World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

Check for updates

The effects of vitamin E acetate and its role in vaping: A systematic review

Vishav Sehdev [1,*], Meghan Cheung [2,*], Akanksha Sharma [3] and Dinali Obeysekera [4]

[1] *Saint James School of Medicine, Albert Lake Dr. The Quarter, Anguilla, British West Indies.*
[2] *St. George's University, University Centre Grenada, West Indies, Grenada.*
[3] *Department of Pulmonary, Critical Care and Sleep medicine, Yale School of Medicine, New Haven, CT, United States.*
[4] *Medical University of the Americas, C/O R3 Education Inc. 27 Jackson Road, Suite 302 Devens, Massachusetts 01434, United States.*

World Journal of Advanced Research and Reviews, 2022, 14(01), 487–495

Publication history: Received on 19 March 2022; revised on 23 April 2022; accepted on 25 April 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.14.1.0353

Abstract

Hypothesis: The inhalation of vitamin E acetate (VEA) results in an e-cigarette or vaping use associated with lung injury (EVALI) and lipoid pneumonia in individuals who vape.

Methods: We utilized databases such as PubMed, Google Scholar, Medline, Medscape, and gray literature to search for relevant literature.

Results: Our study displayed that after inhalation of vitamin E acetate from vaping, the chemical elicits a strong immune response. Vape liquid has been extensively studied for its composition and toxicity in humans. Many emergency departments have reported cases of EVALI in healthy individuals that have required ventilatory support for survival. Careful history taking of these individuals revealed that they had inhaled vape smoke that contained VEA. In addition, the bronchoalveolar lavage (BAL) fluids of other patients with a positive vaping history showed numerous lipid-laden macrophages, suggesting that exogenous exposure to VEA plays a role in the etiology of lipoid pneumonia.

Conclusions: Our study concluded that when heated, vitamin E acetate and its additives are capable of causing significant respiratory harm. However, further research is needed to determine the exact effects of vitamin E acetate in individuals who vape.

Keywords: Vitamin E acetate; Vaping; Lipoid pneumonia; E-cigarettes

1. Introduction

With the pandemic of e-cigarettes in 2019 declared by the Centers for Disease Control and Prevention (CDC), clinicians should be alert for respiratory distress in young healthy patients with a history of vaping [1]. Vaping was introduced to the public in order to help quit smoking. In a 2021 Gallup poll based on telephone interviews of 1,007 adults, 17% of Americans aged from 18 to 29 admitted to using vaping products, compared to 7% of Americans aged from 30-60 [2]. The term vaping refers to the inhalation of the vapor or aerosol produced by the vaping device into the lungs [3]. The device is made up of three components: a battery source, a heating element, and a liquid holding unit [4]; they use a battery-powered heated coil that vaporizes a liquid in a cartridge making an aerosol that the user then inhales through a mouthpiece. These devices include vape pens, e-cigarettes, dab pens, and personal vaporizers [5]. The liquid contains a solvent (usually propylene glycol and vegetable glycerin), nicotine as well as various additives such as flavors. Since they do not contain tobacco but function to deliver nicotine to the brain it is widely believed that vaping can be used to help in the cessation of smoking. However, more evidence is needed to support or refute this claim as well as look into

* Corresponding author: Vishav Sehdev and Meghan Cheung

its long-term health effects [3,4]. According to Hopkins medicine: vaping is equally addicting to traditional tobacco cigarettes due to the fact that they both contain nicotine. Furthermore, the Food and Drug Administration (FDA) has not approved vaping as a smoking cessation method [6].

Although once thought to be safe, in 2019, a pattern of lung injury in previously healthy individuals in the United States was recognized and was found to be a result of vaping. This has now been termed e-cigarette or vaping use associated with lung injury (EVALI) [5]. EVALI is linked to various respiratory problems, including shortness of breath, coughing, and hypoxemia [3]. One of the lung disorders associated with EVALI is lipoid pneumonia. Lipoid pneumonia occurs when lipids enter the lungs and build up within the alveoli and airspaces. This can be a result of inhaling products [3]. It can present from being asymptomatic to needing ventilatory support and clinical examination is often unremarkable. Chest radiograph commonly shows extensive bilateral consolidation or ground-glass opacities, predominantly in mid and lower zones. Diagnosis can be made by bronchoalveolar lavage (BAL) fluid and histology showing foreign body inflammation around lipid components [7].

