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# Thermal injuries from exploding electronic cigarettes

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## ABSTRACT

**Introduction:** There are an estimated 2.75 million electronic cigarette (EC) users in the United States. ECs have become the most commonly used nicotine-containing product in young adults ages 18-24 years. Thermal, blast, and missile injuries from EC explosions has grown rapidly in recent years. Burn surgeons must remain up to date regarding management and treatment of burn injuries related to EC device ignition.

**Methods:** An IRB approved retrospective review of all patients admitted to the Massachusetts General Hospital Burn Center from January 2015 to April 2017 was performed. Fourteen patients with injuries associated with EC use were identified. Patient demographics, injury location, size and degree of burn, treatments required, length of stay (LOS), time to 95% closure, associated complications and injuries, and the circumstances that led to the injury were identified.

**Results:** The mean age was  $28.6 \pm 8.6$  years with a range of 19-50 years ( $n=14$ ). EC burns occurred in males 93% (13/14) of the time. The majority of EC explosions caused 2nd and 3rd degree burns (57%) within the same wound bed, followed by deep 2nd degree (29%), and superficial 2nd degree (14%). The average TBSA from EC burns was  $4.7 \pm 2.4\%$  with a range of 1-10%. The most common location of the device or battery at the time of the injury was a pant pocket 86% (12/14), followed by 7% hand (1/14) and 7% purse (1/14). Isolated lower extremity burns occurred in 43% (6/14) of patients, while lower extremity and hand burns occurred in 21% (3/14) of patients. Nine of 14 patients required an operating room encounter under general anesthesia. Eight of 14 patients required skin grafting for definitive wound closure. The mean hospital length of stay was  $6.6 \pm 4.7$  days with a range of 0-15 days. Time to 95% wound closure was  $18.4 \pm 10.8$  with a range of 8-40 days.

**Conclusion:** Thermal and blast injuries associated with EC device failure tend to cause small TBSA burns that are deep 2nd and 3rd degree wounds. The most common location for EC device storage among males was the front pants pocket. EC device users should be made aware of the dangers associated with EC use and advised to carry EC devices away from their body in dedicated carrying cases without loose metallic items.

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## 1. Introduction

Electronic cigarettes (ECs), or “e-cigarettes,” are devices capable of vaporizing nicotine-containing solutions that when exhaled resembles tobacco smoke. The devices are referred to by many different names, including “personal vaporizers,” “e-cig,” “vapes,” “vape pens,” “e-hookahs” and “tank systems.” Most designs consist of a liquid containing cartridge, a heating element, a flow sensor, and a lithium-ion battery to vaporize the solution without a combustion element. As of 2014 an estimated 90% of the world’s ECs are produced in mainland China where they were first invented and released in 2003 [1,2]. ECs were first sold in the United States in 2007 and prior to August 2016 they were not federally regulated, allowing companies to produce vaporizers with wide design variations [3,4]. In addition, personal vaporizer devices known as “mods” allow the user to swap out different commercially available parts, including batteries, further complicating design features. The devices range from \$30 to 300 dollars depending on homemade modifications, but all function to vaporize a nicotine solution, propylene glycol, glycerin and flavorings; and may contain unknown chemicals [5,6].

The use of ECs in the United States has increased significantly in response to television and online advertising [7,8]. The devices are marketed as a safer alternative to smoking tobacco or as a smoking cessation aid, despite lack of sufficiently powered long term research studies [9]. ECs in young adults aged 18–24 have become the most commonly used nicotine-containing product. In 2015 the United States spent an estimated \$3.5 billion on ECs [7,10].

Although there is research indicating that use of ECs can decrease traditional cigarette use, the vaporized solutions may pose a risk from unknown chemicals, and the devices themselves have been known to explode during use, while charging, or during storage and transport [2,11–13].

As of 2016 there are an estimated 2.75 million EC users in the United States [5]. While the devices are in widespread use and largely viewed as “safe,” the lithium-ion batteries that power them do pose a risk of ignition. ECs are different from other consumer electronic devices in that the battery sits within a sealed cylindrical device which is structurally weakest at each end. As the battery ignites, pressure within the device builds leading to rupture at the device’s end, causing a directed stream of energy that can propel the device or if restrained, direct thermal injury deeper into tissues [2].

A recently published article by Arnaout et al. reviewed 3 EC associated thermal injuries while providing a literature review which included a series of 3 patients treated at our regional burn center [14,15]. In addition, there have been published reports of ocular chemical injury from EC solutions, chemical burns, contact dermatitis from nickel, and blast and missile injuries involving injury to the oral cavity and cervical spine [16–21]. As EC associated burns have become increasingly more common in the literature, a grading system has been developed to categorize the injury [22].

Our institution is immediately aware of the dangers of ECs. Recently we have seen an increase in the frequency of EC associated burns to the thigh, perineum and hand requiring inpatient admission, local debridement and/or excision and

skin grafting. This current paper seeks to continue to define the injuries associated with EC use, which are different than injuries associated with traditional cigarette use. We also provide demographic and social data of patients with EC burns.

## 2. Methods

We performed an IRB approved retrospective review of all patients admitted to the Massachusetts General Hospital Burn Center from January 2015 to April 2017. The inclusion criteria included patients that sustained a burn from either their EC device or batteries used to power their EC device. Exclusion criteria included patients burned from traditional tobacco cigarettes, or chemical burns associated with EC nicotine solution. A retrospective review of our burn registry identified 14 patients with injuries associated with EC use. Patient demographics, location, size and degree of burn, treatments required, length of stay (LOS), time to 95% closure, associated complications and injuries, and the circumstances that led to the injury were identified. The mean with standard deviation and range was calculated for age, TBSA, hospital length of stay, and time to 95% wound closure. If a patient was discharged from the ED the hospital length of stay was considered 0 days. Any patient admitted to ED observation was considered to have stayed 1 day. One patient did not follow up and was excluded from the time to 95% closure statistic ( $n=13$ ). In addition, data regarding previous tobacco use, length of time using EC, reason for starting EC, and intent to quit following burn was sought for each patient.

## 3. Results

A total of 14 patients were identified with burns attributed to EC devices or EC batteries (Table 1). The mean age was  $28.6 \pm 8.6$  years with a range of 19–50 years ( $n=14$ ; Table 2). EC burns occurred in males 93% (13/14) of the time (Table 3). The most common location of the device or battery at the time of the injury was 86% pant pocket (12/14), followed by 7% hand (1/14) and 7% purse (1/14). Isolated lower extremity burns occurred in 43% (6/14) of patients, while lower extremity and hand burns occurred in 21% (3/14) of patients. Isolated upper extremity injuries occurred in 1 out of 14 (7%) patients. Four out of 14 (29%) patients had multiple burn injuries at differing locations involving the thigh, buttock, genitalia and/or hand. Bilateral buttock injuries were associated with carrying the device or battery in a back pants pocket (2/14), while genital burns were associated with carrying an EC device or battery in the front pants pocket (2/14).

The majority of EC explosions caused second and 3rd degree burns (57%) within the same wound bed, followed by deep 2nd degree (29%), and superficial 2nd degree (14%). The average TBSA from EC burns was  $4.7 \pm 2.4\%$  with a range of 1–10%. None of the EC burns required ICU admissions, with the majority (12/14) requiring floor admission for initial debridement and local wound care. One patient was immediately discharged from the ED with local wound care only, while another patient refused admission and was followed in clinic as an outpatient.

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