Summer 2022

Electronic - Cigarettes and Anesthesia Implications

Duane Robinson
robinson17@otterbein.edu

Electronic – Cigarettes and Anesthesia Implications

Duane Robinson BSN, RN, CCRN
Otterbein University, Westerville, Ohio

Introduction

- This document presents details about electronic cigarettes (ECs), their effects to the body, and implications for anesthesia.
- There is a general lack of knowledge about the effects of electronic cigarettes (Arndt et al., 2020).
- There is limited information available regarding the perioperative impacts of vaping (Bulat et al., 2022).
- This topic was selected because it is relevant to my future medical practice as a Certified Registered Nurse Anesthetist (CRNA).
- The number of people who use ECs exceeds 14M users in the U.S. (Bulat et al., 2022).
- ECs became available in 2007. They were marketed as a safer alternative to smoking (Arndt et al., 2020).
- ECs use a heating element to aerosolize nicotine-containing flavored liquids (Arndt et al., 2020).
- There are over 7,700 flavors on the market (Krishna et al., 2020).
- In 2015, there were 3.6M adolescent users and 10.8M adult users in the U.S. (Bulat et al., 2022).
- Flavors like mango, mint, and bubblegum appealed to the pediatric population (Arndt et al., 2020).
- The Centers for Disease Control (CDC) issued warnings in 2018 stating the liquid contents of ECs were addictive, toxic, and hazardous to the user's health (Arndt et al., 2020).
- Ingredients of the liquid include nicotine (0-24 mg), propylene glycol, glycerin for flavor, acetone, formaldehyde, and acetaldehyde (Arndt et al., 2020).
- The heated liquid produces vapors containing heavy metals (cadmium, chromium, copper, lead, nickel, and tin), N-nitrosamines, toluene (carcinogenic), and diacetyl (Arndt et al., 2020) which is associated with bronchiolitis obliterans (Bulat et al., 2022).
- Ingestion of the liquid by small children can cause seizures, coma, respiratory arrest, and death (Arndt et al., 2020).

Pathophysiological Processes

- Airway hyperactivity (Arndt et al., 2020)
- Asthma and chronic obstructive pulmonary disease (COPD) exacerbation (Alqahtani et al., 2022)
- Hemoptysis (Alqahtani et al., 2022)
- Ion channel transport dysfunction (Lin et al., 2019)
- Mucin production (Arndt et al., 2020)
- Mucus hypersecretion (Alqahtani et al., 2022)
- Cytokine and protease release (Arndt et al., 2020)
- E-cigarette or Vaping Use-Associated Lung Injury (EVALI) (Traboulsi et al., 2020)

Signs and Symptoms

- Cough reflex disturbances
- Throat irritation
- Bronchospasm and bronchoconstriction
- Increased chronic respiratory ailments
- Increased occurrences of sinusitis and rhinitis
- Increased inspiratory flow resistance
- Increased peripheral airway resistance
- Reduced cardiovascular vasodilation activity
- Increased platelet activation
- Increased risk of arrhythmias, heart failure, and sudden cardiac death
- Neuronal deficits among adolescents
- Increased inflammatory effects, cytotoxicity, and decreased immune system performance during the perioperative period
- Increased risk of respiratory failure, myocardial infarction, venous thromboembolism, cerebrovascular events, and pneumonia during the postoperative period.

(Arndt et al., 2020)

Underlying Pathophysiology

- EC vapors contain particulate matter, gases, heavy metals, and toxins. Lung damage varies and is based on the components of the vaping liquid, the voltage of the cartridge, presence of tetrahydrocannabinol (THC), and cutting agents.
- Lung surfactants, mucus clearance, and phagocytosis of inhaled particles are needed to maintain homeostasis of lung tissue.
- Lung epithelial cells are protected by alveolar type 1 and type 2 cells, alveolar macrophages, and granulocytes. These cells are the first line of defense against toxins and particulate matter from vaping.
- Alveolar macrophages are damaged when exposed to vaping and their ability to mitigate inflammation is significantly reduced.
- Type II alveolar cells experience oxidative damage reducing the amount of surfactant available to prevent alveoli from collapsing.
- Neutrophils undergo degranulation at the site of injury in the lungs. Neutrophil-derived extracellular traps (NETs) composed of DNA, histones, and elastase cover and contain the irritants to kill the pathogens. An abundance of NETs can trigger an auto-immune reaction causing tissue damage to the host.
- EC liquids heated in excess of 500°F can create various hydrocarbons like acrolein, 1,3-butadiene, benzene, toluene, and propene. Aromatic/volatile hydrocarbons have been linked to histopathological findings of burnt, blackened lungs.

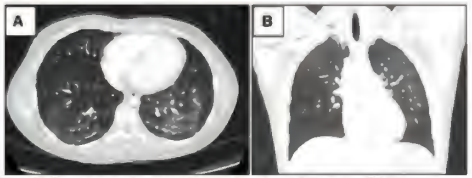
(Chand et al., 2020)

- The hydrocarbon acrolein is associated with the onset and proliferation of chronic bronchitis and COPD severity (Lin et al., 2019).

