Jeffrey D. Ho
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Atlas of Conducted Electrical Weapon Wounds and Forensic Analysis

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The dedication of this book is clearly owed to my understanding family. My wife, Julie, and my daughters Kaitlyn and Kristen are incredibly tolerant in allowing me to spend time between the worlds of medicine, academia, and law enforcement. Without your support, I would be nothing.

Jeffrey D. Ho, M.D.

I am dedicating this book to my wife, Shandi, and my two daughters, Ella and Hannah. I am grateful for their love and their support of my many "careers."

Donald M. Dawes, M.D.

I would like to dedicate this book to the new members of my family: Audrey, Gabriel, Kurt, Niki, Renee, Sarah, and Tara.

Mark W. Kroll, Ph.D.

Preface

We conceptualized this book after receiving numerous requests over the years to consult with bodies of government, industry, public safety agencies, and the judicial system in cases involving wounds and forensic analysis related to conducted electrical weapons (CEWs). These cases are often emotionally contentious and typically involve allegations of civil rights violations surrounding perceptions of excessive force. To our surprise, we found that time and time again we encountered people that were very eager for some basic knowledge in this area. In several cases, there was confusion over what turned out to be an exaggerated claim. In some, there would be concern over an inability to make sense of the available forensic data. Still in others, it was clear that the only reason that a claim had been made was because of a well-meaning but uneducated statement made by a clinician or investigator early in the post-event analysis process that led to an expensive and unnecessary prolonged investigation and legal challenge. In all of them, there was a clear lack of uniform knowledge that was readily available on the subject.

Collectively as editors of this work, we have decades of experience in this field. Over the years, we have been unwittingly amassing a repository of scientific facts, real-time observations, prospective analyses, and retrospective anecdotes related to this subject. It was not until we realized this during informal discussions that we felt that we could help close this knowledge gap. In the areas where we did not have express expertise, we enlisted a strong cadre of fellow authors to assist in creating this book that is intended to be part text, part atlas, and all educational. Our intent is to make this knowledge available to those that need it most. We hope it does just that.

Within the last decade, the handheld conducted electrical weapon (CEW) has created a unique convergence of interest and knowledge within the fields of medicine, law enforcement, and biomedical engineering. These have combined to develop the modern CEW as an advanced technology. Several CEW ideas have progressed into mass production for use by the military, law enforcement officers (LEOs), and civilians. Over time, society has become more willing to accept the CEW as a tool that is common for use in repelling, controlling, and restraining violent or potentially dangerous persons.

This acceptance has not been without debate. Prior to 2003, there was little interest in knowing more about CEWs. This is likely due to the fact that although CEW technology had been around and available for decades, the CEWs available before that year were largely deemed to be of questionable utility and effectiveness (see Chap. 2 for more detailed historical CEW information).