In the past decade, vaping has become more popular due to various reasons such as experimentation, smoking cessation aid, and attractive flavorings. Although widely believed to be safer than smoking there are few regulations surrounding vaping. As it is relatively new and we are just learning more about its effects on our health, particularly lung injury, more studies need to be conducted on the short-term and long-term health effects of vaping.

Important factors that need to be investigated are the many different additives used in vaping cartridges and the different effects they can cause on our body as well as how to recognize lung injury due to vaping and the different treatment modalities.

A common finding in the EVALI cases that have been studied is vaping which contains tetrahydrocannabinol (THC) and vitamin E acetate [8]. Vitamin E acetate (VEA), which is commonly found in illegal THC cartridges in the United States and Canada, is one of the most studied additives in vaping [9]. VEA is an oily chemical that is commonly added to THC vaping liquids to dilute or thicken them and can remain in the lungs for extended periods of time causing lung injury [9]. When vitamin E acetate is ingested it accumulates in surfactant because it is unable to be adequately absorbed by pulmonary tissue [5]. VEA can be commonly found in many products such as supplements and creams; however, the safety profile of inhaling VEA has not yet been thoroughly studied [10].

2. Methods

Our systematic review obeyed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) to validate the quality of the study.

PubMed, Cochrane, Medscape, Medline, and Google Scholar were databases used to accumulate potential articles. To help search for relevant articles, four concepts were made and used to search databases, which are the following: “healthy subjects,” “vaping,” “lipoid pneumonia,” and “vitamin E acetate.” The 4 concepts were then combined together to acquire articles that contained those key terms specifically in each database. The following helps illustrate our concepts and keywords used to search databases:

Concept 1: healthy subjects

keywords: “healthy,” “normal,” “good health,” “well,” “physically fit,” “good shape”

Concept 2: vaping

keywords: “electronic cigarette,” “e-cigs,” “smoking,” “aerosol,” “inhalation,” “vaporizer,” “inhale vapor,” “mod”

Concept 3: lipoid pneumonia

keywords: “EVALI,” “respiratory illness,” “lobar pneumonia,” “acute lung injury”

Concept 4: vitamin E acetate

keywords: “Alpha-tocopherol,” “3,4-Dihydro-2,5,7,8-tetramethyl-2-(4,8,12-trimethyl tetradecyl)-2H-1-benzopyran-6-ol,” “d-alpha-Tocopherol”

The majority of our study includes case reports of patients who came into the emergency department or visited their primary care physicians. The case reports in our review deemed any healthy individual with respiratory distress with a history of vaping eligible for their case reports. In addition, the authors of the case reports have obtained the consent of the patients. The other reports used in our study consist of literature reviews.

2.1. Eligibility Criteria

2.1.1. Inclusion criteria

To narrow articles on databases, our inclusion criteria consisted of articles only included: healthy individuals who are 16 years of age and older, history of vaping nicotine and/or THC, studies conducted in the United States, Canada, Mexico, and the United Kingdom, and studies conducted in the past 10 years (time range: 2011-2021). Studies that were conducted in animal models such as non-human primates and mice were also included. No restrictions on gender were made.

2.1.2. Exclusion criteria

Articles were excluded using the following criteria: studies conducted outside of the United States, Canada, Mexico, and the United Kingdom and any studies that occurred before 2011.

It should also be acknowledged that all articles that were used were freely available.

Population, Intervention, Comparison, Outcome (PICO): We implemented the PICO format to compose our research question. Population: healthy participants. Intervention: history of vaping e-cigarettes. Comparison: participants who do not vape or smoke. Outcome: the presence of EVALI and lipoid pneumonia.

