Electronic cigarette explosions involving the oral cavity

Rebecca Harrison, DMD, General Practice Residency, Palmetto Health, Columbia, South Carolina, USA
David Hicklin Jr., program director, DMD, Department of Dental Education, Palmetto Health, Columbia, South Carolina, USA

Electronic cigarettes (e-cigarettes) were introduced in 2007, and since that time 2.5 million Americans have begun using battery-powered personal vaporizers (1). The most common device resembles a traditional cigarette, called a cigalike, and is considered a first-generation e-cigarette. Later devices, which produce more vapor, include mods, e-hookahs, vapes, and vape pens (2). Regardless of the design, the same core components are present. A lithium-ion battery powers a heating element that atomizes a liquid solution creating a vapor that is inhaled. The heating coils are activated in two different manners: when the user inhales deeply on the mouthpiece or when the user depresses a button (1).

The pharmacologic properties of the addictive and toxic chemicals are difficult to assess given that many different e-cigarette designs (more than 250 brands are on the market) and liquid contents vary (3). The liquid solution consists predominantly of nicotine, flavoring, glycerin, and propylene glycol (1). Nicotine is the primary addictive ingredient in the liquid solution and has concentrations ranging from 0 to 87.2 milligrams per milliliter (3,4). Investigators in a 2014 study reported a discrepancy, by up to 50%, between the concentration indicated on the packaging and the concentration measured in the actual solution (4). Anabasine, nornicotine, and acetaldehyde can be found in e-cigarette liquids, and these chemicals possess additional addictive properties (3).

Carcinogenic and toxic chemicals such as formaldehyde are present in e-cigarette vapor (5). In the absence of quality standards, the consistency and ingredients of e-cigarette products are a noteworthy concern (4). The US Fire Administration (1) published a document entitled Electronic Cigarette Fires and Explosions in 2014. At the time of publi-
cigarette. The November 2015 fire and explosion case involv
tective unit has a better battery
is used to charge the batteries” (1). Although it has been con
charging unit. This helps to ensure that a proper power supply
that are removed from the vaporizer and placed in an external
the PVs [personal vaporizers] and mods use larger batteries
had been reported. The document stated, “Most of
was in use (1). Also, at the time of the US Fire Administra
tion-reported case involving the
mouth occurred in November 2011 and involved a Colorado
man who spent 8 days in the hospital after his mouth, face, and
eyes were burned with debris and battery acid. The second case
documented by the US Fire Administration occurred in Febru
ary 2012 and involved a Florida man who lost teeth and part of
his tongue after an e-cigarette explosion (1).

Only two events involving the oral cavity have been docu
mented officially by a federal agency; however, an internet
search results suggest that e-cigarette explosions involving
the oral cavity are occurring more frequently. Five events in
the United States have been reported on the internet since
the publication of the document by US Fire Administration in
October 2014. The five events occurred in Georgia, Colorado,
Arkansas, and Florida between September 2015 and Novem
ber 2015 (6-10). Events outside of the United States have been
reported in the United Kingdom and Canada (11,12).

The most commonly documented injuries to the oral cavity
after an e-cigarette explosion include intraoral burns, luxa
tion injuries, and chipped and fractured teeth (6-8,10). Of the
five cases, three had concerns outside of the dentition (6,7,9).
One man sustained a dime-sized hole in his hard palate, caus
ing a communication between the oral and nasal cavities. At
the time the report was written, the patient was awaiting a
prosthesis to occlude the oronasal communication to prevent
nasal regurgitation during eating and to aid in speech (6). An
other person, listed as being in critical condition, sustained a
spinal fracture, which may prevent him from walking again
(7). Internal burns are a serious consequence of an e-cigarette
explosion; one man was placed in a medically induced coma
because of respiratory tract burns (9).

