

Case Report**VAPING-ASSOCIATED PULMONARY INJURY**Aparna Alavalapadu,¹ Raphael Mattamal^{1*}**Author information:** 1. Department of Pediatrics, Texas Tech University Health Sciences Center, Amarillo, Texas, USA.

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Abstract: Vaping-associated pulmonary injury (VAPI) is a newly evolving medical condition caused by inhalation of substances including tetrahydrocannabinol- or nicotine-containing products via vaping. Vaping is the act of inhaling and exhaling an aerosol, which can contain fine particles that have been identified as toxic chemicals, produced by an e-cigarette or similar device. Presenting symptoms of VAPI include respiratory symptoms (dyspnea, chest pain, cough, and hypoxia), gastrointestinal symptoms (nausea, emesis, diarrhea, and abdominal pain), and constitutional symptoms (fever, chills, weight loss, and fatigue). The diagnosis and management of VAPI are being studied and it is considered a diagnosis of exclusion. Most patients are young, with male predominance, and history of vaping. The severity of presenting symptoms varies. Radiographic findings vary in severity with chest x-rays showing bilateral infiltrates, although those findings may be absent early in the disease course. Computed tomography of the chest can show bilateral ground-glass opacities with pleural effusions and pneumomediastinum. Management of VAPI is based upon clinical presentation with empiric antibiotics for CAP coverage and steroids if indicated for reducing lung inflammation.

Keywords: Vaping; Pulmonary; Inhalation; Marijuana; Nicotine

INTRODUCTION Vaping-associated pulmonary injury (VAPI) is a newly evolving medical condition caused by inhalation of substances including tetrahydrocannabinol (THC) or nicotine. Vaping is the act of inhaling and exhaling an aerosol containing fine particles that may be identified as toxic chemicals, produced by an e-cigarette or similar device. Presenting symptoms include respiratory symptoms (dyspnea, chest pain, cough, and hypoxia), gastrointestinal (GI) symptoms (nausea, emesis, diarrhea, and abdominal pain), and constitutional symptoms (fever, chills, weight loss, and fatigue). Radiographic features include bilateral infiltrates on chest x-ray and ground glass opacities on computed tomographic (CT) scans of the chest.

First described in the summer of 2019 with over two thousand cases reported to the Centers of Disease

Control as of early 2020, the disease severity was alarming. Many young people experienced respiratory distress leading to death. It is important to bring attention to today's youth that vaping can lead to severe pulmonary disease and death.

Management includes respiratory support and antibiotics with steroids. We will discuss the presentation and management of VAPI in two teenagers.

CASE REPORTS *Patient 1* was a 16-year-old male with severe GI symptoms (roughly 10 episodes per day of nonbilious nonbloody emesis with maximum 9/10 abdominal pain for over a week), respiratory symptoms (nonproductive cough and pleuritic chest pain), and fever of 102.6° F for 6 days prior to presentation. The patient had smoked marijuana for 2 years with intermittent vaping. Initial lab studies showed an elevated white blood cell count with neutrophil predominance, elevated erythrocyte sedimentation rate, and an elevated C-reactive protein level. The boy had an extensive work-up due to the severity of his GI symptoms. CT imaging of chest found diffuse peripheral interstitial markings and ground

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glass attenuation with a mild basilar gradient and subpleural sparing (Figure 1). The patient was started on intravenous fluids and antibiotics (ceftriaxone in ER which was replaced with linezolid and piperacillin-tazobactam), given pain control with acetaminophen and ketorolac tromethamine, and ondansetron as needed for nausea.

Patient 2 was an 18-year-old female with fever greater than 101° F, weight loss of 9 pounds, and respiratory symptoms (cough, shortness of breath, hypoxemia, squeezing substernal chest pain, and severe deconditioning indicated by inability to climb stairs) for 5 days prior to presentation. She had been vaping THC for 3 months. Initial lab studies found an unremarkable white blood cell count with neutrophil predominance, an elevated erythrocyte sedimentation rate, and an elevated C-reactive protein level. CT imaging of chest found bilateral near diffuse fine interstitial and alveolar pulmonary opacities predominating in a perihilar distribution with peripheral sparing (Figure 2). The patient was started on intravenous fluids, oxygen support via nasal cannula, antibiotics (ceftriaxone and azithromycin which were discontinued after a couple of days due to VAPI diagnosis), and steroids (prednisone 40 mg daily x 5 days). Summary of clinical presentations and actions are shown in Table 1 for comparison.