Table 1 Overview of past literature from the article selection process

First Author, Reference	Year of Publication	Study Design	Study Population
Traboulsi, H [3]	2020	Literature review	Adults, male, aged 18+
Dinardo, P [4]	2019	Literature review	Adults, male and female, aged 18+
Aldy, K [5]	2020	Literature review	Adults, male and female, aged 18-34
Viswam, D [7]	2018	Case-report	Female, aged 34
Shields, P [8]	2020	Literature Review	Adults, aged 18+
Boudi, F [9]	2019	Case-report	Male, aged 17
Blount, B [10]	2020	Literature review	51 healthy patients, aged 16-67, the mean age range is 23
Landman, S.T. [11]	2019	Case-report	Healthy male, aged 17
Ind, P.W. [12]	2020	Literature review	Healthy male, aged <35
Davidson, K. [13]	2019	Literature review	5 healthy patients, aged 18-35
Bhat, T.A. [14]	2020	Experimental	30 mice
Freathy, S. [15]	2020	Case-report	Male, aged 27
Gay, B. [16]	2020	Case-report	Male, aged 46

After screening full-text articles and removal of duplicates from databases, our review was finalized with 24 articles. The past 10 years were the time constraint used for articles, our oldest article dates to 2018. Two of these articles were cross-sectional studies. Five of the 16 articles were case reports. Eight of the 16 articles were literature reviews. One of

the 16 articles was an experimental study. None of the 16 articles were clinical trials. The PRISMA diagram (Figure 1) in the Appendix illustrates our article selection process. (Table 1) which can also be found in the Appendix displays the articles finalized in our review.

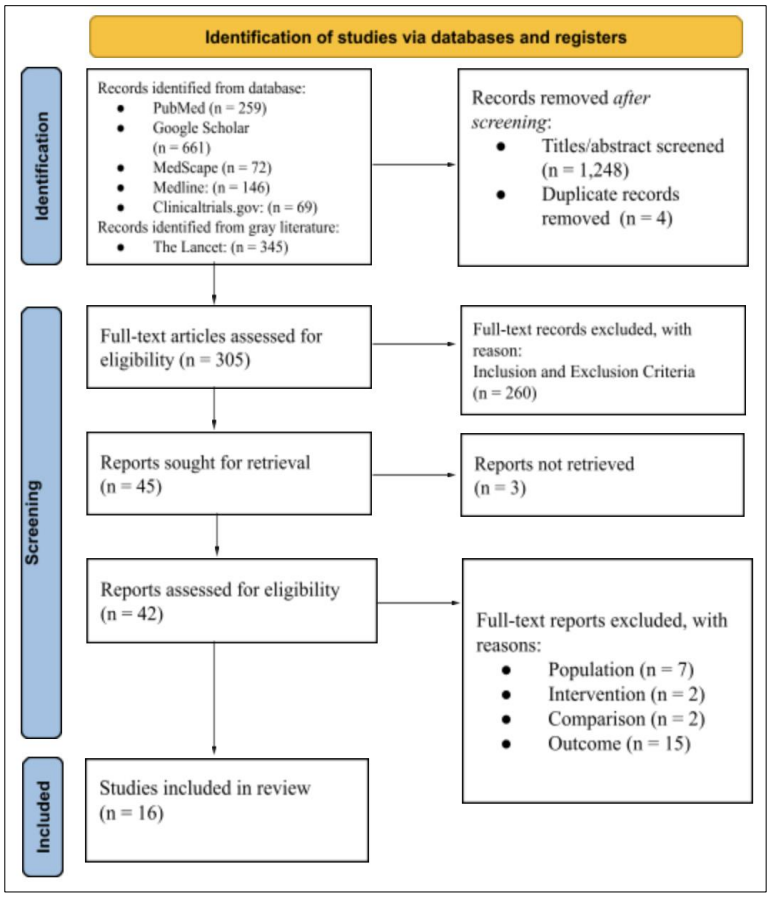

Figure 1 PRISMA diagram illustrating the article selection process.

3. Results

Research has shown that there is a high likelihood that VEA can cause EVALI and also lipoid pneumonia. The exact pathophysiology of VEA-induced lung injury is still unknown but one theory is that it may lead to lipid accumulation in the lungs and/or interfere with surfactant functioning [5]. An inflammatory response to these lipids in the alveolar space can then cause lipoid pneumonia [7]. Lipoid pneumonia can present from being asymptomatic to needing ventilatory support and clinical examination is often unremarkable. Chest radiograph commonly shows extensive bilateral consolidation or ground-glass opacities, predominantly in mid and lower zones. Diagnosis can be made by BAL fluid and histology showing foreign body inflammation around lipid components [7].

