Case Report

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Extensive Hand Thermal and Blast Injury From Electronic Cigarette Explosion: A Case Report

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Abstract

Background: As the use of electronic cigarettes rises, more reports of injuries related to device explosion are surfacing. **Methods:** Presented here is the case of a 35-year-old man sustaining extensive thermal and blast injuries to his hand when the device exploded while he was holding it. He required multiple surgeries involving groin flap coverage, tendon transfer, and nerve grafting to optimize his postinjury function. **Results:** While much of his hand function has been restored, he has continued deficits in range of motion and sensation as a result of the incident. **Conclusions:** With increasing numbers of such injuries, hand surgeons must be aware of the blast mechanism involved so as to avoid missing deep soft tissue injury or disruption of deep structures, as demonstrated in this case.

Keywords: electronic cigarette, vapor, vaping, hand burn, explosion

Introduction

Electronic cigarettes (e-cigarettes), or electronic nicotine delivery systems, are becoming increasingly popular with as many as 15% of Americans reporting having tried them.[8] It has been proposed that the health risks associated with e-cigarettes may be less than with traditional tobacco cigarettes due to the reportedly lower levels of carcinogens.[4] There are, however, other potential safety risks unrelated to what is inhaled with vapor use. Due to the lithium battery used in most rechargeable e-cigarettes, there is a risk of device explosion resulting in blast-type injuries and burns, which is underreported by both e-cigarette manufacturers and the medical literature.

Such explosions have, however, been reported in the media. Most of these cases occurred when an e-cigarette exploded while recharging, causing property damage with associated injuries occasionally reported.[6] We present a case of a patient who sustained extensive hand blast trauma and burns when his e-cigarette spontaneously exploded immediately after replacing the lithium battery.

Methods

Case Presentation

A 35-year-old, right-hand-dominant male videographer with no significant medical history or prior hand trauma presented to the emergency department of our Level 1 Trauma Center after sustaining a blast injury to his right hand when his e-cigarette device exploded. He was using a Dark Horse atomizer with a SMPL Mec Mod battery device. He reported that immediately after changing the battery, the device began to rapidly heat up until it suddenly exploded while grasped between his right thumb and index finger. Workup and examination were significant for deep partial- and full-thickness burns to the volar aspect of his thumb and thenar eminence with a 1 × 1 cm open wound in the volar first webspace (Figure 1). There was also a palpable foreign body in the area of the thenar eminence. Neurovascular exam revealed adequate digital perfusion with appropriate capillary refill but decreased sensation to light touch and pinprick on the radial and ulnar aspects of the thumb and index finger. Motor examination suggested functionally intact flexor and extensor tendons. Plain film radiographs were consistent with multiple radiopaque foreign bodies in the soft tissue of the thenar eminence.

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Figure 1. (a) Initial injury. (b and c) Defects following initial debridement.

Surgical Course

The patient was taken urgently to the operating room for exploration of his wounds, foreign body removal, and debridement of devitalized tissue. Due to concern for impending carpal tunnel syndrome, he also underwent a carpal tunnel release. All visible foreign bodies, which were noted as copper colored and metallic in nature, were removed. During exploration, defects were noted in the radial and ulnar proper and common digital nerves to the thumb from approximately the interphalangeal joint down to the origin of the median nerve at the carpal tunnel. The radial proper digital artery to the thumb was also found to be missing an approximately 2 cm segment with visible blast injury to both the proximal and distal ends of the vessel. Due to the poor vessel quality and mechanism of injury, the thumb radial digital artery was ligated. The thumb ulnar digital artery was noted to be intact.

The patient underwent several serial debridement procedures over the next week resulting in partial debridement of the right abductor pollicis brevis, flexor pollicis brevis, adductor pollicis brevis, opponens pollicis, and the first dorsal and volar interosseous muscles as well as a full-thickness portion of the right flexor pollicis longus (FPL) and index flexor digitorum profundus with a final soft tissue defect of approximately 60 cm^2. Once a clean wound bed was achieved, a groin flap was performed for soft tissue coverage with subsequent flap division and inset 3 weeks later.

Five months after the initial injury, the patient uderwent surgery for transfer of the right flexor digitorum superficialis of the long finger to FPL tendon. Sural nerve grafting was performed to reconstruct the thumb ulnar and radial

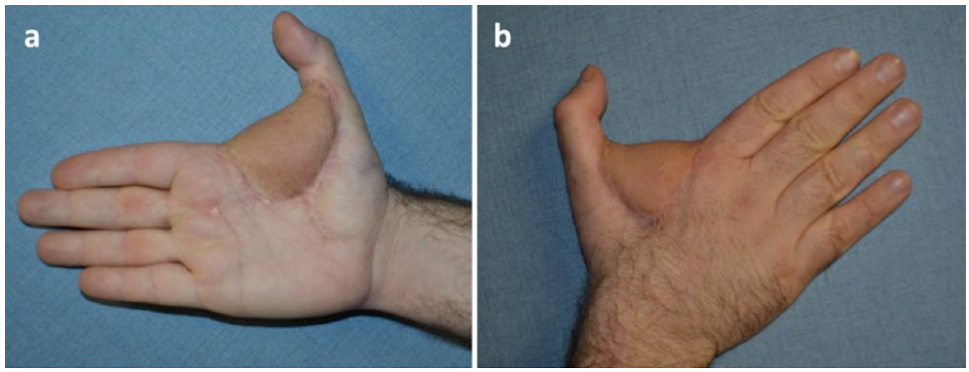

Figure 2. (a and b) Fifteen months after injury following groin flap, tendon transfer, and nerve grafting.

proper digital nerve. He also simultaneously underwent release of a scar contracture on a palmar scar with a 4-flap Z-plasty, flap debulking, and reconstruction of the thumb A2 and oblique pulleys using extensor retinaculum. Thirteen months after the initial injury, he required tenolysis of the FPL tendon and neurolysis of the ulnar proper digital nerve to the thumb with defatting of the flap.

