Blast Injuries Caused by Vape Devices: 2 Case Reports

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Blast Injuries Caused by Vape Devices

2 Case Reports

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Abstract: Vaporizing devices have become a popular alternative to conventional nicotine products. They are thought to be safer as they produce aerosolized nicotine powered by a lithium ion battery. Many people have used these electronic devices as a tool to quit smoking; however, the batteries can be unstable and explode.

We present 2 case reports where explosions of electronic vapor devices caused significant injuries. The first patient sustained a combustion injury to the maxilla resulting in bone and anterior maxillary tooth loss requiring reconstruction. The second patient had a severe blast injury to the hand which ultimately resulted in loss of a digit. Toxicology was consulted due to concerns for systemic absorption of metals in the soft tissue of the hand. Cobalt and manganese were initially elevated but decreased after surgical debridement. The patient did not have any systemic symptoms.

Currently, there is no federal regulation of electronic cigarettes or vape devices in the United States. With the increasing use of these devices and no standard regulations, we anticipate more blast injuries occurring in the future. Medical providers will need to be able to be prepared to manage the devastating clinical injuries that ensue.

Key Words: vaporizing device, blast injury, federal regulation of electronic cigarettes

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The use of electronic cigarettes and vape devices has rapidly increased over the last few years. It has become a popular choice for attempted smoking cessation due the lower amounts of carcinogens by 9- to 450-fold greater than conventional cigarettes.1 Increasing prices for nicotine products and the currently improving economy may also play a role in the shift to using electronic cigarettes. In 2013, consumers spent $642 million on electronic cigarettes; however, this is still less than 1% of total tobacco products sold nationally.2

China was the first to commercialize electronic cigarettes in 2003, and currently 2.5 million people in America that use these devices.4 During 2010 TO 2013, the use of electronic cigarettes doubled in current and former cigarette smokers.5 Electronic cigarettes and vaporizers are battery powered devices that distribute varying amounts of nicotine vapor. The device consists of liquid nicotine with propylene glycol or glycerin, stabilizers, a lithium battery power source, a heating element (an atomizer or cartomizer), and other elements that can be added by the user, such as flavoring additives.1

Lithium ion batteries are responsible for powering cell phones, watches, electronic cars, and medical devices. Nickel-cadmium batteries were replaced with lithium ion batteries starting in the 1970s providing a lighter powerful battery that can retain the charge for a longer period of time.3 They have a higher-energy density and are safer compared with older batteries. Lithium ion batteries have exponentially reformed technology but have their drawbacks. Modifications are constantly being made to make lithium batteries more powerful. However, more power makes the batteries more unstable.

Currently, there is no federal regulation or product safety testing on electronic cigarette or vape device batteries.7 Many people have attempted to modify these devices to increase the amount of vapor produced. By modifying the lithium batteries, the voltage can be increased producing higher amounts of vapor and nicotine.8 The voltage can range from 2.9 to 6.0 V and can reach up to 350°C.9 Often, these modified devices are homemade and are called personal vaporizers or Mods. Manufactured electronic cigarettes have built-in timers to prevent overheating; however, these are not present in the modified devices.4 This inherent lack of safety may lead to combustion of the chemicals in the device with the lithium ion battery.

We present case reports on 2 patients who sustained significant injuries secondary to vape device explosions. Both patients were using either a modified or mechanical vaporizing device which most likely led to an unstable chemical reaction with the liquid component of the device and the lithium ion battery.

CASE REPORT

Patient 1

Patient 1 is a 19-year-old healthy man who was admitted after sustaining a flash burn to the face secondary to a homemade vaporizer. He came into the emergency department as a trauma and was admitted to the step down unit for airway monitoring. On examination, he sustained a laceration to his tongue and buccal mucosa as well as had multiple chipped and missing maxillary teeth.

Diagnostic tests performed included an arterial blood gas, basic metabolic panel, coagulation panel, complete blood count, and urinalysis which did not show any abnormalities. A chest x-ray was obtained which was within normal limits and a panorex which showed anterior maxillary bone loss as well as loss of teeth numbers 8, 9, and 10. The injury was evaluated by oral maxillofacial surgery and an Erich arch bar was placed over the maxillary teeth. After 23 hours of observation, the patient was sent home with follow-up with the Oral Maxillofacial surgeons team.