Accumulation of vaped oils in the lungs has been shown to cause an immune system response similar to a foreign body, which can lead to inflammation and in turn cause lipoid pneumonia [9]. As vitamin E acetate has been shown to be the main culprit in EVALI cases, this systematic review will focus on vitamin E acetate additives in vaping cartridges and if they can cause EVALI and lipoid pneumonia.

In 2019, 2,172 cases of EVALI were reported to the Centers for Disease Control and Prevention in the United States, with 42 confirmed deaths. Although not all ingredients causing lung injury in these cases have been examined, BAL samples from 29 of these patients contained VEA. The CDC has identified VEA as a chemical of concern; however, their evidence is not yet adequate to rule out other chemicals and more investigations need to be done [11]. In regards to our research question, these results show that there is a causal link between inhaling VEA and EVALI.

In 2019, 52% of THC cartridges examined during the 2019 EVALI outbreak contained VEA. A recent study also found VEA in 48 out of 51 BAL samples from EVALI cases in 16 states while no VEA was detected in BAL samples of a control

group of 99 individuals. These 99 individuals were never smokers, exclusive vaping of nicotine only, and exclusive cigarette smokers (Figure 2). Although these results suggest VEA is a strong suspect in causing EVALI, 13% of EVALI patients reported only vaping nicotine-containing cartridges or e-liquids [3,5,12]. It is also important to note that other chemicals used as additives in vaping products such as plant oils, medium-chain triglyceride oil, coconut oil, petroleum distillates, and diluent terpenes were found in BAL samples from a few cases of EVALI showing these chemicals are likely to be the other causes of EVALI [10]. However, VEA was found to be extremely higher than the other chemicals. This further adds to the evidence that it is the inhalation of VEA rather than other chemicals found in vaping cartridges that leads to EVALI.

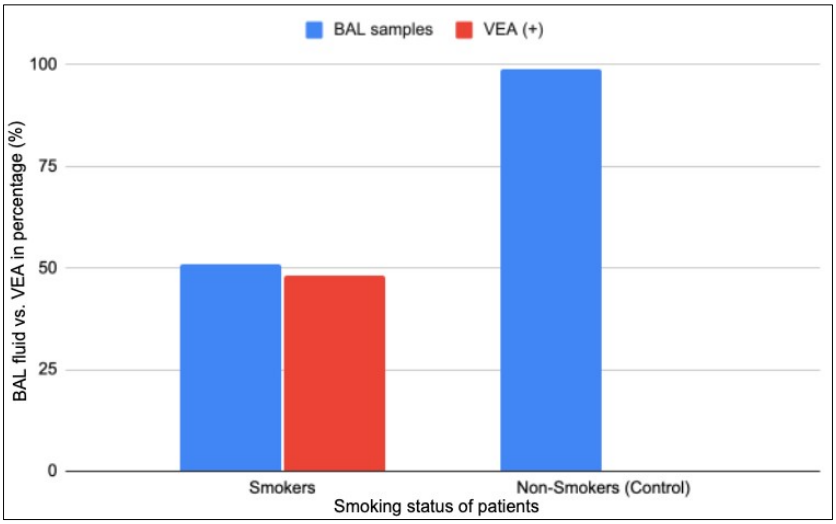

Figure 2 Comparison of BAL samples collected from two sample populations from 16 states in the USA in 2019 and testing for VEA (+)

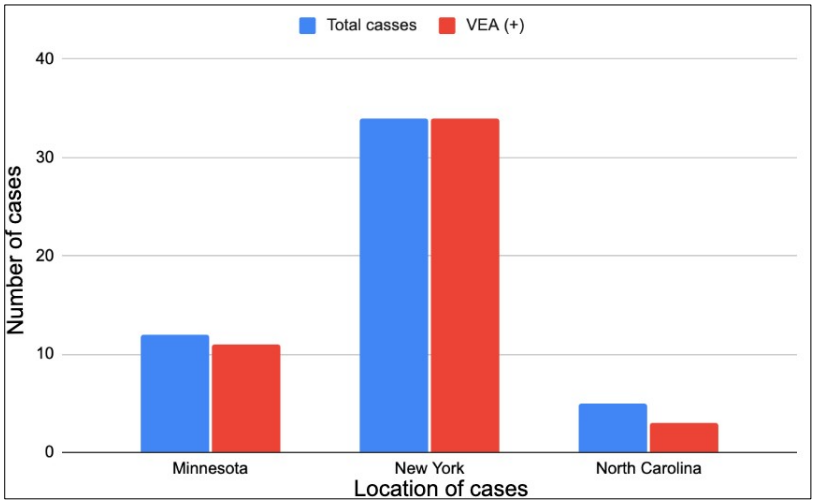

Figure 3 Comparison of EVALI outbreaks in 2019 in three states reported by the CDC.