Results

The patient is now 15 months out from the initial injury and 2 months out from his most recent revision (Figure 2). His thumb interphalangeal joint is fixed in 30° of flexion with no ability to actively or passively flex or extend. He does, however, have good range of motion of the thumb metacarpophalangeal and is able to oppose to the small finger metacarpal head. He continues to have decreased sensation on the radial aspect of the index finger and both radial and ulnar sides of the thumb with a positive Tinel at the base of the radial index finger and at the mid-proximal phalanx of the thumb on the radial and ulnar aspect. He is scheduled to undergo additional flap debulking in the first webspace with a thumb interphalangeal joint capsulotomy and tenolysis.

Discussion

Electronic cigarettes use, or "vaping," has become an increasingly popular nicotine delivery system.[8] This use has been promoted as a harm-reduction device both to aid in smoking cessation and as a safer alternative to traditional cigarettes due to lower levels of carcinogens. Despite these claims, relatively little data regarding their short- and long-term health implications are available.[4]

An additional potential harm of the device—blast injuries and burns due to e-cigarette explosion—has also received little attention in the literature. The media, however, has reported several such cases. Multiple local news sources have reported apartment or house fires as a result of e-cigarette explosion while the devices were charging. In some cases, patients sustained burns as a result of these fires.[1,10] Others present cases of intra- and perioral trauma from devices which exploded in their mouths with injuries including dental, palatal, and neck fractures.[3,10] Thigh and torso burns have occurred when e-cigarettes spontaneously explode in the user's pocket.[9,10]

In 2014, the Federal Emergency Management Agency (FEMA) published a statement including 25 reported e-cigarette explosions and fires, 9 of which resulted in injury. Only 2 of these injuries were deemed "serious" oral burns. Eighty percent of reported incidents occurred while the device was charging. Many devices use a universal USB charger which is interchangeable with many other small electronic devices. In some of the reported e-cigarette explosions, a USB charger other than that provided with the device was used for charging. FEMA advises e-cigarette manufacturers to utilize a charging device which is not interchangeable with chargers used for other electronics in an attempt to prevent this potential risk and also calls for clearer consumer warnings on packaging.[2]

There are only a few case reports and small case series describing injuries sustained as a result of e-cigarette explosions in the medical literature, none of which appear in hand surgery publications. Only 1 of 13 identified articles discusses an injury related to explosions in the hand. This case report involved a 24-year-old-male who sustained a blast injury to his long finger when an e-cigarette exploded in his hand. He ultimately went on to require amputation of the digit at the level of the metacarpophalangeal joint.[5]

While the design of e-cigarettes on the market varies greatly, most utilize a lithium battery to power a heating element, which vaporizes a liquid containing nicotine and often a flavor. Lithium batteries have previously demonstrated a phenomenon known as "thermal runaway." When this occurs, the exothermic chemical reaction between the

battery's electrode and its electrolyte set raises the device's temperature to a point where the heat generated far exceeds the rate of heat dissipation, eventually causing the battery to ignite or explode.[7] This phenomenon, however, is not commonly seen in other devices that use lithium batteries. It is unclear why e-cigarettes seem to be prone to this problem.

In this case report, we present a patient who sustained extensive trauma to his dominant hand when his e-cigarettes exploded shortly after changing the device's lithium battery. His injuries required 10 surgeries with extensive reconstruction including interpolated flap coverage, tendon transfer, and nerve grafting. This involved a total of 18 days of hospitalization and has left the patient with significant, lifelong impairment in his hand function.

While a few case reports appear in the medical literature and public media, the risk for severe thermal and blast injuries related to e-cigarette explosion has not been widely publicized. Electronic-cigarette consumers should be aware of this potential risk and any factors that might increase the likelihood of thermal runaway such as improper charging or battery change. This knowledge could prevent explosions from occurring or prevent injury by allowing users to recognize when a device is overheating and to move away from it prior to explosion.

Currently, e-cigarette devices do not come with product warnings related to the risk for overheating and explosion. Furthermore, the Food and Drug Administration currently does not regulate e-cigarettes, so there is no product quality or safety oversight and no product warning requirements. Such oversight and product safety labeling may help protect e-cigarette users.[11]

In the medical community, particularly among hand surgeons, understanding the combined thermal and blast mechanism of injury associated with e-cigarette explosion is critical for optimal evaluation and treatment of these patients. Such injuries may require urgent intervention to clear the wound of potentially harmful chemicals from the device or to address acute carpal tunnel or compartment syndrome. As demonstrated in this case, multiple structures and tissue types may be involved. Such injuries should be referred to and carefully evaluated by a hand surgeon to optimize functional and aesthetic outcomes.

Conclusions

Electronic cigarette use is increasing, as are reports of injuries sustained from device explosions. As reported in this case, such explosions in the hand can result in extensive thermal and blast injuries, which can require the expertise of a hand surgeon to reconstruct multiple tissue types and structures to optimize restoration of form and function.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was not required for this study as the patient present is not identifiable and no risk or harm was incurred by the patient as a result of the study.

Declaration of Conflicting Interests

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