DISCUSSION There is an increasing number of VAPI cases that are being investigated in the United States. The diagnosis and management of VAPI is being studied and is not well established. Differentials include common diagnoses such as community acquired pneumonia (CAP), organizing pneumonia / interstitial lung disease (ILD), and hypersensitivity pneumonitis, to more rare entities such as acute eosinophilic pneumonia (AEP), lipoid pneumonia (classically from aspiration of mineral or vegetable oil), and giant cell pneumonitis (classically associated with heavy metal exposure).

Most patients are young, with male predominance and a history of vaping [1]. Severity of presenting symptoms varies. Some cases require intubation and extracorporeal membrane oxygenation. Fatalities have been reported [2].

Findings from chest x-rays vary in severity and include findings of bilateral infiltrates, although those findings may be absent early in the disease course [3]. Computed tomography (CT) of the chest can show bilateral ground glass opacities with pleural effusions and pneumomediastinum.

In reported cases, bronchoalveolar lavage samples were collected to rule out infection. Bronchoalveolar lavage often showed neutrophilic predominance and, in some cases, lipid-laden macrophages. Lipoid pneumonia is an inflammatory response to the presence of lipids within the alveolar space and results from aspiration of hydrocarbons or oil-based products (such as THC oil). CT findings usually show fat attenuation in the lungs in lipoid pneumonia, and this was not seen in VAPI [3].

We found the work-up and treatment of patients varied based on symptom presentation. The VAPI literature concludes it is a diagnosis of exclusion [2]. Healthy young adults with no significant medical histories are simpler to diagnose with VAPI given a positive vaping history (especially with illicitly acquired vaping cartridges or THC containing cartridges), lack of other reported exposures, and lack of response to standard therapies for community acquired pneumonia. In the current age, a negative COVID-19 test and/or antibody profile is also helpful given similar findings that may be present to COVID pneumonia on CT scan or CXR.

Management of VAPI is symptomatic and benefits from antibiotics and steroids. Patient 1 had an extensive work-up and was treated with antibiotics and no steroids and had a longer length of stay in the hospital. Patient 2 was treated with antibiotics and steroids and had a shorter duration of stay. The addition of steroids may have accelerated improvement in the patient's clinical status. Antibiotics have not been found to help as this is not an infectious process, but an inflammatory one [2]. However, given the presentation of a VAPI patient, it is reasonable to begin antibiotics until the diagnosis is confirmed. Steroid treatment in VAPI is still a controversial topic. Several randomized controlled trials have shown that steroids may reduce length of stay and risk of intubation in severe community-acquired pneumonia patients [5]. Given that knowledge, patients with no contraindications to steroids may be given a 10-day course of prednisone to help reduce inflammation. The regimen and dosing of steroids has not been firmly established for VAPI, though the most common course is lower dose steroids (e.g. methylprednisolone, prednisone, etc. at 0.5 to 1 mg/kg/day for a total of 5-10 days). The CDC has also published interim guidelines for clinicians [6].

