Maxillofacial injury related to an exploding e-cigarette

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SUMMARY

Electronic cigarettes (also known as e-cigarettes or electronic nicotine delivery systems) were invented in China in 2003 then introduced to the British market in 2007. They remain popular among the public and are deemed to be effective in reducing tobacco smoking (the UK being one of the first countries to embrace them in a harm reduction policy). However, reports in the media of e-cigarettes exploding are of concern, considering the potential functional and psychological impairment that lifelong disfigurement will cause, especially given their uptake among people of any age. We present a case of this rare, but dramatic, effect of e-cigarette use as a warning to the public.

BACKGROUND

Many years from the introduction of electronic cigarettes, we become aware of many more associated risks. This case is a warning to the public: the electronic cigarettes are not without risks and the cases of battery-related explosion are increasing with their increased popularity and diffusion.

While the doctors need to become accustomed to these potentially life-threatening presentations, we also want to shine a light on the thermal runaway risk inherent to lithium-ion batteries, which are ubiquitous in many electronic devices. We hope that lawmakers at national and European level will listen to these concerns and reduce the risk by altering the current technology or developing a new one.

CASE PRESENTATION

A previously fit and well 19-year-old boy was transferred to the regional Major Trauma Centre from a local trauma unit after the e-cigarette he was using, without warning, exploded in his mouth (figure 1). The noise was loud enough to alert his brother who attended his room, gave him first aid and called for an ambulance.

On his arrival at his local trauma unit, it was clear he had suffered a significant hard and soft tissue injury to his oral cavity, in particular to his anterior left maxilla, but he was able to maintain his airway and his vital observations were normal. In addition, he had epidermal burns to the surrounding face, including the lips and upper chest, yet surprisingly, his upper lip sustained minimal soft tissue damage only although it had become oedematous.

As the patient presented with signs of inhalation injury (hoarse voice, facial and oral burns, carbon deposits in his mouth), he was intubated, and intravenous fluid administration was commenced followed by further examination to rule out occult burns (figure 2).

INVESTIGATIONS

More detailed examination at this stage followed by a CT head, neck, chest, abdomen and pelvis showed this to be an injury isolated to the upper jaw, but with obliteration of the alveolar bone in the left anterior maxilla and shattering of the upper left central and lateral incisors and decoronation of the upper left canine and first premolar with associated root fractures (figures 3 and 4). The associated gingivae and oral mucosa were both burned and lacerated, but the lip continuity was preserved. The bony injury neither extend into the nasal floor nor were any missing teeth noted in the upper aerodigestive tract on the CT scan.

TREATMENT

He was subsequently transferred to the Major Trauma Centre within 90 min. He remained stable throughout his transfer and during our trauma survey and was reviewed by the oral and maxillofacial team before being transferred to the intensive care unit. The following day, he underwent

Figure 1 A photograph of the e-cigarette minutes after the explosion.

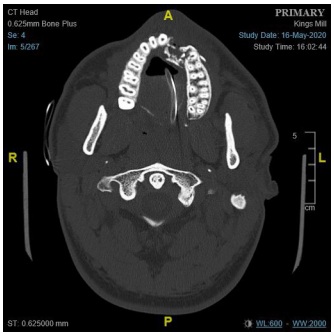

Figure 2 CT imaging showing the maxillofacial injury.

debridement of the comminuted maxillary fracture, removal of four teeth and closure of his intraoral wounds.

OUTCOME AND FOLLOW-UP

He was extubated without incident the day after surgery and was discharged 24 hours later with broad-spectrum antibiotics for 5 days and a soft diet. He will be followed up by the oral and maxillofacial team and his dentist for dental rehabilitation

DISCUSSION

E-cigarettes, in their most basic form, are composed of a battery (mainly lithium-ion, due to their ability to store large amounts of energy in a compact amount of space), heating element and vaping liquid. Their primary cited benefit has been focused on their chemical composition: since they do not burn tobacco, they avoid carcinogens and other toxins contained in tar and vapour-phase toxins such as carbon monoxide,[1 2] while the nicotine itself is not a significant health hazard, excluding the addiction it causes. There is evidence that electronic cigarettes contain other toxic substances like small amounts of formaldehyde and acetaldehyde, which are carcinogenic to humans and, in some cases, vapour contains traces of cadmium, nickel, lead and carcinogenic nitrosamines but evidence is lacking on regular exposure over many years.[3]

Concerns related to other health and safety conditions related to e-cigarettes (e-liquid ingestion/poisonings, fires and battery explosions) have been growing in recent years: the lithium-ion batteries pose an inherent and well-recognised risk of fire and explosion especially when heated. This problem is principally caused by a reaction called 'thermal runaway.'[4]

Figure 3 A 3D reconstruction showing the acute comminuted displaced fracture of the alveolar process of the left maxillary bone resulting from the device's explosion.

