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CASE REPORT

Toxicology

E-cigarette or vaping product use-associated lung injury (EVALI) characterized by pulmonary ultrasound

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Abstract

Pulmonary ultrasound is a useful tool in the diagnosis and resuscitation of emergency department (ED) patients with dyspnea. We present the case of a patient who was diagnosed with E-cigarette or vaping product use-associated lung injury (EVALI) using pulmonary ultrasound. Many of these cases are diagnosed using x-ray, computerized tomography, or bronchoscopy and to our knowledge this is the first published case that demonstrates utility of ultrasound in diagnosing EVALI. While more investigation is needed on the use of this technique, the patient in this case was diagnosed with EVALI based on positive history, presence of normal cardiac function, non-cardiogenic pulmonary edema on ultrasound, and absence of pulmonary infection.

1 | INTRODUCTION

E-cigarette use, or vaping, is increasingly prevalent as a modality for tobacco and tetrahydrocannabinol (THC) consumption. The long-term effects of electronic cigarette use are not yet known due to its relative infancy, but E-cigarette or vaping product use-associated lung injury (EVALI) has become a recognized condition. EVALI is a spectrum of disease that includes diffuse alveolar hemorrhage, lipoid pneumonia, acute eosinophilic pneumonia, hypersensitivity pneumonitis, and organizing pneumonia.^{1,2} Patients may present to the hospital with a myriad of symptoms that can include dyspnea, cough, chest pain, exercise intolerance, gastrointestinal upset and interventions required may range from simple monitoring to supplemental oxygen administration, mechanical ventilation, extracorporeal membrane oxygenation, and lung transplant.³ Due to the diverse nature of complaints, the differential diagnosis in these cases is broad and includes pneumonia, bronchitis, pulmonary edema secondary to cardiac or noncardiac causes, obstructive lung disease, pulmonary embolism, and acute coronary syndrome. Diagnosis is made by clinical history and imaging suggestive of lung injury. Imaging with chest x-ray and computerized tomography (CT) scan can show ground glass opacities indicative of lung injury and bronchoscopy can aid in diagnosis but to date there

are no published reports of pulmonary ultrasound use in diagnosing EVALI.^{4,5}

2 | CASE

A previously healthy 26-year-old male with a medical history of exercise-induced asthma and e-cigarette use presented with dyspnea and cough for 9 days. The patient presented to the hospital in November of 2019, before the Covid-19 pandemic. He was evaluated at an urgent care where he was diagnosed with pneumonia and placed on doxycycline. He remained symptomatic and was seen in an outside hospital ED where azithromycin was added. Two days prior to presentation to our ED he was again seen at urgent care and given albuterol/ipratropium nebulizer treatments, an intramuscular dose of dexamethasone, and levofloxacin. One day prior to arrival he developed blood-tinged sputum. His last use of e-cigarettes containing THC was 5 days prior to arrival, though he reported over 1 year of using THC-containing canisters.

On presentation to our ED, the patient was found to be hypoxic to 88% on room air and tachypneic. He was placed on 2L O₂ by nasal cannula with some improvement in symptoms and vital signs.