Eighty percent of the explosions the US Fire Adminis
tration reported occurred during charging; however, the
events involving the mouth occurred while the e-cigarette
was in use (1). Also, at the time of the US Fire Administra
document, no explosions with associated fires related
to mods had been reported. The document stated, “Most of
the PVs [personal vaporizers] and mods use larger batteries
that are removed from the vaporizer and placed in an external
charging unit. This helps to ensure that a proper power supply
is used to charge the batteries” (1). Although it has been con
jectured that the external charging unit has a better battery
design (1), it is evident that mods may not be safer devices; in
the case we report below, the patient was using this type of e-
cigarette. The November 2015 fire and explosion case involv
ing the Colorado man also was caused by a mod (7).

Many consumer products are required to be tested by a na
tionally recognized organization, such as UL (formerly known
as Underwriters Laboratories) (1). However, e-cigarettes are
not required by law to undergo product safety testing. Al
though no specific regulations are in place, an e-cigarette user
could opt to use a battery that has been tested and certified
by UL, because UL developed lithium-ion battery standards.
Consumers also can decrease the chance of a lithium-ion bat
tery explosion or fire by following the manufacturer’s instruc
tions for charging the battery and only charging it with the
unit that was sold with the e-cigarette. E-cigarette users also
should be aware that the battery should not be charged with a
standard USB port because the voltage and current provided
can vary greatly. Instead, they should use the USB port and
connection device provided by the manufacturer of the e-
cigarette. The use of nonapproved power adapters appears to
be responsible for most incidents, because the battery is sub
jected to a higher current than is safe and ultimately can result
in an explosion or fire (1).

Case report
A 28-year-old man, with no relevant medical history aside
from smoking, was transported via ambulance to the emer
gency department of a level I trauma center in South Carolina
after an e-cigarette explosion and fire. The patient reported
uneventfully using the e-cigarette for 11 days from December
25, 2015, to January 4, 2016. On January 4, the e-cigarette
unexpectedly exploded and burst into flames. The patient was
using the e-cigarette as a smoking cessation aid at the time,
as he switched from traditional cigarettes to e-cigarettes in
an attempt to titrate his nicotine consumption down. On the
day of the event, the patient charged the lithium-ion battery
in a standard 120-volt outlet in an external charging device
that was purchased separately. After a standard charge cycle,
the patient inserted the batteries into the device, placed the
mod between his lips, and depressed the button. The patient
described feeling a warm sensation in his right hand and see
ning a bright light, followed by severe pain in his mouth. The
patient then realized that his e-cigarette had exploded, and he
had to act to control the fire that ignited his clothes hamper
and bedding. After he extinguished the fire, the patient was
driven by a private vehicle to a regional hospital.

After seeking care at an outlying hospital, the patient was
transported via ambulance to a facility equipped with a trau
ma team. On admission to the emergency department, the
trauma team evaluated and stabilized him. The preliminary
concern was airway security. However, the patient’s respira
trory tract was unaffected by the explosion, and the patient
was maintaining 100% oxygen saturation with room air. The
trauma team ordered computed tomographic (CT) scans and
radiographs to assess the trauma to the anterior maxilla and
to evaluate the oral cavity and gastrointestinal tract for potential foreign bodies. Specifically, the trauma team ordered abdomen and chest radiographs, CT scans of the facial bones without contrast material, CT scans of the cervical spine without contrast material, and CT scans of the head without contrast material. The CT scans and radiographs indicated that no foreign bodies were present and helped confirm the need for a dental consultation.

The dental resident and attending on-call performed an intraoral clinical examination that revealed that teeth nos. 8 and 10 were either avulsed or fractured along the root surface, tooth no. 9 was luxated palatally, and tooth no. 7 was subluxated (Fig. 1). The CT scans verified the avulsion of tooth no. 10 and the trauma to teeth nos. 7, 8, and 9 and the maxillary alveolar bone (Figs. 2 and 3). The trauma team consulted the oral and maxillofacial surgery department, and they confirmed the diagnoses reached by the dental resident and attending on-call. Lastly, the trauma team consulted the speech pathology department to conduct a swallow study, but the patient refused the test because he was swallowing secretions with no difficulty. At the time of discharge, the patient’s only concerns were related to the oral cavity. The trauma team devised a plan to provide follow-up dental care in an outpatient setting.

Fig. 1. Initial appearance in the emergency department, with the patient displaying burns to the dorsal surface of the tongue, maxillary gingiva, and mucosa.