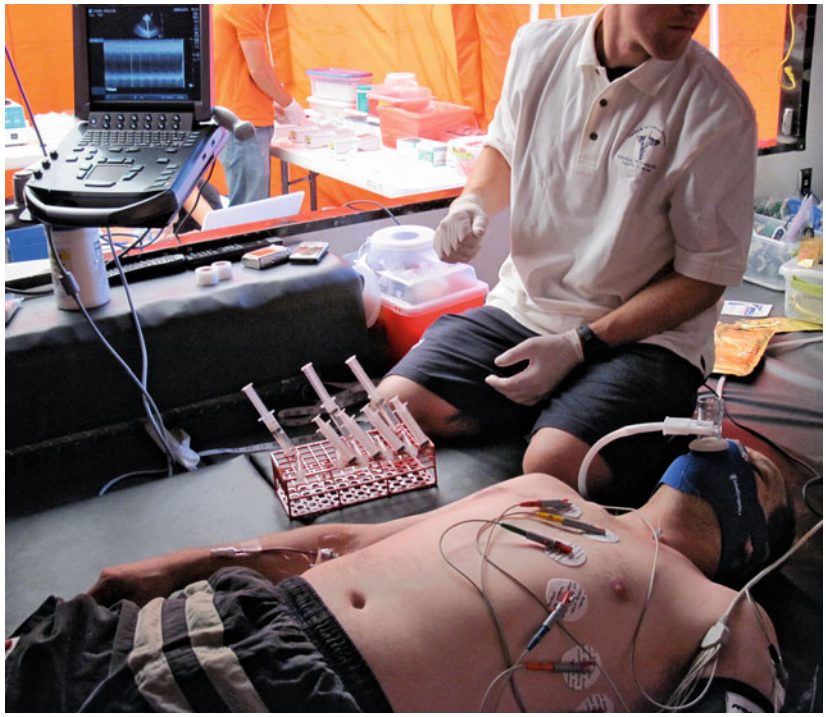

Fig. 1 A standard CEW human effect research study test involving several modern diagnostic tools to capture data on human effects

Because of this, there was no widespread acceptance or use of this technology by any single group or profession.

However, in 1999, this changed with the introduction of the Advanced TASER M26 CEW (TASER International, Inc., Scottsdale, AZ). Although the TASER CEW was originally meant for civilian self-defense purposes, this particular CEW was a near-instantaneous hit with LEOs because of its combination of skeletal muscle incapacitation and ability to be applied from a reasonable distance. It brought utility and effectiveness to the CEW marketplace and allowed an entire professional group to accomplish parts of their job in a manner that was deemed safer to both suspects and operators.

As CEW technology has matured, the knowledge about these devices has grown in depth and sophistication. Multiple studies, both animal- and human-based, have been performed to ascertain effect and safety. Over the past decade, many of these studies have focused on determining basic physiology associated with these devices. There have been a few groups of scientists that have been consistently successful at gathering useful data in these areas, several of whom are chapter authors in this text. Research groups such as mine (Ho and Dawes, et al., Minneapolis, MN) have been using modern medical diagnostic tools to answer CEW questions related to human physiologic effects (Figs. 1, 2, and 3). This has led to our involvement in helping to balance the ratio between desired effect and overall safety of the modern CEW.

Because much of our scientific work in the past 6 years has focused on basic science physiologic research, we felt that there was a lack of accessible

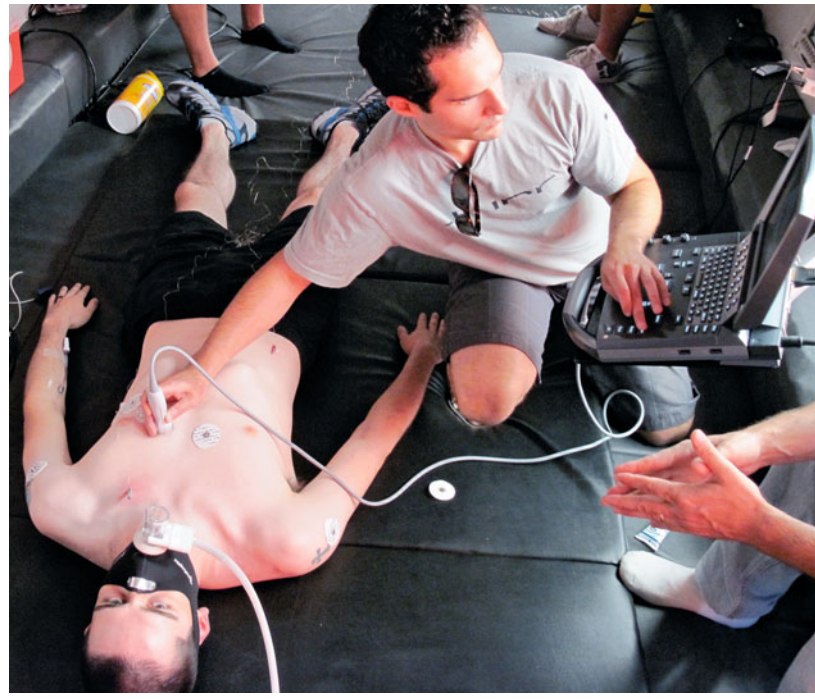

Fig. 2 Research use of echocardiography to determine real-time cardiac function during a CEW exposure to establish human effects

