEW (4–14). The older-technology CEWs are understood by experts to be safe and the newer-technology CEWs are proposed to be even safer. The TASER X2 CEW (Figure 2) represents new-generation CEW technology and has completely different waveform and output specifications that have significantly changed the electrical characteristics of this weapon when compared with previous CEWs. It also has the capability of firing two cartridges in a "semi-automatic" mode. This study is the first to examine comprehensive human physiologic effects of this newer-generation CEW.

METHODS

This was a prospective, observational study of human subjects. The Minneapolis Medical Research Foundation Institutional Review Board (Minneapolis, MN) approved this study. The study was conducted at the CEW manufacturer corporate headquarters in Scottsdale, AZ during a 2-day time period. The study volunteers were a convenience sample of LEOs or correctional officers participating in a training exercise and receiving an X2 CEW exposure as part of their training. They were approached during their training course with the offer to be a part of this study. Declining to participate in this study did not absolve them from receiving CEW exposure during training.

Figure 1. Old generation TASER X26 CEW.

Figure 2. New generation TASER X2 CEW.

The volunteers provided informed consent and completed a medical history questionnaire that was reviewed by a study physician. There were no specific exclusion criteria except known pregnancy and subjects had to be at full-duty status with their department and taking part in the training course. Each study volunteer was given a TASER X26 CEW as compensation for their participation.

Each volunteer had an i.v. placed by a certified paramedic before the testing. Baseline vital signs (blood pressure, heart rate, and pulse oximetry) were measured with an automated machine (Nonin 2120 Tabletop Monitor, Plymouth, MN) and baseline blood sampling from the i.v. occurred for the following values: creatine kinase (CK), potassium, pH, lactate, and troponin-I. The pH and lactate were immediately analyzed after withdrawing the blood sample using a Point-of-Care i-STAT analyzer and CG4 cartridges (Abbott Laboratories, East Windsor, NJ). The remaining blood was centrifuged and stored on site in ice, and transported at the end of each testing day to a local professional laboratory analysis site (Laboratory Corporation of America, Burlington, NC) for completion of the remaining tests. A commercial skin resistance analyzer (Omron Fat Loss Monitor HBF-306, Omron Healthcare, Inc., Bannockburn, IL) was used to determine body-fat percentage. All volunteers had been instructed to refrain from significant exertion for 24 h before and after their CEW exposure to avoid confusing their blood sample analyses.

The volunteers were fitted with face, neck, and groin protection and wore athletic shorts. Male volunteers wore no shirt and female volunteers wore a T-shirt or

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