In 2019 during this EVALI outbreak, studies were also done specifically in Minnesota, New York, and North Carolina. In a study by the Minnesota Public Health Department, they found that 24 products from 11 out of 12 EVALI patients contained VEA and no VEA was found in 10 products that were collected in 2018 before the EVALI outbreak in 2019 [3]. The New York State Department of Health Wadsworth Center Laboratory investigated 34 patients who had used THC-containing vaping products and also had a respiratory illness and found that although they used multiple products, all patients used at least one product containing VEA [10] (Figure 3). Again, in the above two studies, VEA seems to be the common culprit that is contributing to EVALI in these patients. In North Carolina, two hospitals reported five patients with probable EVALI. Three of these patients had a bronchoscopy with BAL showing considerable lipids within

the alveolar macrophages. Based on extensive medical history and workup, acute exogenous lipoid pneumonia was diagnosed in all five patients. One hypothesis for these results is the inhalation of aerosolized oils from vaping products causes a local inflammatory response impairing gas exchange. Testing for the presence of VEA in these patients was not done [13].

An experimental study also found lung injury in mice when exposed to inhaled aerosols of VEA. Examination showed increased levels of albumin in BAL, an increased number of leukocytes, and considerable amounts of lipid-laden macrophages [3,14]. These findings show that the inhalation of VEA can cause EVALI and likely lipoid pneumonia based on the BAL samples obtained from the subjects.

Three case reports were studied that reported vaping induced lung injury leading to lipoid pneumonia. In 2020, Freathy et al. reported a case of lipoid pneumonia that they believe was secondary to EVALI. The case reports a 27-year-old male with a history of asthma and nicotine and THC vape use reporting to the emergency department with dyspnea. His last reported vape use was three months before this visit. On bronchoscopy, bronchial alveolar lavage showed intracytoplasmic Oil Red O staining of alveolar macrophages which indicates the existence of lipids. Repeat bronchoscopy with transbronchial biopsy-confirmed acute lung injury showing the distinct feature of vacuolated macrophages as seen in lipoid pneumonia. Although the exact etiology of acute lung injury is not clear, one theory postulates that those presenting with lipoid pneumonia are a result of aerosolized oils inhaled from vaping products causing an inflammatory response such as THC vaping cartridges containing VEA [15]. This case study provides strong evidence that the inhalation of VEA leads to EVALI and lipoid pneumonia in individuals who vape. It is also important to note that EVALI and lipoid pneumonia can occur months after stopping vaping and not just acutely while vaping.

Another case was reported on a 34-year-old female who presented with acute type 1 respiratory failure, three-month history of progressive dyspnea on exertion, and a daily cough with white sputum. She reported a 10-pack-year smoking history and a three-year history of vaping before her current admission to the hospital. Her medical history included congenital dysmorphism with thrombocytopenia and iron deficiency anemia, closure of a ventricular septal defect at age one, gastroesophageal reflux disease, and hypothyroidism. A chest CT showed diffuse ground-glass opacities throughout all pulmonary lobes, apical subpleural cysts, and interlobular septal thickening. On further investigation, a video-assisted thoracoscopic surgical lung biopsy of the right upper, middle, and lower lobe showed considerable amounts of lipid-filled macrophages and cholesterol clefts and inflammation illustrating lipoid pneumonia. Investigation for causes of inhaled lipids only found vegetable glycerin found in vaping products as the most likely cause [7]. While this case study does not show VEA as the source of lipoid pneumonia, it does point to another compound that should be investigated for its possible role in lung injury. This study also does not rule out VEA as a cause of EVALI and lipoid pneumonia.