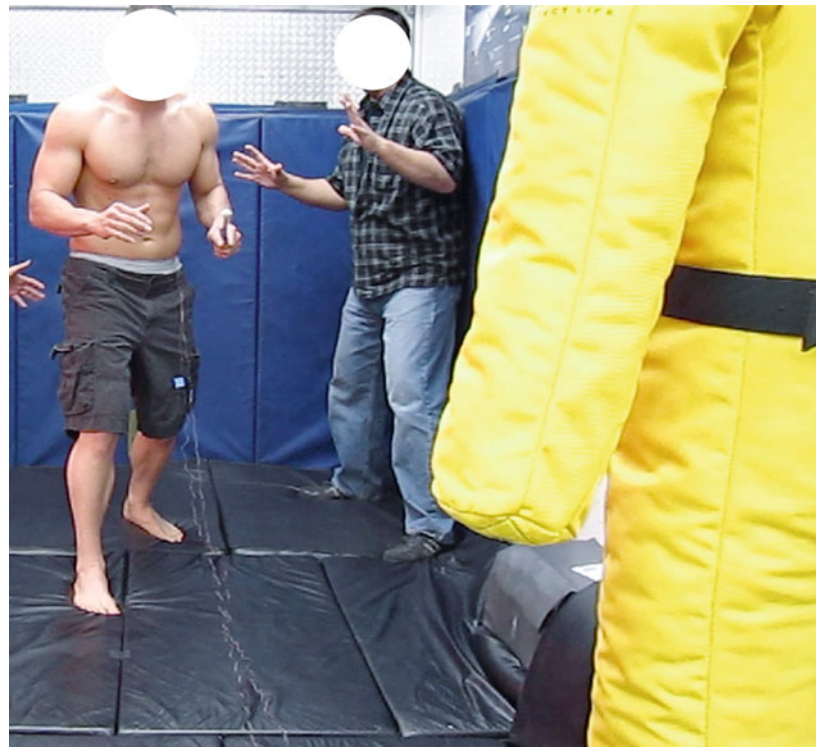

Fig. 3 Research involving a test of motivation during a CEW exposure to establish human effects (test subject attempting to inflict injury upon the yellow "dummy" with a rubber knife)

forensic information available on this subject matter. The overriding reason for this book was to fill the knowledge gap that currently exists. Therefore, we assembled a very specialized group of editors and authors who are subject matter experts.

The field of CEW technology involves extensive knowledge and understanding of many scientific as well as field-use principles and concepts. Because of this, we asked two of my good friends to join me in editing this text as well as authoring some of the chapters where we have expert command of the subject matter. The three of us combined bring a wealth of slightly different experience and knowledge to this project. Each of us has been extensively involved in the scientific proliferation of CEW knowledge for the past several years in many different ways. What was clear to us when we started this textbook idea was the fact that there are good sources of CEW information available in the form of manufacturer specifications, scientific research articles, and a comprehensive didactic textbook [1]. However, lacking was a good source of information for interpretation of CEW wounds, device analysis, and relevant case law. Despite this knowledge gap, there remained plenty of people willing to provide uninformed opinions about these topics. Unfortunately, these opinions have lead to needless investigations and frivolous litigation.

Perhaps one of the best ways to make this point is to provide a synopsis of a real case that demonstrates this as an example: In mid-2004, we was asked to evaluate a case that was winding its way through the legal system. The case ended in a confidential settlement that included a requirement to not identify it in future proceedings; therefore, all identifying information in this case has been omitted. It was a fairly simple case of a shirtless person that physically resisted attempts at control while being arrested by several police officers. The subject was not intoxicated but had a warrant for their arrest and did not want to go to jail. A short scuffle ensued, and the subject was placed prone on the ground where they continued to vigorously resist the police. The subject received a single drive-stun to the left calf as a measure of pain compliance, and this caused them to end their resistance. The subject was taken to jail without further incident. This incident was witnessed by bystanders and documented well by all the officers at the scene. The subject was evaluated at the scene by paramedic personnel for abrasions. The paramedic documentation—and the recollections of all witnesses and officers—was consistent with the single drive-stun to the left calf. At the scene, all witnesses and officers indicated that there was only a single drive-stun to the calf during the sequence of events. The CEW download showed a single trigger activation. Upon being released from jail 72 h later, the subject read a mass-media article about CEW technology and filed an excessive-force lawsuit. The subject stated in his complaint that the reason that he deemed it to be excessive was because when he was young, he was told that electricity was dangerous. Hence, he did not believe that it was safe to use electrical current to restrain someone. Furthermore, the suspect took photographs of multiple abrasions on his chest and the single drive-stun marks on his calf as "evidence" of damage caused by the CEW application. Despite fact that the abrasions were consistent with the reports that the subject was

