ORIGINAL RESEARCH LETTER

Severe acute respiratory distress syndrome requiring extracorporeal membrane oxygenation support: a consequence of vaping

To the Editor:

Since the emergence of electronic cigarette products on the retail market just over a decade ago, there has been an exponential rise in their use, particularly amongst young adults [1] and the global market is now estimated by Euromonitor International to be worth $19.3 billion, up from $6.9 billion 5 years ago [2]. Despite being marketed as a safer alternative to traditional cigarettes, "vaping" generates aerosols containing a heterogenous mix of potentially harmful substances and pulmonary disease related to vaping has been identified in recent case clusters [3–5].

We present the case of a previously fit and well man in his 40s who attended the emergency department with a 10-day history of coryzal symptoms, pleuritic chest pain and worsening shortness of breath. His only medical history was an appendicectomy. He reported a 20-pack-year cigarette smoking history, cannabis use in the distant past and occasional binge drinking of alcohol. He had ceased smoking cigarettes 6 weeks previously and had commenced the regular use of a peppermint-flavoured vaping device as an aid to ongoing smoking cessation. His vaping device contained 18 $mg \cdot mL^{-1}$ nicotine without tetrahydrocannabinol (THC).

On arrival to hospital he was normothermic, hypoxic and tachycardic. The emergency department physicians noted halitosis. His initial chest radiograph demonstrated a large bulla in the right lower zone, and opacification of the right lower zone and lingula. Within hours of presentation, he required intubation and mechanical ventilation, and he continued to deteriorate over subsequent hours, developing severe acute respiratory distress syndrome (ARDS) necessitating venovenous extracorporeal membrane oxygenation (ECMO).

At the time of instituting ECMO, <24 h after hospital presentation, the patient was *in extremis*, with an arterial oxygen tension of 6.1 kPa, on maximal ventilatory support with 100% inspired oxygen, and profoundly acidaemic, with a pH 6.99, arterial carbon dioxide of 11.1 kPa and a lactataemia of 7.8 $mmol \cdot L^{-1}$. There was significant cardiovascular instability with a heart rate of 120 $beat \cdot min^{-1}$ and mean arterial blood pressure of 55 mmHg on noradrenaline 0.8 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and adrenaline 0.2 $\mu g \cdot kg^{-1} \cdot min^{-1}$.

Computed tomography (figure 1) demonstrated a destructive process and features consistent with ARDS. There was widespread patchy bilateral lung consolidation, a right sided bronchopleural fistula with a collapsed right lower lobe and associated right hydropneumothorax. Background bullous disease and emphysema were noted. There were no enlarged thoracic lymph nodes.

His initial white cell count and C-reactive protein measured $10.6 \times 10^9\ L^{-1}$ and 272 $mg \cdot L^{-1}$ respectively. Other than *Candida albicans* in his sputum at admission, there were no positive cultures from sputum, blood or bronchoalveolar lavage (BAL), and PCR assays for bacterial, fungal and viral pathogens were negative. An HIV test was negative and an autoimmune screen was also negative. His BAL cytology demonstrated a predominance of lipid-laden alveolar macrophages without significant neutrophilia or eosinophilia and there were no features to suggest malignancy.

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In the past decade, vaping has become more prevalent globally. Since mid-2019, reports have linked the use of vaping devices to lung injury (EVALI). This is the first reported adult case outside the USA to require ECMO for a severe vaping complication. https://bit.ly/39hf2ZY

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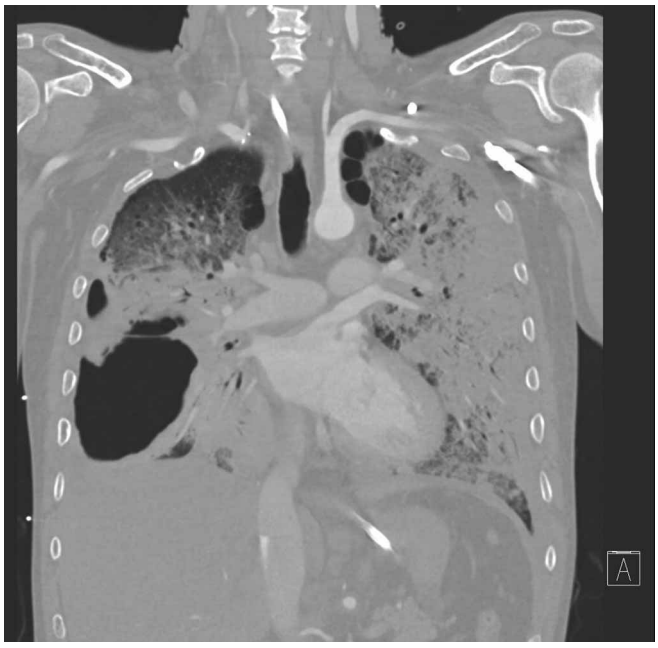

FIGURE 1 Coronal reconstructions of thin-slice axial computed tomography of the chest.

Based on the Centers for Disease Control and Prevention (CDC) Case Definition Case Definitions [6], this patient met the criteria for a "confirmed" diagnosis of vaping-associated lung injury (EVALI). Although his radiology highlighted a degree of pre-existing structural lung disease, in-keeping with his history of cannabis and cigarette exposure, his acute decline occurred within 90 days of vape exposure and in the absence of confirmed pulmonary infection or another plausible diagnosis. EVALI is associated with a range of pneumonitis patterns on imaging; however, dependent consolidation and diffuse ground-glass opacification, as seen in this patient, are well recognised [7]. The identification of foamy macrophages in his BAL is also believed by some clinicians to support the diagnosis [8–10].