One month after sustaining these injuries, he underwent right mandibular ramus graft to the anterior maxilla, extraction of impacted teeth numbers 1, 16, 17, 32, and excision of left neck epidermal inclusion cyst by the oral maxillofacial surgeons. Eventually, dental implants will be placed into the bone graft to restore the anterior maxillary traumatic tooth loss.

Patient 2

Patient 2 is a 24-year-old right hand–dominant man who was admitted after his commercially purchased mechanical vaporizer exploded in his right hand. According to the patient the specific type of electronic cigarette used was a Lone Wulf Mechanical Mod cigarette. Examination of his right palm revealed a 1.5-cm diameter defect
between his index and middle finger webspace involving full thickness skin and soft tissue loss with intact but ecchymotic dorsal skin. His middle finger was noted to be completely pale with no capillary refill (Fig. 1). Additionally, he also suffered 3% total body surface area deep partial thickness, second-degree burns to his chest and left forearm.

Plain films of the right hand revealed dense radiopaque foreign material scattered around the level of the index and small finger metacarpophalangeal joints extending to the dorsal wrist with subcutaneous air tracking to proximal forearm.

The patient was emergently taken to the operating room for exploration and washout of his hand and examination of his digital vessels to the middle finger. Intraoperatively, the common digital vessel to the index and middle finger was transected at the level of the bifurcation. The common digital vessel to the middle and ring was found to be thrombosed over a 4-cm segment with thrombus extending as far distally as the distal interphalangeal joint of the middle finger with no dopplerable signal to the middle finger (Fig. 2). As confirmed by Doppler signal, the index and ring fingers were only perfused by the border digital vessel. Finally, there were significant carbonaceous deposits correlating with the radiologic findings. These deposits had tracked along the flexor tendon sheath and neurovascular bundles on the volar surface and dorsally following the extensor tendons proximally to the level of the wrist crease (Fig. 3).

The medical toxicology consult service was contacted with concerns for systemic absorption of metals in the soft tissue of the hand. We were able to contact the manufacturer and obtain the material safety data sheet. Chemicals in the battery with respective percentages were as follows: aluminum foil (2–10%), nickel compound (0–25%), manganese compound (0–15%), cobalt compound (4–50%), styrene-butadiene-rubber (<1%), polyvinylidene fluoride (<5%), copper foil (2–10%), carbon (10–30%), electrolyte (10–20%), and stainless steel, nickel and inert materials. Proprietary compounds were not revealed, but are known to often contain oxides. This explained black staining of the tissue. Concentrations of copper, aluminum, lithium, cobalt, and manganese were obtained. The serum lithium concentration was also ordered because lithium batteries are common. The blood was obtained on day 3 of hospitalization and results were as follows: plasma cobalt, 16 μg/L (0–0.9); plasma manganese, 3.5 μg/L (<2.5); lithium, less than 0.1 mmol/L; serum copper, 114 μg/dL (70–140); aluminum, 4 μg/L (0–9). There were no other historical exposures which could attribute to these elevated concentrations. Because only the cobalt and manganese concentrations were elevated, they were repeated on hospital day 10, and cobalt decreased to 11.3 μg/L and manganese decreased to 2.8 μg/L.

The patient required four operations to debride devitalized tissue and to remove all the foreign materials. He ultimately required an amputation of his middle finger at the level of the metacarpophalangeal joint.

DISCUSSION

Although there is a body of literature investigating the potential harms and benefits of these devices, the focus has been placed on the efficacy of electronic cigarettes and vaporizers as smoking cessation aids as well as its overall health effect. Although more cases of vape and electronic cigarette injuries are being reported by the media, as of the time of this writing, there has been no publication in the medical literature describing the injury patterns seen when these devices explode.

Our surgical experience has demonstrated injury patterns that are similar to high-pressure injection injuries such as those seen with grease or paint gun injection injuries when they occur in the hand. Although

FIGURE 1. Patient 2 on presentation after vape explosion.