shirtless and resisting wildly—while prone on the asphalt—and that the calf marks exactly matched the pattern and measurements of a single drive-stun, an attorney was found that also promoted the notion that the chest abrasions were caused by the CEW (from an unexplained mechanism). The attorney instructed the subject to obtain medical care to document the injury, and a physician (with no prior CEW knowledge) provided a diagnosis in the subject's medical record of "complex electrical burns to the chest." After 18 months of discovery and countless hours of work, the case was dismissed. Although the injury pattern and abrasions in this case did not support the allegations, this frivolous complaint was allowed to fester based upon a very uninformed physician. The knowledge of the complainant and the attorney is more difficult to ascertain.

It is exactly this type of case that we hope this text will address. We recognize that this text cannot provide images or discussion that covers every possible CEW usage scenario or allegation of misuse and that there can be variations on the topics that are discussed. However, we have chosen to put this information and these images out for easy accessibility in the hope that it will stimulate thoughtful discussion and analysis related to CEW application. The scope of work in this text is broad. It includes wound analysis, human forensic considerations of CEWs, and a historical as well as legal perspective for context, and much of this work is amenable to an atlas format style. We hope that this work provides a balance of clinical reality and academic theory. Along with the other two editors, we have had the good fortune of working with some prominent experts in this field, and the three of us have learned a lot more about these topics in working through the editorial process. We hope you enjoy reading it as much as we enjoyed putting it together.

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The Conducted Electrical Weapon: Historical Overview of the Technology

1

Paul C. Nystrom

The acronym TASER® is virtually a household word, thanks to media attention and many "YouTube" style clips like the now infamous "Don't Tase Me, Bro" segment [1]. However, there are many other conducted electrical weapons (CEWs) and manufacturers. CEWs come in many varieties and go by many names. They are also called stun guns, conductive energy devices (CEDs), electronic immobilization devices (EIDs), and electronic control devices (ECDs). Some of the earliest models were handheld-only devices that were supposed to be held on an individual and only had an effective range of arm's length. There are now short- and long-range projectile CEW models with more continuously being developed, and some developed in the past are no longer available. In addition, there are weapons that claim to be CEWs or sound like CEWs but are not CEWs at all. This chapter will provide a brief summary of CEWs and manufacturers. When learning about the forensic aspects of the CEW, it is important for the reader to understand that they may encounter different types and that they may have wounds that are dissimilar.

The law enforcement profession and the military are by far the largest markets for CEWs today. In fact, TASER International, Inc. (Scottsdale, AZ), as of April 9, 2012: sold approximately 590,000 to more than 16,700 law enforcement and military agencies in 107 countries.

However, there are also individuals who wish to carry these weapons because they meet a recognized definition of nonlethality [2]. In fact, the first CEWs were made primarily for civilian self-defense (e.g., TASER International, Inc. founded its company by selling to the public in 1994). It was not until projectile CEWs were developed that the law enforcement community became the biggest consumer of CEWs. This chapter will hopefully provide an understanding of the technology progression from its earliest stages to the present. Finally, it will discuss some unique CEW-like products that may be of comprehensive interest in this unique area of technology.

Early CEW Concepts and Resulting Products

Many products have come and gone, and this chapter will not dwell on the specifics of every CEW ever made. Most of the earliest models were variations of the same general theme. There are usually two small metal contact points, 9–13 mm (1/3–1/2 in.) in length, spaced approximately 2.5–5.0 cm (1–2 in.) apart on a small, handheld device. This type of CEW is intended to be pressed into the body of an individual so that an electrical shock can be delivered to cause pain

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Fig. 1.1 The "Space Thunder" handheld CEW

and possibly some degree of incapacitation. See Fig. 1.1 as an example. The electricity is often provided by standard 9-volt (V) batteries or similar small, sometimes rechargeable, power sources. Without any projectile component, these devices have an effective range of arm's length. They are still made today by any number of manufacturers and can be ordered from many online websites.