Figure 4 The patient upon his arrival at the trauma centre. Note the soft tissue injury.

This phenomenon occurs when a battery's cell achieves elevated temperatures due to thermal failure, mechanical failure, internal/external short circuiting and electrochemical abuse (from overcharging or overdischarging the cell). At these elevated temperatures, exothermic decomposition of the cell materials begins. Eventually, the self-heating rate of the cell is greater than the rate at which heat can be dissipated to the surroundings, the cell temperature rises exponentially, and stability is ultimately lost, thus resulting in thermal and electrochemical energy being released to the surroundings in the form of a fire or explosion.[5 6] Given the distribution of those batteries and the variety of devices using them, reports of exploding batteries and recalls due to safety concerns appear on the news from time to time, with the latest involving tech giant Samsung and the multinational aerospace corporation Boeing.[7–10] Such a reaction appeared to occur in the case we have described resulting in a significant maxillary injury that will require multiple procedures to correct.

Their explosions, as noted in the available literature, have caused mostly flame burns, contact burns, chemical burns and blast injuries, with damage to hands, thigh, groin area and genitals' soft tissue and/or bony injuries, as the e-cigarette often explodes while in the patient's hand or pocket.[5] However, in a minority of cases, it exploded while in the patient's mouth, causing a variable range of injuries: maxillofacial injuries, ocular injuries,[11] c-spine fractures,[12] traumatic tattooing and facial burns complicated by exposure to the chemicals from the battery and even a fatal projectile wound to the head.[13 14]

Although rare, e-cigarette explosions are a growing concern due to the increased popularity of these devices and the devastating injuries that they can cause. Furthermore, the risks of 'thermal runaway' seem to be little acknowledged by both the British and European regulatory bodies that govern the safety of the batteries in these devices and their contents[15 16]. Similar concerns have been shared in many US papers. The true incidence of facial injuries related to exploding e-cigarettes is not known as only isolated case reports exist, but by their very nature, the risk of oral injury is significant, and so design changes, which include overcharging protection circuits, thermal power cut-offs and internal overpressure relief mechanisms that can help prevent 'thermal runaway', are needed immediately.[17] The inherent safety drawbacks of lithium-ion batteries seem to

Patient's perspective

The patient had a very traumatic experience. We asked him to provide insight. This is what he described:

How I felt, after waking up from what happened, I did not feel the same, almost did not feel real.

The pain was horrifying and almost like a nightmare; as soon I was told I could leave and make my way home, after coming into the house where it happened, it was very daunting, a flush of a sick feeling overcame me.

Learning points

- E-cigarettes explosions can cause thermal and/or chemical burns, blast injuries depending on where they were located (pockets, hands, mouth).
- As per Advanced Trauma Life Support (ATLS) teaching, consider the possibility of airway compromise in facial burns and consider early intubation.
- Keep in mind the indicators of inhalation injury: lost teeth, smoke inhalation, foreign objects are all possibilities in a situation like the one we described.
- The phenomenon of 'thermal runaway' resulting in overheating of the battery is responsible for e-cigarette explosions and can cause thermal and chemical burns and blast injuries.
- There is a risk of airway compromise from an exploding e-cigarette, which can be caused not only by the burning of the airways but also by dislodgement of nearby teeth, fragmented bone and debris from the device itself.
- The e-cigarette industry should actively pursue technological solutions that mitigate against the risk of fires and explosions related to their devices.
- Battery producers should seek new technologies that avoid the inherent danger of lithium-ion batteries.

be at the heart of the problem, but without a safer and more efficient alternative, they will be part of our lives and our portable and non-portable devices for the foreseeable future.

Contributors ALV wrote the case report and reviewed the literature on the subject. ROC reviewed the drafts and added his contribution to the discussion on the patient's therapy and outcome. The work was supervised and reviewed by RF and AB.

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