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Anatomophysiological repercussions of the electronic cigarette with emphasis on the respiratory and nervous systems: a narrative review

Abstract

An alternative option to conventional cigarettes, electronic cigarettes are being presented as a new habit, especially among the young population. Offering flavors and high concentrations of nicotine, it has already established itself as a choice among teenagers and young people. Since 2019, lung diseases have been described and associated with electronic cigarette use, but data is still scarce. Thus, this review aims to aggregate data on the effects of electronic cigarettes on the respiratory and nervous systems, becoming a source for new research or information for the population.

Keywords: electronic cigarette, respiratory system, nervous system

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Abbreviations: EVALI, electronic cigarette-induced lung injury; VEA, vitamin E acetate; NLM, national library of medicine; ECMO, extracorporeal membrane oxygenation; VTA, ventral tegmental area

Introduction

Smoking is known to accelerate in the late nineteenth and early twentieth centuries, along with the growth of mass production technologies and advertising.[1] Thus, as an alternative to smoking in places where smoking was prohibited, the first commercially available e-cigarette device was developed in China in 2003 and shortly thereafter was introduced in the USA in 2006.[2] E-cigarettes, also known as cigalikes, e-pipes, mods, vape pens, vapes, or tank systems, refer to a device that delivers nicotine through the respiratory system, hence its proposed technical name of an electronic nicotine delivery system.[3] First-generation devices, commonly known as cig-a-likes or vape sticks, are disposable, non-rechargeable electronic devices that have a very similar appearance to a traditional nicotine cigarette or pipe. This was followed by more powerful devices with customizable features called "box-mods" and "pod mods", with different flavors that can imitate substances such as fruits, chocolates, and mint and offer up to eight thousand different flavors, already available on the market.[2,4] This more current version opts for the use of nicotine salts instead of the freebase nicotine of previous generations.[5] However, the diversity of flavors and components highlights the importance of regulation and research to understand the health impacts since, in addition to the presence of nicotine, these devices contain thousands of chemicals, such as reactive aldehydes, which have been associated with carcinogenic properties.

Tobacco and e-cigarette users reported using e-cigarettes as an aid to quit smoking (52.6%), to avoid secondhand tobacco smoking (16.1%), and also as a harm reduction tool (8%).[3] Khanna et al. (2023) report that about 18.1% of 18–24-year-olds use e-cigarettes and those men vape more often than women (7.3% and 5.5%, respectively). Cigarette and e-cigarette smoke, which is rich in harmful toxins, is known to be a significant cause of diseases with fatal health impacts, such as coronary disease, stroke, increased risk of cancer and susceptibility to bacterial and viral infections, in addition to having negative impacts during pregnancy.[6] After inhalation, e-cigarettes expose their contents to the respiratory system, where the atomized smoke is not completely metabolized in the lungs. Some of these substances are absorbed into the bloodstream, affecting systems such as the cardiovascular, central nervous, and immune systems, contributing to health damage.[3,5] In the summer of 2019, an acute, mysterious, and deadly respiratory illness, related to vaping primarily in young individuals, was described in the US, which soon reached epidemic proportions, called EVALI (Electronic cigarette-induced lung injury). Numerous users of electronic cigarettes, predominantly men aged between 13 and 34 years, manifested respiratory, gastrointestinal and systemic symptoms after vaporization. Analyses of vaporized electronic liquids and samples of the airways of those affected found vitamin E acetate (VEA). When VEA (a transparent and viscous solution used as a diluent to increase the profits of tetrahydrocannabinoid sellers) is heated to the typical temperatures of an electronic device of nicotine and flavors, it decomposes into highly harmful ketene gas. Before EVALI, vaporization had been associated with several pulmonary conditions, from lipoid pneumonia to diffuse alveolar hemorrhage, but in reduced quantities.[7] Thus, the use of e-cigarettes has become a major public health concern worldwide, encouraging collaboration between researchers and health professionals to prevent a possible epidemic of lung disease related to nicotine/e-cigarette addiction at the end of the twenty-first century.[8] Given this, the objective of this text, which seeks to gather information about electronic cigarettes and their use, becomes of paramount importance, either to support future research or as a source of information to the general population about the harms of this new habit that is already plaguing the population, especially the younger population.