The biggest variations between these CEWs are in terms of the advertised voltage and the actual size and appearance. Little or no testing has been done comparing voltages and the actual claims of many of these CEWs. The voltage claims vary from roughly 100,000 to 5,000,000 V. Since air breaks down (arcs over) with about 75 kV (between sharp electrodes spaced 5 cm apart), any voltage claim beyond 75 kV is clearly incorrect. Hence, the advertised high voltages are designed to sell products and do not necessarily correlate with the actual output of the device. In any event, they will deliver some degree of shock to the target, but their reliability is questionable. The degree of incapacitation caused by that shock is also questionable (Fig. 1.2). Some CEWs claim that the attacker will be momentarily stunned, while others claim he or she will be unable to do anything but lie on the ground, unable to move for up to 30 min, while another has stated, "a 5-second shock can leave an attacker feeling as if he fell out of a two-story building and landed on a concrete sidewalk!" There is little data to back up any of these claims.

Some CEWs are the size of a large pen or small enough to fit into a cigarette box; others are disguised as a cell phone or flashlight. If you were to search the Internet, you would find CEWs shaped like "electric knuckles" as well as stun guns that look like a tube of lipstick, a cell phone, and other novel designs. Some are reported to be equipped with audible alarms or a disabling pin attached to a wrist strap that makes the CEW inoperable when the pin is removed. Stun batons are also available that use the same technology but position the metal electrodes at the end of a baton, similar to what some law enforcement officers carry. The purpose of the stun baton is to increase the effective range of the device. For many reasons, and essentially in any situation, being able to incapacitate an attacker from farther away is a safety benefit to the user. As will be discussed later, increasing the effective range of CEWs has been one of the biggest advances in CEW technology. Pushing the limits of effective range remains an active challenge to current CEW manufacturers. Unfortunately, attempts to obtain these devices for purchase and to contact the manufacturers/distributors by this author have not been met with success. Therefore, original images for this book are unavailable. This leads one to wonder if these devices are actually available for purchase and use even though they continue to be advertised for sale. Although far from comprehensive, to view several of these novel concepts, I recommend Internet searching the following terms for excellent examples that were available for viewing at the time of this writing:

- "Stun pen"
- "Electric knuckles"
- "Mini lipstick shocker"

An early CEW that gained popularity in the late 1990s was called the Myotron sold by