FIGURE 2. Patient 2 during initial debridement.

FIGURE 3. Carbonaceous deposits tracking along flexor and extensor tendons.
exploding lithium batteries in cellphones and laptops have been reported, the batteries associated with these devices are rectangular and encased in a sealed flexible plastic pouch. These devices are not encased in a cylindrical metal shell; therefore, they do not explode violently when they fail. The cylindrical shape of electronic cigarettes or vape devices combined with the mouthpiece creates a focused nozzle of escaping gas and particles of combustion. Additionally, when users modify these devices by adding more powerful batteries, the safety mechanisms that prevent overheating are often tampered or omitted altogether leading to a higher chance of exploding. When these devices explode, it generates a relatively concentrated area of direct thermal injury. This creates an entryway into the skin for the expanding gas and particles which explains the diffuse distribution of radiopaque substances in tissue planes far away from the point of injury. To date, we do not know the quantity of toxic chemicals that is introduced into the wound or the amount that would cause permanent toxic injury.

Our greatest experience with cobalt toxicity comes from metal on metal prosthetic hips. The cobalt can be systemically absorbed and cause hearing loss, visual impairment, hypothyroidism, rash, fatigue, paresthesias, and cardiomyopathy. In a case series of these patients, they had either elevated blood, plasma, serum concentrations (23–625 μg/mL), or they had exposure for months to years. Toxicity occurs when serum concentrations approach 100 μg/mL. Our patient had none of these signs or symptoms, a brief exposure with already declining plasma concentrations, and adequate renal function. These factors favor expedient elimination of the cobalt and less opportunity for toxicity.

The effects of manganese toxicity are neurological and psychological. Toxicity is seen in prolonged exposure of workers. It starts with visual hallucinations, behavioral changes, decline in cognition, and anxiety. Eventually, Parkinson-like findings, such as tremor, bradykinesia, and gait disturbances, can occur due to lesions in dopaminergic neurons of the globus pallidus. The best matrix for testing of manganese exposure is a whole blood concentration. The plasma concentration will be less than whole blood, but because the value in this patient was not very elevated and decreased on repeat testing, there was no further concern about body burden.

The decreasing concentrations were expected because decontamination of the soft tissue is a critical action in preventing toxicity. The patient did not have ongoing absorption of these metals, so further decontamination of the soft tissue was not recommended. Future testing for plasma metal concentrations is not needed unless symptoms develop. In general, there is no definitive indication for chelation. It was definitely not indicated in this asymptomatic patient with declining plasma metal concentrations. If this patient started to exhibit signs and symptoms of toxicity, debridement would have been the course of therapy.

Because these devices are relatively new to the US market, they are mostly unregulated. The majority of these products are manufactured overseas where the standards and quality control measures are unknown. The Food and Drug Administration is proposing to address only the health effects of inhaling the vapors but there is no requirement for the electronic or battery component of these e-cigarettes to be tested by a nationally recognized laboratory. In October 2014, the US Fire Administration investigated fires and explosions caused by electronic cigarettes and reviewed 25 incidents in the United States from 2009 to 2014. Although the majority of fires (80%) occurred while the device was charging, 2 serious injuries occurred when the devices exploded in the users’ mouth. In most instances, these fires are a result of using improper or non–manufacturer-supplied charging devices. Because there is no regulation on modifying electronic cigarettes, there have been an increased number of harmful explosions.

Regulations vary between different countries. Nicotine-based electronic cigarettes are not authorized for market sale in Canada, New Zealand, or Australia but are readily available in the United States. In France, they are regulated as medical devices and looked at as therapeutic devices used for smoking cessation. Many countries require a medical prescription for the use of electronic cigarettes or have made these devices illegal for any use.

There are currently 2.5 million electronic cigarette users in the United States and the number of users continues to rise. The use of these devices has steadily increased due to popularity and ease of accessibility. Without standard regulations for electronic cigarette and vaporizing devices, we anticipate that we will see more device explosions leading to devastating face and hand injuries.

REFERENCES