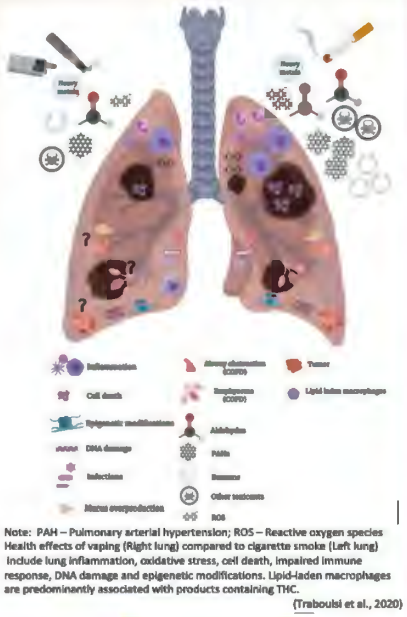
Significance of Pathophysiology

- Nicotine, a central nervous system stimulant, increases the release of catecholamines causing hemodynamic instability under general anesthesia (Arndt et al., 2020).
- ECs introduce toxins to the body in addition to the harmful effects associated with regular cigarettes and tobacco (Krishna et al., 2020).
- ECs contain over 7000 chemicals and 70 have been identified as carcinogenic (Sapru et al., 2020).
- Albuterol and anticholinergic agents may be needed prior to anesthesia induction due to pulmonary instability (Krishna et al., 2020).
- ECs expose the user to higher levels of nicotine which increases its addictive properties (Krishna et al., 2020).
- EC usage impairs coronary artery blood flow increasing the risk of myocardial infarction (Arndt et al., 2020).
- EC usage Increases the risk of surgical incision infections, necrosis, and poor wound healing (Arndt et al., 2020).
- Volatile compound intoxication may alter the minimum alveolar concentration (MAC) needed to achieve a desired level of anesthesia (Bulat et al., 2022).
- Epinephrine, ketamine, or magnesium may be needed due to intraoperative refractory bronchospasm (Krishna et al., 2020).
- There is a strong association between tetrahydrocannabinol (THC)-containing ECs and electronic cigarette vaping associated lung injury (EVALI) (Bulat et al., 2022).
- One study documented significant increases in heart rate within 20 minutes of using an EC (Franzen et al., 2018).

Imaging



Chest CT of severe e-cigarette or vaping product use-associated lung injury (EVALI).
A & B, Cross-sectional and coronal view on hospital day (HD) 1. C & D on HD 39. E & F on HD 71.
(Aldy et al., 2020)



Note: PAH – Pulmonary arterial hypertension; ROS – Reactive oxygen species
Health effects of vaping (Right lung) compared to cigarette smoke (Left lung) include lung inflammation, oxidative stress, cell death, impaired immune response, DNA damage and epigenetic modifications. Lipid-laden macrophages are predominantly associated with products containing THC.

(Traboulsi et al., 2020)

Health Effects of Vaping vs. Smoking

Implications for Nursing Care

- Anesthetists should manage chronic electronic cigarette users similarly to COPD and reactive airway patients (Arndt et al., 2020).
- Questions during the preoperative evaluation need to be specific to EC usage. Many people do not regard EC usage as tobacco usage or smoking (Krishna et al., 2020).
- EC users presenting to the operating room for emergent cases may be under the CNS-depressant effects of volatile organic compounds (VOC). Anesthesia providers should be cognizant of possible decreased anesthetic requirements (Arndt et al., 2020).
- The presence of nicotine and harmful byproducts increases the risk of complications during general anesthesia (Arndt et al., 2020).
- EC usage induces P450 enzyme CYP1A2 activity. Higher levels of rocuronium and vecuronium are needed due to increased drug metabolism(Arndt et al., 2020).
- Anesthesia providers should have a heightened awareness for cardiovascular changes among EC users (Arndt et al., 2020).
- Anesthesia providers should consider the interactions between ECs and anesthetic drugs, including volatile agents, opioids, and neuromuscular blocking drugs (Arndt et al., 2020).
- Laryngotracheal topical anesthesia should be used prior to intubation to prevent laryngospasm (Arndt et al., 2020).
- Avoid desflurane due to respiratory irritant properties causing increased blood pressure and heart rates (Arndt et al., 2020).

Conclusions

- The use of ECs is widespread among adolescents and adults.
- EC usage can exacerbate existing morbidities and create cardiopulmonary diseases.
- The effects of ECs can cause central nervous system changes and alter the impact of drugs given by anesthesia providers.
- E-cigarette vapors have a direct correlation with causing cell inflammation, apoptosis, and necrosis in the respiratory system. Patients who use ECs have a higher risk of intraoperative and postoperative pulmonary complications. (Arndt et al., 2020)
- The Federal Drug Administration (FDA) regulates the nicotine content of ECs, but there is minimal regulation of the remaining constituents of EC liquids (Lin et al., 2019). The long-term effects of ECs are not known and require additional research (Krishna et al., 2020).

Electronic Cigarette

(Key Compounding Pharmacy 2022)

References

OTTERBEIN UNIVERSITY