A case report of a 46-year-old male with no significant medical history presented with shortness of breath and flu-like symptoms. He reported a 20 plus years history of smoking marijuana, less than one year of cigarette use, and a four to six-month history of vaping with and without flavoring additives. Computed tomography (CT) imaging showed extensive bilateral airspace disease with increased reticulation, traction bronchiectasis, and ground-glass opacities. Bronchoscopy with transbronchial biopsies from the right lower lobe showed considerable intra-alveolar inflammation including foamy macrophages and activated type ii pneumocytes consistent with organizing pneumonia. The BAL sample stained with Oil red O was consistent with lipoid pneumonia showing large amounts of lipid-laden macrophages and intra-alveolar macrophages containing blackish-brown pigment. The patient revealed he disposed of his vaping products after diagnosis and as a result samples for testing were unable to be collected and no conclusion of the role of VEA in lipoid pneumonia can be made in this case [16]. Unfortunately, VEA could not be tested for and it cannot be said whether or not VEA had a role in this patient's lipoid pneumonia.

4. Discussion

The findings in this study suggest that VEA may in fact lead to EVALI and/or lipoid pneumonia. Before the study, our null hypothesis stated that VEA does not cause EVALI or lipoid pneumonia whereas the alternative hypothesis was that VEA does lead to EVALI or lipoid pneumonia. After reviewing the data there is substantial evidence that supports the alternative hypothesis. Vaping is not a safer alternative to traditional cigarettes and our study supports this argument. This argument is made evident by several case reports and literature reviews, one in particular by Gay et al. showed high levels of VEA in BAL fluids from individuals who vape, and absent in healthy individuals, alluding that VEA is the causative agent in EVALI [16,17], diagnosing them with EVALI, a type of exogenous pneumonitis, which is a diagnosis of exclusion and requires a negative bacterial and viral culture. Most currently, a negative severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is now necessary to diagnose EVALI [17]. Furthermore, Viswam et al. studied CT images, obtained from a young patient, revealing diffuse bronchiolitis, ground-glass opacities, and consolidation,

suggesting severe lung damage [7]. Viswam et al. also discovered septal thickening with infiltration of macrophages and neutrophils on histology, however, the radiographic and histologic results are quite nonspecific and often occur in acute inflammation and reactive changes. Meanwhile, laboratory workup on bacterial and viral cultures on this patient was negative excluding any microbiological causes of EVALI or lipoid pneumonia. Altogether, these data support our hypothesis therefore, we reject the null hypothesis and accept the alternative hypothesis. Yet many other chemicals such as ketene, coconut oil (found in 2% of EVALI cases), medium-chain triglycerides, terpenes (found in 1% of EVALI cases), and mineral oil which is used to dilute the THC-containing e-liquids may contribute to the inflammatory response-that may go undetected in conventional lab assays-resulting in lung injury [18,23]. Previous literature showed higher levels of VEA in the lower lobes of the lungs as opposed to the upper lobes of the lungs, possibly due to the small size of VEA (< 1μm). This is consistent with the same lung regions (the right lung more dominant than the left lung) affected in EVAL [23]. The small size of VEA has the potential to alter airway homeostasis, change the integrity of surfactants, and promote oxidative damage [23]. Thus, it is important to know the lung deposition pattern of VEA and other e-liquid constituents which may help with the management and treatment of EVALI. Additionally, there are many other variables that have not been accounted for such as the pattern of lung deposition, number of puffs, duration of vaping, type/brand of e-liquid, the voltage of the battery, and whether the e-liquid contained nicotine or THC. In fact, illegal THC-containing e-liquids have been the most reported type of vaping e-liquid that leads to EVALI [17]. Only after all these variables have been controlled can we say VEA is the sole ingredient causing EVALI and/or lipoid pneumonia, but due to the diverse nature of vaping and newness, it is difficult to study and control these variables. Regardless of the variables and outcome, all clinicians should remain suspicious of EVALI or lipoid pneumonia in vaping individuals with lung disease who present to the emergency department. Further research should entail how to control, and measure said variables. One suggestion is to perform a meta-analysis on similar studies on VEA which then may be pooled together for statistically significant results.