Globally, there is an increasing recognition of the potential hazards of vaping, with case reports emerging in the medical literature and popular press [3, 4, 5, 11]. In the USA, the CDC have identified 2807 cases of lung injury requiring hospitalisation and 68 deaths associated with the use of vaping products (data as of 18 February 2020). Two thirds of hospitalised patients are male, with a median age of 24 years [12]. The incidence of EVALI outside the USA has yet to be defined. This is the first reported adult case of EVALI outside the USA to require ECMO support.

The aetiology and mechanism of EVALI remain unclear but it is postulated that exposure to inhaled toxic substances may lead to an airway-centred chemical pneumonitis [8, 13, 14]. The high percentage of patients with EVALI who report the use of THC-containing products (~80%) warrants closer evaluation [11, 15]. Vitamin E acetate and pulegone (used in mint and menthol flavouring) are also emerging as potentially significant toxicants [16, 17].

Since May 2017, UK regulations have restricted e-liquids to a nicotine strength of $\leqslant 20\ mg{\cdot}mL^{-1}$ and specific ingredients, including THC and vitamin E acetate, are not permitted. Similar restrictions exist across Europe. It is uncertain whether these regulations have contributed to the lower frequency of EVALI cases reported in the UK and Europe compared to the USA.

In summary, the patient we present developed a life-threatening acute lung injury following exposure to a vaping device in the UK. He ultimately survived this acute illness and was repatriated to his referring hospital after the discontinuation of ECMO support. This case highlights that EVALI is not an exclusively North American phenomenon and while the risks may be ameliorated by UK and European legislation to reduce inhaled toxicant exposure, there is an ongoing hazard of life-threatening lung injury associated with the use of these devices.

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References

1 Mirbolouk M, Charkhchi P, Kianoush S, *et al.* Prevalence and distribution of e-cigarette use among U.S. adults: behavioral risk factor surveillance system, 2016. *Ann Intern Med* 2018; 169: 429–438.
2 Jones L. Vaping: how popular are e-cigarettes? www.bbc.co.uk/news/business-44295336 Date last accessed: 1 October 2019. Date last updated: 15 September 2019.
3 Layden J, Ghinai I, Pray I, *et al.* Pulmonary illness related to e-cigarette use in Illinois and Wisconsin – final report. *N Engl J Med* 2020; 382: 903–916.
4 Hswen Y, Brownstein J. Real-time digital surveillance of vaping-induced pulmonary disease. *N Engl J Med* 2019; 381: 1778–1780.
5 Kalininskiy A, Bach C, Nacca N, *et al.* E-cigarette, or vaping, product use associated lung injury (EVALI): case series and diagnostic approach. *Lancet Respir Med* 2019; 7: 1017–1026.
6 Centers for Disease Control and Prevention. 2019 lung injury surveillance primary case definitions. www.cdc.gov/tobacco/basic_information/e-cigarettes/assets/2019-Lung-Injury-Surveillance-Case-Definition-508.pdf Date last accessed: 1 October 2019. Date last updated: 18 September 2019.
7 Henry T, Kanne J, Kligermann S. Imaging of vaping-associated lung disease. *N Engl J Med* 2019; 381: 1486–1487.
8 Butt Y, Smith M, Tazelaar H, *et al.* Pathology of vaping-associated lung injury. *N Engl J Med* 2019; 381: 1780–1781.
9 Maddock S, Cirulis M, Callahan S, *et al.* Pulmonary lipid-laden macrophages and vaping. *N Engl J Med* 2019; 381: 1488–1489.
10 Pambuccian SE. Testing for lipid-laden macrophages in bronchoalveolar lavage fluid to diagnose vaping-associated pulmonary injury. Are we there yet? *J Am Soc Cytopathol* 2020; 9: 1–8.
11 Schier J, Meiman J, Layden J, *et al.* Severe pulmonary disease associated with electronic-cigarette–product use — interim guidance. *MMWR Morb Mortal Wkly Rep* 2019; 68: 787–790.
12 Centers for Disease Control and Prevention. Latest information. www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html#latest-information Date last accessed: March 10, 2020.
13 Lee M, LeBouf R, Son Y, *et al.* Nicotine, aerosol particles, carbonyls and volatile organic compounds in tobacco- and menthol-flavored e-cigarettes. *Environ Health* 2017; 16: 42.
14 Lee M, Allen J, Christiani D. Endotoxin and (1→3)-β-D-glucan contamination in electronic cigarette products sold in the United States. *Environ Health Perspect* 2019; 127: 47008.
15 He T, Oks M, Esposito M, *et al.* "Tree-in-bloom": severe acute lung injury induced by vaping cannabis oil. *Ann Am Thorac Soc* 2017; 14: 468–470.
16 Blount B, Karwowski M, Shields P, *et al.* Vitamin E acetate in bronchoalveolar-lavage fluid associated with EVALI. *N Engl J Med* 2020; 382: 697–705.
17 Jabba S, Jordt S. Risk analysis for the carcinogen pulegone in mint- and menthol-flavored e-cigarettes and smokeless tobacco products. *JAMA Intern Med* 2019; 179: 1721–1723.