Methodology

The present study consists of a narrative review of the literature. The objective of this methodology is to obtain a more in-depth knowledge of a given phenomenon, based on previous studies on the subject. This method allows published research to be synthesized into

a single article, making the results more accessible. Studies of this type should be conducted using rigorous methodological criteria, following well-described steps, and with presented results. To this end, we focus on research conducted at the National Library of Medicine (NLM) – PubMed (https://www.ncbi.nlm.nih.gov/pubmed/). Articles published between 2019 and 2023 were included, limiting review-only articles, with access to the full text free of charge. For the search strategy, the combination of the uniforms "electronic cigarette" AND "respiratory system" AND "nervous system" was used. The following steps were used for data extraction:

I. Reading the titles of all articles found;

II. Reading of the pre-selection abstracts, which should contain mention of electronic cigarettes and/or their actions on the respiratory and nervous systems;

III. Reading, in full, the articles of the partial sample;

IV. Analysis of the articles;

V. Consideration of emerging and relevant content;

VI. Elaboration of the results based on categories identified in the researched material.

The search in the database yielded 291 results. After reading the 291 titles, 55 articles were pre-selected, whose abstracts were read. Articles that did not meet the objective of this study were excluded. After the exclusions, 31 articles remained to be read in full, following the same exclusion criteria described above. In the end, 19 articles were selected to compose this review. The details of the inclusion and exclusion criteria can be seen in Figure 1.

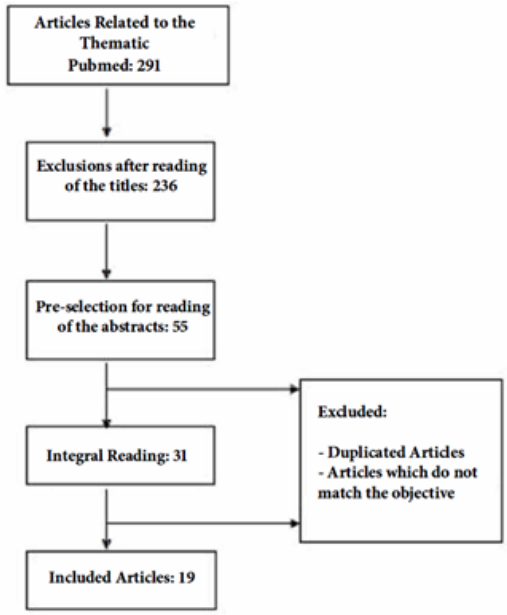

Figure 1 Diagram of the articles included and excluded, according to the criteria established in the study.

Results and discussion

For more than 50 years, a solid amount of incontrovertible evidence has revealed that smoking cigarettes is a cause of disease in almost every organ of the body.[3] Individuals often present with an acute or subacute illness with nonspecific respiratory symptoms,[9] including chest pain, cough, and shortness of breath, gastrointestinal symptoms such as diarrhea, vomiting, and abdominal pain, and flu-like symptoms such as fever, chills, and headaches.[10] In order to better understand the effects of electronic cigarettes on the body, it is important to understand how they work. E-cigarettes are composed of essential elements such as a battery, heating coil, wick, cartridge with e-liquid, and an inhalation mouthpiece.[11] The heating coil of these devices is also a suspected source of lung toxicity. When heated, both propylene glycol and vegetable glycerin produce a thick, smoke-like vapor.[2] Therefore, at temperatures as high as 350 °C, chemical reactions can occur between the constituents of the e-liquid, resulting in the formation of other substances, such as benzene.[11] Thus, the use of e-cigarettes raises concerns about the users' exposure to harmful substances, where there is a risk of exposure to heavy metals from batteries and heating coils, which may be carcinogenic or toxic to the heart and lungs.[12] Therefore, the health impacts resulting from exposure to electronic cigarettes, especially in prolonged use, are still unclear. However, it is evident that these devices emit a range of harmful substances, such as volatile carbonyls, reactive oxygen species, furans and metals such as nickel, lead and chromium, many of which present risks to lung health.[1] These findings underscore the importance of a cautious assessment of the risks associated with the use of e-cigarettes. While there is still a paucity of data on the long-term effects of e-cigarette use, thousands of users have become seriously ill in an epidemic of lung injuries associated with the use of e-cigarettes or vaping products.[11] Most of these injuries are related to vaping products containing tetrahydrocannabinol or other cannabinoids.[9]

