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Fatal and non-fatal burn injuries with electrical weapons and explosive fumes

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ABSTRACT

Introduction: While generally reducing morbidity and mortality, electrical weapons have risks associated with their usage, including eye injuries and falls. With the presence of explosive fumes or fuels there also exists the possibility of burn injury.
Methods: We searched for cases of fatal and non-fatal major burns with TASER® electrical weapon usage where there was a possibility that the weapon ignited the explosion.
Results: We confirmed 6 cases of fatal burn injury and 4 cases of major non-fatal burns out of 3.17 million field uses. The mean age was 35.5 ± 9.7 years which is consistent with the typical arrest-related death. Moderate, minor, and noninjurious fires — typically due to a cigarette lighters in a pocket, petrol, recreational inhalants, or body spray were also noted.
Conclusions: The use of electrical weapons presents a small but real risk of death from fatal burn injury. It also presents a small risk of major non-fatal burn injury. The ignition of petrol fumes dominates these cases of major fatal and nonfatal burns.
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1. Introduction

Death during arrest is a recognized event, for which there are many known causes; sometimes the cause of the death remains unexplained.[1,2] Annually there are about 800 000 arrests in which force is used in the United States and approximately 800 non-firearm ARDs (arrest-related-deaths) yielding a mortality rate of about 1:1000.[3,4] About 80% of resistant subjects have co-morbidities of mental illness, drug abuse, or intoxication; the majority has at least 2 of these.[5,6]

The conducted electrical weapon (CEW) is involved in a minority of ARDs.[2,7] There have been 3.17 million field uses as of Sept 2016. There have also been 2.13 million CEW training exposures for a total of ~5.3 million human CEW exposures.[8]

Prospective studies have found suspect injury rate reductions of about 65% with electronic control[9,10] This is similar to the 2/3 reduction in fatal police shootings where CEW usage is not overly restricted.[11]

Electrical weapons are, after all, weapons, and there are indeed risks associated with their usage, including blinding eye injuries and fatal head and neck injuries from falls.[12,13] They are also electrical and hence present a risk of igniting explosive fumes. The goal of this paper is to summarize the mechanisms and risks of such fires and explosions.

1.1. Burn injury definitions

The American Burn Association (ABA) defines major burn injury as partial thickness burns involving more than 25% of TBSA (total body surface area) in adults (age 11–50) or full thickness burns involving more than 10% TBSA. Any burns involving the face, eyes, ears, hands, feet or perineum that may result in functional or cosmetic impairment are also considered major.

Moderate burn injury includes partial-thickness burns of 15–25% of TBSA in adults (age 11–50) and full–thickness burns involving 2–10% of TBSA. Minor burn injury includes burns involving less than 15% of TBSA in adults (age 11–50) and full-thickness burns involving less than 2% of TBSA.

1.2. Chemistry of a fume explosion

Fresh petrol has a lower explosive limit (LEL) of 1.4%. This means that a mixture that is 98.6% air and 1.4% petrol vapor is explosive.

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Surprisingly, this concentration level (1.4%) is not considered acutely toxicologically dangerous but in the "recreational" intoxication range for petrol sniffers.[14,15] The upper explosive limit (UEL) is 7.6% and thus petrol, *per se*, is not explosive. The minimum ignition energy (MIE) for petrol is 0.24 mJ compared to the ~1 mJ of the popular TASER X26 probe-wire connection and thus the fumes are easily ignited by the arc in the "needle-eye" at the back of the probe with an optimal concentration. See Fig. 1.

There are other liquids that have similar explosive capabilities. Benzene (commonly used for methamphetamine production) has a LEL of 1.34%. Butane (often used to manufacture hash oil) has a higher LEL of 1.81–1.86% in different forms. Its isomer, isobutene, is also present in cigarette lighters.