While VEA appears to be closely linked to cases of EVALI and lipoid pneumonia, studies have been limited due to the relative newness of vaping and the ban on e-cigarettes. As VEA was not found in all results. Blount et. al observed BAL fluids of 51 EVALI patients and found 1 case found coconut oil to be the cause, thus it cannot be concluded that coconut oil is the cause of lipoid pneumonia in the above EVALI cases. Also, while lipid-laden macrophages may indicate exogenous lipoid pneumonia it is a nonspecific marker and can also be seen in other medical conditions such as chronic aspiration. An examination of 17 pathology samples from EVALI cases found no pathologic features of exogenous lipoid pneumonia [3]. Further studies need to be done on the role of the inhalation of VEA and its role in lipoid pneumonia.

In regard to future research, by-products of these chemicals would be important to study such as ketene. Ketene is a by-product of VEA when heated and is a highly toxic chemical [21]. Unfortunately, ketene is currently immeasurable by BAL fluid [22]. Other variables that are important to research are differences in vape devices, brand-named cartridges versus generic cartridges, the temperature of the heating coil, and the number and length of inhalations. The amount of VEA deposited into the lung tissue may be different from the amount of VEA exposed from second-hand smoke. Therefore, second-hand vape exposure, as well as long-term complications and consequences of EVALI and lipoid pneumonia, are also important topics to discuss. Further research into these topics can help us improve our understanding of these diseases and help us to better identify, test, and treat them in the future.

The number of study data in our review was limited due to the inclusion/exclusion criteria used in the study method. Our search criteria included factors such as age and location. Although there are reports that vape devices are used by younger individuals [19] and throughout the world [20], our area of interest was on individuals sixteen years or older within North America and the United Kingdom. Therefore, future research should include individuals younger than 16 years of age and other parts of the world such as Asia and South America. More importantly, to study the effects of second-hand exposure to VEA to determine the potential widespread harmful effects of vaping.

5. Conclusion

While there seems to be an association between vitamin E acetate and EVALI and lipoid pneumonia in individuals with a history of vaping, more clinical research needs to be done to confirm this association and whether or not it is the sole culprit or is a result of a combination of factors. Results and findings could then be used to create regulations surrounding vaping and cartridge ingredients such as local and federal authorities passing laws to regulate vaping which may include restrictions on age, accessibility to products, and indoor usage. Clinicians and health care providers alike should educate the public on the dangers of vaping. With further research, regulations, and education then we could perhaps observe decreases in vaping-related illnesses.

Compliance with ethical standards

Acknowledgments

We acknowledged to Muhammad Hassan, Sidharth Midha.

Disclosure of conflict of interest

No conflict of interest.

Funding

This research did not receive a specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

[1] American Lung Association. Helping teens quit [Internet]. Lung.org. [cited 2020 Aug 31]. Available from https://www.lung.org/quit-smoking/helping-teens-quit

[2] Hrynowski Z, Brenan M. What percentage of Americans vape? [Internet]. Gallup. 2021 [cited 2021 July 6]. Available from: https://news.gallup.com/poll/267413/percentage-americans-vape.aspx

[3] Traboulsi H, Cherian M, Abou Rjeili M, Preteroti M, Bourbeau J, Smith BM, Eidelman DH, Baglole CJ. Inhalation toxicology of vaping products and implications for pulmonary health. International journal of molecular sciences. 2020 Jan; 21(10):3495

[4] Dinardo P, Rome ES. Vaping: The new wave of nicotine addiction. Cleveland Clinic journal of medicine. 2019 Dec 1; 86(12):789-98

[5] Aldy K, Cao DJ, Weaver MM, Rao D, Feng SY. E-cigarette or vaping product use associated lung injury (EVALI) features and recognition in the emergency department. Journal of the American College of Emergency Physicians Open. 2020 Oct; 1(5):1090-6

[6] U.S. Department of Health and Human Services. National Institutes of Health. National Cancer Institute. Using nicotine replacement therapy [Internet]. Smokefree.gov. [cited 2022 Apr 19]. Available from: https://smokefree.gov/tools-tips/how-to-quit/using-nictoine-replacement-therapy.