Fig. 1. Patienten netop ankommet til traumecenter med forbrændinger på tungeryggen, gingiva og mundslimhinde.

Fig. 2. Sagittal CT scan showing multiple alveolar fractures.

Fig. 2. Sagittal CT-scanning viser multiple alveolære frakturer.

Fig. 3. Sagittal CT scan shows tooth no. 9 displaced from the socket.

Fig. 3. Sagittal CT-scanning viser +1 displaceret fra alveolen.
E-cigarettes are a new nicotine-based product with a novel delivery system and have the potential to affect public health significantly. E-cigarette explosions and fires pose unforeseen risks and may cause damage to the dentition and soft tissues of the mouth.

**Findings**

As a result of the explosion, the patient received the following injuries:
- tooth no. 7: subluxated;
- tooth no. 8: 5 millimeters of root apex present in the socket after a root fracture;
- tooth no. 9: lateral luxation 6 mm to the palate and extruded 4 mm;
- tooth no. 10: avulsed;
- multiple fractures of the maxillary anterior alveolus;
- burns on the dorsal surface of the tongue: coagulation necrosis of the superficial tissue;
- burns of the maxillary anterior gingiva and mucosa: diffuse sloughing with frank ulceration;
- sensitivity associated with teeth nos. 6, 7, and 11 from concussive injury.

The dental treatment of this e-cigarette explosion required immediate, interim, and long-term treatment plans. The initial treatment was delayed 3 days to allow the lips and gingiva to heal because the oral mucosal lesions were too painful to begin addressing dental concerns immediately (Fig. 4). The patient rinsed with saline and 0.12% chlorhexidine until any treatment commenced. Because of the pain associated with the intraoral burns, we administered systemic analgesics and educated the patient about preventive measures. The patient was to avoid hot, spicy, and acidic foods and beverages. We recommended a soft diet and the avoidance of carbonated and alcoholic beverages. We obtained periapical radiographs (Fig. 5). We removed tooth no. 9 and the remaining portion of tooth no. 8 by using elevators and forceps with local anesthetic. We noted multiple fractured segments of alveolar bone within the traumatized maxillary segment. We irrigated the extraction sites with copious amounts of saline and sutured with 4-0 chromic gut sutures. Tooth no. 7 had decreased mobility compared with that of other teeth. We removed tooth no. 7 due to subluxation.
the day of the event, but the tooth was in hyperocclusion. We adjusted the occlusion as indicated to reduce excessive forces on tooth no. 7. We discussed the need to perform ongoing pulp testing and possible endodontic therapy for teeth nos. 6, 7, and 11. We reviewed oral hygiene procedures at this appointment, with the instructions to brush the unaffected teeth carefully while avoiding the ulcerated and necrotic areas, and the patient continued the 0.12% chlorhexidine rinse for 2 weeks.

The patient returned 16 days later (Fig. 6) for alginate impressions for interim maxillary partial fabrication. The dorsal surface of the tongue was healed almost completely (Fig. 7). He then returned for the delivery of the wire and acrylic partial (Fig. 8). The patient is expected to be in this interim prosthesis for approximately 4 to 6 months when we will evaluate him for implant prosthetics.

Discussion
E-cigarettes are not under the authority of the US Food and Drug Administration (FDA) but are considered to be a tobacco product under US law. This essentially means e-cigarettes have been marketed, sold, and consumed in an unregulated environment with little evidence of short- and long-term effects (2). An example of an e-cigarette liquid component lacking definitive safety data is propylene glycol, the chemical found in theater fog machines. This organic chemical is responsible for generating the e-cigarette vapor and accounts for 66% of the fluid content. The FDA deemed propylene glycol to be generally recognized as safe more than 60 years ago (13). However, documented adverse effects of propylene glycol include mouth and throat irritation, dry cough, central nervous system effects, behavior changes, and spleen damage (3,5). The adverse effects could be more severe than documented because propylene glycol has never been studied under the conditions of use in e-cigarettes. There are no studies that specifically simulate the duration, inhalation, and frequency of use (5). However, investigators in other studies have documented the following health consequences associated with e-cigarette use: elevated heart rate and blood pressure, airway inflammation, impaired immunologic response, impaired bac-

25 dage efter eksplosionen

25 dage efter eksplosionen

Fig. 8. Appearance of the maxillary partial in place 25 days after the explosion.