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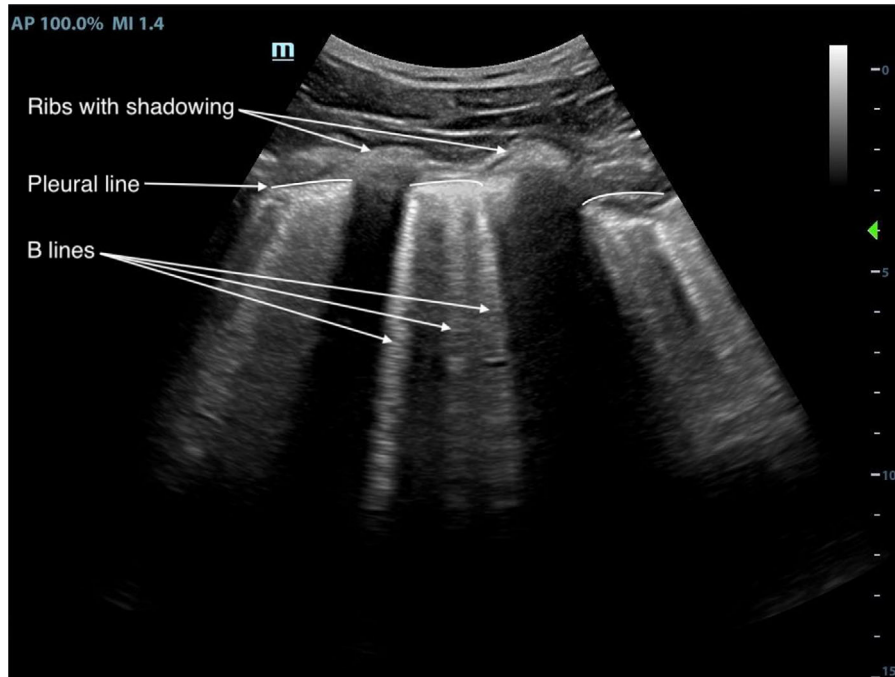


FIGURE 1 Ultrasound of right lung apex demonstrates diffuse B lines indicating pulmonary edema

Pulmonary exam revealed diffuse rales with mild expiratory wheezes. The differential diagnosis in this otherwise healthy patient with new onset dyspnea, cough, and oxygen requirement included pneumonia, bronchitis, asthma exacerbation, pneumothorax, pulmonary embolism, heart failure, and cardiogenic pulmonary edema. Given the patient's history of e-cigarette use, EVALI was also considered.

Point-of-care ultrasound of the lungs and transthoracic echocardiogram were performed to evaluate the patient's disease process. Bedside echocardiogram consisting of the standard subxiphoid, parasternal long and short, IVC, and apical 4 chamber views showed a grossly normal left ventricular ejection fraction (LVEF), no right heart strain, and no pericardial effusion. Ultrasound of the lungs was performed using the bedside lung ultrasound in emergency protocol and 6 views were obtained.⁶ Views of the inferior and superior anterior lungs and mid-thoracic posterior axillary line were obtained for a total of 6 images and diffuse B lines were visualized throughout all lung fields (Figure 1). The presence of multiple B lines, or discrete hyperechoic reverberation artifacts emanating from the pleural line and extending into the lung parenchyma, indicated interstitial fluid.⁷ The patient had appropriate lung sliding bilaterally, indicating the absence of a pneumothorax. The posterior axillary line views showed no pleural effusion. There was no evidence of pneumonia as the patient had no visualized consolidations or air bronchograms and there was no hepatization of the lungs.⁸ The presence of diffuse B-lines in conjunction with a normal LVEF led to the diagnosis of diffuse noncardiogenic pulmonary edema. The patient's history of using THC-containing vape cartridges and evidence of lung injury on imaging were consistent with EVALI. A CT scan of the patient's lungs confirmed the diagnosis (Figure 2).

The patient's condition improved over the course of his hospitalization. He received steroids and nebulizer treatments and was eventually