[7] Viswam D, Trotter S, Burge PS, Walters GI. Respiratory failure caused by lipoid pneumonia from vaping e-cigarettes. Case Reports. 2018 Jul 6; 2018:bcr-2018

[8] Shields PG, Song MA, Freudenheim JL, Brasky TM, McElroy JP, Reisinger SA, Weng DY, Ren R, Eissenberg T, Wewers MD, Shilo K. Lipid laden macrophages and electronic cigarettes in healthy adults. EBioMedicine. 2020 Oct 1; 60:102982

[9] Boudi FB, Patel S, Boudi A, Chan C. Vitamin E acetate as a plausible cause of acute vaping-related illness. Cureus. 2019 Dec 11;11(12)

[10] Blount BC, Karwowski MP, Shields PG, Morel-Espinosa M, Valentin-Blasini L, Gardner M, Braselton M, Brosius CR, Caron KT, Chambers D, Corstvet J. Vitamin E acetate in bronchoalveolar-lavage fluid associated with EVALI. New England Journal of Medicine. 2020 Feb 20; 382(8):697-705

[11] Landman ST, Dhaliwal I, Mackenzie CA, Martinu T, Steele A, Bosma KJ. Life-threatening bronchiolitis related to electronic cigarette use in a Canadian youth. Cmaj. 2019 Dec 2; 191(48):E1321-31

[12] Ind PW. E-cigarette or vaping product use-associated lung injury. British Journal of Hospital Medicine. 2020 Apr 2; 81(4):1-9

[13] Davidson K, Brancato A, Heetderks P, Mansour W, Matheis E, Nario M, Rajagopalan S, Underhill B, Wininger J, Fox D. Outbreak of electronic-cigarette–associated acute lipoid pneumonia—North Carolina, July–August 2019. Morbidity and Mortality Weekly Report. 2019 Sep 13; 68(36):784

[14] Bhat TA, Kalathil SG, Bogner PN, Blount BC, Goniewicz ML, Thanavala YM. An animal model of inhaled vitamin E acetate and EVALI-like lung injury. New England Journal of Medicine. 2020 Mar 19; 382(12):1175-7

[15] Freathy S, Kondapalli N, Patlolla S, Mora A, Trimmer C. Acute lung injury secondary to e-cigarettes or vaping. InBaylor University Medical Center Proceedings 2020 Apr 2; 33(2); pp. 227-228. Taylor & Francis

[16] Gay B, Field Z, Patel S, Alvarez RM, Nasser W, Madruga M, Carlan SJ. Vaping-induced lung injury: A case of lipoid pneumonia associated with E-cigarettes containing cannabis. Case reports in pulmonology. 2020 Oct; 2020

[17] Blagev DP, Lanspa MJ. Autopsy insights from the EVALI epidemic. The Lancet Respiratory Medicine. 2020 Dec 1; 8(12):1165-6

[18] Chand HS, Muthumalage T, Maziak W, Rahman I. Pulmonary toxicity and the pathophysiology of electronic cigarette, or vaping product, use associated lung injury. Frontiers in pharmacology. 2020 Jan 14; 10:1619

[19] Jankharia B, Rajan S, Angirish B. Vaping associated lung injury (EVALI) as an organizing pneumonia pattern-A case report. Lung India: Official Organ of Indian Chest Society. 2020 Nov; 37(6):533

[20] Rao DR, Maple KL, Dettori A, Afolabi F, Francis JK, Artunduaga M, Lieu TJ, Aldy K, Cao DJ, Hsu S, Feng SY. Clinical features of e-cigarette, or vaping, product use–associated lung injury in teenagers. Pediatrics. 2020 Jul 1; 146(1)

[21] Nelson B. Vaping, lung damage, and cytopathology: A new twist in the medical mystery: Accumulating evidence has clarified the role of cytopathology in the diagnosis of vaping-associated lung injuries and implicated vitamin E acetate as a likely culprit. Cancer Cytopathology. 2020 Mar;128(3):153-4

[22] Cobb NK, Solanki JN. E-cigarettes, vaping devices, and acute lung injury. Respiratory care. 2020 May 1; 65(5):713-8

[23] Ranpara A, Stefaniak AB, Williams K, Fernandez E, LeBouf RF. Modeled Respiratory Tract Deposition of Aerosolized Oil Diluents Used in Δ9-THC-Based Electronic Cigarette Liquid Products. Frontiers in public health. 2021; 9