Fig. 8. Midlertidig partiel protese i overkæben 25 dage efter eksplosionen.
terial phagocytosis, ulcerative colitis, lipid pneumonia, and subacute bronchial toxicity (2).

Another adverse effect that remains unstudied is second-hand and third-hand exposure. The high concentration of the nicotine found in some e-cigarette liquids can increase exposure risks to nonusers, particularly children. The residual nicotine found on indoor surfaces can lead to third-hand exposure because it can remain on surfaces for weeks to months. Another risk that e-cigarette liquids pose to children is accidental ingestion. Poison control has reported an increase in unintentional nicotine ingestion, particularly by children (4).

The largest growing population of e-cigarette users is adolescents. Many investigators have identified factors such as aggressive marketing, social media, tempting flavor choices, and the ability to obscure use (2). A history of tobacco use is the strongest risk factor for e-cigarette use among adolescents; however, some nicotine-naïve adolescents initiate e-cigarette use. It is this population of approximately 160,000 that represents a growing public health concern (2). It is for this reason that e-cigarettes are speculated to serve as a gateway drug (5). Adolescents experimenting with e-cigarettes may develop nicotine dependence inadvertently and then transition to using traditional combustible tobacco products (2).

Young adults have become the second largest population of e-cigarette users. In contrast to the adolescent population, young adults are turning to e-cigarettes as a smoking cessation aid. E-cigarette manufacturers make no therapeutic claims about serving as a nicotine replacement therapy; therefore, the FDA does not regulate them as a replacement therapy (5). Despite this fact, many people still may view e-cigarettes as a reasonable alternative to smoking traditional tobacco cigarettes.

Investigators in one uncontrolled cohort study found that at a 6-to-24-month follow-up, 10% to 50% of people who used traditional cigarettes, but the data are deficient (4).

The findings reported in the literature are conflicting about the effectiveness of smoking cessation because variable factors such as type of system, liquid concentration, battery voltage, puff length, intervals between puffs, and user characteristics in the articles differ. E-cigarettes have potential advantages over traditional combustible tobacco products (2).

Although some may assume that e-cigarettes are a safer alternative to traditional tobacco cigarettes, this viewpoint may be unsubstantiated because the short- and long-term health effects are essentially unknown. The negative health consequences of nicotine use are well known and include carcinogenesis, cardiovascular disease, teratogenicity, and toxicity (5). The use of e-cigarettes compounds the negative effects of nicotine with the unknown factor of the likely harmful constituents such as aldehydes, metals, volatile organic compounds, and reactive oxygen species that are not found in tobacco smoke (2). Only limited data are available about the effects of long-standing exposures to aerosolized nicotine, propylene glycol, and flavorings (5). Essentially, evidence of the decreased harm of e-cigarettes compared with that of traditional cigarettes with long-term use is not available. There are considerable discrepancies in the health-effects research and data for e-cigarette use (4).

Conclusions
E-cigarettes are a new nicotine-based product with a novel delivery system and have the potential to affect public health significantly (4,5). E-cigarette explosions and fires pose unforeseen risks and may cause damage to the dentition and soft tissues of the mouth.


Disclosure. Drs. Harrison and Hicklin did not report any disclosures.

**ABSTRACT (DANSK)**

Eksplosion af elektroniske cigaretter involverer mundhulen

**Baggrund** – Brug af elektroniske cigaretter (e-cigaretter) er hastigt voksende i hele USA. E-cigaretter er forbundet med risiko for eksplosion og brand.


**Konklusioner og praktiske implikationer** – Denne kasusstik giver klinikerne større viden om e-cigaretteres opbygning, brug og risici; risikoen for spontane fæl og eksplosion af e-cigaretter bør diskuteres med patienten, også for at forstå behandlingsudfordringer ved en e-cigareteksplosion.
Literature