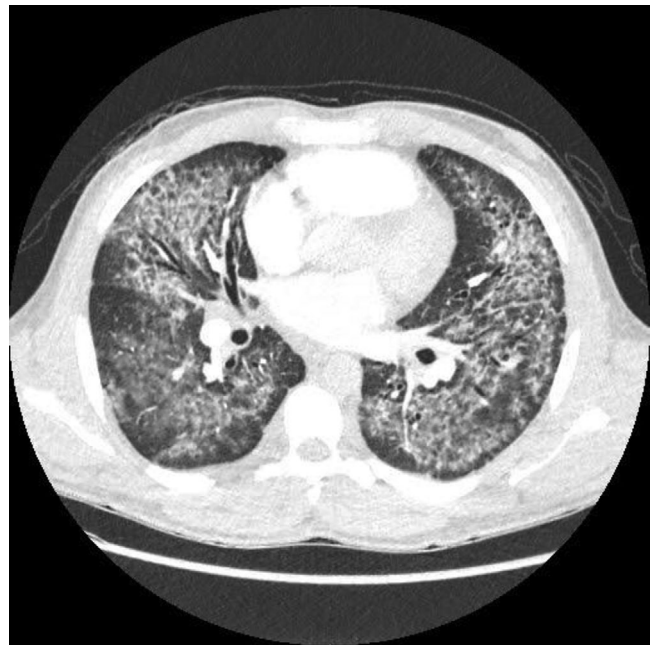


FIGURE 2 CT scan of chest showing diffuse alveolar hemorrhage

weaned off supplemental oxygen. On discharge, the patient was able to ambulate without oxygen while maintaining a normal oxygen saturation. He was found to be negative for streptococcus pneumoniae, legionella, influenza, RSV, HIV, hepatitis, and mycoplasma. A comprehensive respiratory viral panel was also negative. Sputum and blood cultures were negative. A CT scan the day of discharge showed resolution of his lung injury.

3 | DISCUSSION

Pulmonary edema, most likely secondary to diffuse alveolar hemorrhage, is a known complication of e-cigarette use. While there is no consensus on a single cause of EVALI, the presence of vitamin E acetate in THC oil-containing samples has been linked to lung injury.⁹ Surfactant disruption by hydrophobic vitamin E likely results in lung injury, causing non cardiogenic pulmonary edema. Despite having significant lung injury and vital sign abnormalities, these patients often have normal exams by pulmonary auscultation. In this patient, use of ultrasound helped diagnose EVALI by presence of B lines without any consolidation, effusion, or pneumothorax.

Importantly, this patient had previously been diagnosed with pneumonia after chest x-rays at an urgent care and outside hospital. While his symptoms of cough and dyspnea in the presence of an abnormal chest x-ray were concerning for pneumonia, the patient did not improve with antibiotics and fortunately continued to seek medical care. Point-of-care lung ultrasound ultimately proved more valuable in diagnosing his condition. The presence of B-lines on the patient's bedside ultrasound with appropriate lung sliding and lack of air bronchograms or hepatization indicated pulmonary edema rather than pneumonia as the most likely diagnosis. As stated previously, the absence of anechoic pleural effusions in the inferior thorax and the presence of appropriate lung sliding excluded other potential causes of the patient's symptoms.

While EVALI represents a spectrum of disease, this patient's particular injury resulted in the development of interstitial fluid and pulmonary edema that was visible by ultrasound. Point-of-care ultrasound is well recognized as a useful modality in dyspneic patients, and in this patient with hypoxemia pneumothorax, effusion, consolidation, and cardiogenic causes were quickly excluded. While auscultation and chest x-ray can diagnose pulmonary edema, they alone are not sufficient to determine its cause. Ultrasound was useful in diagnosing pulmonary edema in this patient by demonstrating diffuse B lines without evidence of other potential causes to the patient's dyspnea. A point-of-care echocardiogram showed normal ejection fraction, which indicated a non-cardiogenic cause to this patient's pulmonary edema. Ultrasound findings identified the patient's pathology and taken with a history of E-cigarette use, the diagnosis of EVALI was confirmed. The patient was therefore treated with steroids rather than diuretics or antibiotics according to the current treatment recommendations for EVALI.¹⁰

4 | CONCLUSION

EVALI represents a spectrum of disease with a broad range of symptom severity. Pulmonary ultrasound is widely recognized as an important

aid in the evaluation of dyspneic ED patients, and this case highlights its utility in diagnosing this emerging disease. More research is needed to determine its sensitivity in diagnosing EVALI and whether ultrasound findings correlate with symptom severity or disease progression.

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