Variable	Patient 1	Patient 2
Age/Gender	16-year-old Male	18-year-old Female
Symptom onset to presentation	6 days	5 days
Presenting symptoms	Severe GI symptoms, respiratory symptoms, fever	Fever, weight loss, respiratory symptoms
Duration of Vaping	2 years of marijuana smoking with intermittent vaping	Vaping of THC containing cartridges for 3 months
Initial Laboratory studies (Norms provided)		
WBC (10 ³ /mcl) (4.5-14.5 10 ³ /mcl)	15.7	6.8
Neutrophils (%) (31-56%)	90.6	83.7
Lymphocytes (%) (28-65%)	5.3	13.7
Eosinophils (%) (0-5%)	0.1	0.0
Erythrocytes Sedimentation Rate (mm/hr) (0-20 mm/hr)	49	48
C-Reactive Protein (mg/L) (<2.99 mg/L)	>190	187
Other work-up values that were normal	Amylase, lipase, gamma-glutamyl transferase, cortisol, magnesium, phosphorous, lipid panel, thyroid studies, human immunodeficiency virus, blood culture, respiratory viral panel, Streptococcal swab, antinuclear antibody panel (family history of systemic lupus erythematosus), cytomegalovirus, Epstein-Barr virus, tuberculosis testing, creatinine kinase, urine toxicology screen.	Magnesium, phosphorous, uric acid, lactase dehydrogenase, prealbumin, thyroid studies, vitamin D level, blood culture, human immunodeficiency virus, urine human chorionic gonadotropin
Medical Management		
Medical therapy	Antibiotics	Antibiotics + steroids
Supportive interventions	Intravenous fluids; pain control; anti-nausea medication.	Intravenous fluids; O ₂ via nasal cannula.
Duration of hospital stay	7 days	4 days
Outcome	Resolution of fever and improvement of presenting symptoms.	Resolution of fever and improvement of presenting symptoms.

Table 1. Summary of clinical findings and actions.

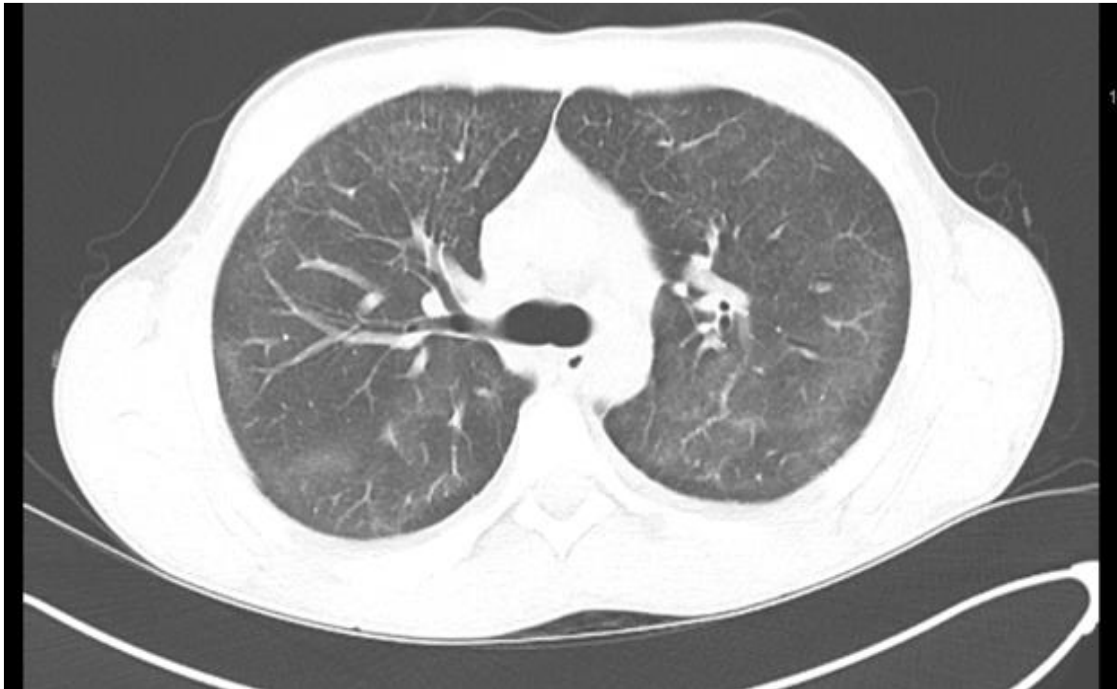


Figure 1. Patient 1: Computerized tomography with contrast shows diffuse peripheral interstitial markings and ground glass attenuation with mild basilar gradient and subpleural sparing.



Figure 2. Patient 2: Computerized tomography with contrast shows bilateral near diffuse fine interstitial and alveolar pulmonary opacities predominating in a perihilar distribution with peripheral sparing.

CONCLUSION The two VAPI cases presented in this report highlight the management variability between cases. VAPI is a new condition that is coming to light in young adults. It is important to get a comprehensive history and physical examination, including a social history. VAPI is a diagnosis of exclusion, and it is imperative to rule out infection.

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