Several documented cases establish a link between e-cigarette use and a wide range of lung diseases, from asymptomatic radiographic findings to complications such as lipoid pneumonia, acute eosinophilic pneumonia, hypersensitivity pneumonitis, and diffuse alveolar hemorrhage.[2] In addition, there is a significant association between atopy, cystic fibrosis complications, and smoking, potentially extending to the use of these cigarettes.[13] Users of these devices further reported a variety of negative symptoms involving the nose, mouth, throat, and airways.[1] Davis et al.,[4] point out that chronic exposure to e-cigarettes can lead to an important dysregulation of homeostatic functions, contributing to even more harmful changes to the respiratory system. While conventional smoking remains a leading cause of cancer-related deaths and respiratory diseases, including COPD, emphysema, and bronchial asthma,[5] dyspnea associated with e-cigarette use can have even more severe consequences, requiring interventions such as intubation, ECMO (extracorporeal membrane oxygenation), which consists of a treatment used in severe cases of respiratory failure, when conventional mechanical ventilation is not sufficient to maintain adequate oxygenation of tissues. However, in extreme cases, it can result in fatal outcomes, even in previously healthy individuals.[14] In a study that analyzed 11 adolescents, research indicates a worrying incidence of pulmonary involvement in this age group. According to Wang et al.,[15] the symptoms observed included fever, nausea or vomiting, shortness of breath, cough, headache, fatigue, myalgias, neck pain, and back pain. These cases exhibited common imaging features, such as bilateral involvement, opacities, interlobular septum thickening, and subpleural and peribronchovascular effusion. Despite the significant pulmonary involvement at presentation, it was observed that the abnormalities in the images may resolve completely or almost completely in a few months, although the long-term effects remain undetermined, as proven in the analyzed examinations.[15]

In the nervous system, nicotine promotes the stimulation of the sympathetic nervous system, resulting in tachycardia, increased blood pressure, and cardiac output, as well as vasoconstriction of cutaneous and coronary blood vessels.[3] Nicotine also has impacts

on the parasympathetic nervous system, including increased muscle activation and decreased body temperature.[8] With prolonged use, these central adaptations can lead to near-permanent changes in neurons and neuronal networks.[8] The action of nicotine focuses on nicotinic acetylcholine receptors on VTA dopaminergic neurons, local GABAergic interneurons, and afferent terminals, affecting the excitability of dopaminergic neurons and local GABAergic and glutamatergic transmission. The mesolimbic reward pathway, which originates in the ventral tegmental area (VTA), is affected by nicotine and other drugs. In summary, nicotine increases dopamine signaling in the VTA, affecting the excitability of dopaminergic cells. This results in motivational and rewarding effects associated with nicotine consumption. However, chronic exposure is linked to a decreased dopaminergic state, with reduced firing of VTA dopamine cells and decreased dopamine levels in specific areas of the brain. These changes can influence the complex effects of nicotine on the nervous system over time.[8,16–18]

Conclusion

It is observable that electronic cigarettes, which today constitute a very common habit among increasingly younger adolescents, should receive attention and adequate regulation, since, as highlighted throughout this review, they can cause rapid and potent harm, especially to the respiratory system, risking the integrity of the individual's overall health. Thus, knowledge is a strong tool for the protection of the population, and guidance measures must be urgently implemented.

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Conflicts of interest

The author declares that there is no conflicts of interest.

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