Oleocapsicum (pepper or OC) spray often uses flammable propellants, such as isopropyl alcohol, ethanol, and methyl isobutyl ketone. A few use nitrogen, which is inherently non-flammable. Many of the OC sprays that are labelled as "non-flammable" actually can be ignited by a CEW.[16] Most of these develop a small flame that is unlikely to produce a severe burn injury. However, the Aerko "Clear Out" OC grenade reportedly will produce a large flame with CEW ignition.[16] TATP (triacetone triperoxide) can be ignited by a CEW discharge.[17]

The probes are deployed at an initial velocity of ~140 fps (43 mps) and the pulse rate is 19 pps. See Fig. 2. Hence the probes travel 2.3 m per pulse. Since the maximum arc is 4 cm, it is unlikely that a probe would ever ignite a gas by arcing from the probe tip as it approached the subject. The probe-wire arcs are the most likely source of the ignition. While each pulse delivers about 100 mJ of energy to the load, the amount of energy delivered to the arc (in each probe) is estimated at ~1 mJ. However, in the event of heavy clothing, or a probe lodged in the clothing on the subject's side there can still be an arcing connection with more energy.

The minimum ignition energy for each substance is given in Table 1. As seen in Fig. 3, the ignition energy goes up rapidly for concentrations either higher or lower than the ideal.[18] This can explain why many electrical weapon probe deployments do not cause an explosion even in the presence of a given fuel.

2. Case reports

Co-author HEW maintains a database of worldwide CEW-proximate arrest-related-deaths. It had 1063 cases (1007 from USA) as of 21 September 2016. This ARD database has been cross-checked with the TASER International, Inc. internal ARD database and is continuously updated with Internet news scans. Autopsies and law-enforcement investigative reports are regularly requested via freedom-of-information letters. The HEW database has been used in previous publications.[13,19] Another author (MWK) did a direct legal and news database search for cases meeting the inclusion criteria.

Fig. 1. Probe conducting to cloth over aluminum foil. Note arcing in the wire-probe connection eye.

For the 6 fatal burn cases, we obtained 5 full autopsy reports or death certificates. We also obtained autopsy summaries from litigation filings, police reports, or news accounts for all fatal cases. We found sufficient incident detail from litigation filings, police reports, a coroner's inquest, or news accounts to support a classification of an electrical-ignited burn for all 10 major burn cases. We excluded 2 additional cases as we judged them to have had an alternative ignition source or an alternative cause of death, respectively.

2.1. *Fatal and non-fatal major burn injury cases*

Cases are listed from earliest incident. See Table 2 for summary.

2.1.1. *Cases #1, #2, and #3*

Two police officers responded to a 911 call to check on the welfare of a man who was depressed and threatening suicide. When the officers arrived, they found the 41-year-old man in his house, and they noticed a strong odor of natural gas inside. The officers entered the house to secure the suspect, but he resisted. To subdue him, an officer discharged his CEW. Immediately, the house exploded into flames with sufficient force to blow down walls and partially collapse the roof. Both of the officers and the suspect received serious burns, and all 3 were transported to a local hospital.

The next day, the suspect died from his injuries. One officer, who was 26 years of age, suffered burns over about 45% of his body. He survived for 33 days before succumbing to his injuries. The other officer, who was 36, received burns over about 35% of his body. He remained hospitalized for 2 weeks, but he recovered from his injuries.

The state fire marshal's office concluded that the evidence was insufficient to determine conclusively the cause of the explosion. Investigators determined that the suspect had turned on the natural gas before officers arrived at his home. The surviving officer said the house exploded as he fired his CEW so we conservatively included this incident as CEW-causal.

2.1.2. *Case #4*

A deputy conducted a routine traffic stop on the suspect, a 52-year-old male. When the officer approached the suspect's van, he suddenly drove away. A short pursuit ensued until the suspect crashed and rolled the van. The suspect emerged from the van and tried to run away, so the deputy applied her CEW. As she did, the suspect's clothes caught fire. The deputy grabbed the suspect, pulled him to the ground, and rolled him into a creek, dousing the flames. Subsequent investigation revealed that the suspect had a fuel container in the van, which splashed him with petrol during the collision. The suspect suffered burns over about 70% of his body. He survived in a hospital for 181 days before he died from complications of the burn injuries.

2.1.3. *Case #5*

Officers received a 911 call of a man pouring petrol around his house and threatening to set it on fire. The suspect, a 47-year-old male, had a history of domestic disturbances with his family. According to family members, he had for months threatened to set fire to himself and his house. When officers arrived, they found the man outside in his car. He was holding a cigarette lighter as he poured petrol on himself and threatened to set himself on fire. He also claimed to have a bomb in the house. When he started to walk into the house carrying a container of petrol and the cigarette lighter, one officer tried to subdue him with pepper spray, but that

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