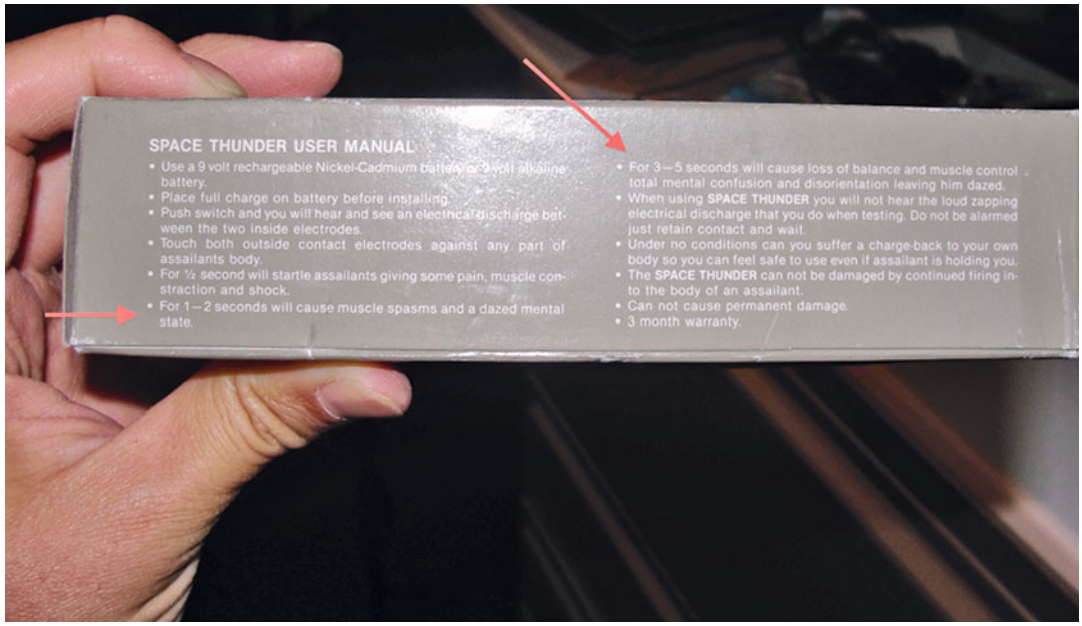

Fig. 1.2 The Space Thunder handheld CEW packing box advertising the unfounded claims of producing a "dazed mental state" with 1–2 s of application and "total mental confusion and disorientation" with applications of 3–5 s

Arianne International (Palm City, FL). It was advertised to override voluntary but not involuntary muscle movements and completely incapacitate an attacker with severe pain, leaving him or her dazed for up to 30 min. Part of the advertising also claimed that it was not a "stun gun." However, there were no apparent characteristics that distinguished it from other handheld stun guns. The manufacturer reported that the device "intercepts and neutralizes brain waves from the motor cortex (voluntary muscle control) and hypothalamic (aggression) regions of the brain" and produced no side effects. However, neither animal nor human subject testing was conducted. The Myotron is no longer available, but images of it can be viewed on the Internet [3].

All of the previously discussed CEWs are most limited in their application by effective range. The next generation of CEWs came on the scene in the early 1990s with the introduction of the first non-firearm TASER brand device and various similar products by other manufacturers.

With advances in technology, CEWs eventually became projectile in nature with the first significant increase in effective range beyond arm's length or the length of a baton. The pair of projectiles consisted of small metal darts (#8 straightened fishhooks) attached to a pair of thin insulated wires that carried the electrical current. The darts and wiring were encased in a replaceable cartridge. The first projectile CEWs used gunpowder, but this was quickly changed to an inert gas propellant to avoid issues of being classified as a firearm. Compressed nitrogen is the most popular propellant used today. Generally, the effective range was pushed to approximately 11 m (35 ft). Most projectile CEWs can also be used like early handheld devices after the projectiles have been deployed. The contact points that connect to the wires in the replaceable cartridge can be held on an individual and will provide an electrical pulse as long as the trigger is depressed (either manually or by built-in timing cycles that can be overridden by the user). In most cases, this provided some degree of pain compliance but not the skeletal muscle incapacitating effect that the projectile probes do.

An example of this technology advancement was the Dual Defense System. This was a projectile CEW made by the Bestex Company

Fig. 1.3 The packaging of the Dual Defense System (DDS) handheld device with 17-ft deployable probes as well as direct contact "stun gun" ability

(Los Angeles, CA) introduced in the late 1990s (Fig. 1.3). It used a gas propellant to fire the darts from a replaceable cartridge up to 5 m (17 ft). And similar to current projectile models, it could be used as a stun gun after the cartridge was expended. Interestingly, to achieve spread between the two darts, the Bestex cartridges deployed its top dart at an upward 4° angle and its bottom dart deployed at a 4° downward angle. Although still advertised online, it is no longer being produced.

Other examples of this technology advance are the CEWs sometimes advertised as "Titan Tasers" (Fig. 1.4) and "Mini Tasers." These are Asian-made CEWs from questionable manufacturer sources that can hold the original AIR TASER™ cartridges (AIR TASER will be discussed later in this chapter). Despite their names, the Titan and Mini are not brand products of TASER International, Inc. (the registered TASER trademark owner). They use 9-V batteries, come with an audible alarm and a wrist strap with disabling pin, and still work as a stun gun when the AIR TASER cartridge has been fired.

Defenders Network, Inc. (Thibodaux, LA) makes a CEW called the Raysun X-1 Multi Mode Police Weapon (Figs. 1.5 and 1.6). This product is

Fig. 1.4 The Titan Taser shown with a genuine TASER device cartridge. This CEW was designed to take advantage of currently available CEW cartridges (Reproduced with express permission of TASER International, Inc., Scottsdale, AZ)

Fig. 1.5 The Raysun X-1 as shown in a marketing brochure (Reproduced with express permission of the manufacturer, Defenders Network, Inc., Thibodaux, LA)