Vaping associated spontaneous pneumothorax – A case series of an enigmatic entity!

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ABSTRACT

The use of electronic nicotine delivery devices (ENDDs) has risen to an epidemic level among high schoolers and people aged 18–34. To our knowledge there are only 7 reported cases of spontaneous pneumothorax (SP-PTX) associated with vaping, and herein we describe 4 additional cases. We propose identifying this disease process as a novel entity, Vaping-Associated Spontaneous Pneumothorax (VASP). VASP requires early interventional treatment and has a high recurrence rate, and we suggest that vaping cessation and early interventional treatment including tube thoracostomy and surgical treatment is necessary in most cases to prevent recurrences.

1. Introduction

The use of electronic nicotine delivery devices (ENDDs) has risen to an epidemic level with a prevalence of 20.8% and 4.8% among high schoolers and people aged 18–34 years, respectively [1]. Since September 2019, vaping-induced lung injury has erupted as its own entity which has been increasingly reported to the Centers for Disease Control and Prevention (CDC) and has resulted in 68 deaths [2]. Our team reported the first case of acute lipoid pneumonia associated with vaping [3]. More recent data has reported an association between vaping and several lung parenchymal diseases such as acute eosinophilic pneumonia, hypersensitivity pneumonitis, diffuse alveolar hemorrhage, acute interstitial lung disease, and respiratory bronchiolitis-associated interstitial lung disease [4]. To our knowledge there are only seven prior reported cases of spontaneous pneumothorax (SP-PTX) associated with vaping, and herein we describe 4 additional cases [4]. We propose to identify this disease process as a separate entity, Vaping-Associated Spontaneous Pneumothorax (VASP). We have briefly reviewed the distinct pathophysiology and management of VASP in our report.

2. Case presentations

2.1. Case 1

A 19-year-old male with no significant past medical history presented to the emergency room (ER) with chest pain, shortness of breath and reportedly a feeling of impending doom. These symptoms started 3 h prior to presentation when the patient was vaping marijuana. He experienced a sudden onset of left-sided sharp pleuritic chest pain, radiating to the left scapula. He had no past medical or surgical history. In addition, there was no personal or family history of Marfan syndrome. The patient denied smoking cigarettes, or consuming alcohol. Physical examination upon presentation was notable for blood pressure (BP) 110/69 mm Hg, Heart Rate (HR) 66 beats per minute, temperature 36.3 °C, respiratory rate (RR) 18 per minute and body mass index (BMI) 19.7 kg/m². Respiratory exam produced decreased left sided breath sounds. A chest x-ray (CXR) done in the ER showed left-sided pneumothorax without evidence of mediastinal shift. Computed tomography (CT) scan of the chest re-demonstrated moderate-sized pneumothorax with small bilateral apical blebs. The patient was advised chest tube placement but refused the intervention. He was admitted for observation and his symptoms improved over the next two days. Repeat chest x-ray 48 hours after admission showed decreasing pneumothorax with further symptom improvement. He was seen in the outpatient clinic multiple times after discharge. Complete resolution of pneumothorax took four weeks. A comparison of CXR obtained at admission and on resolution of pneumothorax is shown in Fig. 1.

The patient follows up regularly in the clinic and no recurrence of pneumothorax has been noted after he quit vaping.
2.2. Case 2

A 20-year-old female with a past medical history of concussion presented to emergency department with a chief complaint of cough. She described a non-productive, progressively worsening cough over five days. Additionally, she reported fatigue and shortness of breath with exertion for the last two days. She denied fever, chills, heart burn, hemorrhages, travel or trauma to the chest prior to the onset of the cough. Review of symptoms was significant for irregular menstruation. The patient reported that her roommate was sick and had a similar cough.

She had no personal or family history of Marfan syndrome. She denied cigarette smoking or alcohol consumption; however, she admitted to vaping marijuana heavily over the two days prior to her presentation. Physical examination revealed temperature of 36.9 °C, HR 72 per minute, BP 110/69 mmHg, RR 26 per minute, and oxygen saturation of 100% on room air. Her BMI was noted to be 15.3 kg/m² (height 170 cm and weight 44.5 kg). Respiratory exam was significant for decreased right-side breath sounds. CXR obtained at admission showed a large right-sided tension pneumothorax with leftward mediastinal shift. A right anterior chest tube was placed, air was aspirated and chest tube was placed to suction. Follow-up imaging revealed resolved tension physiology and a significant decrease in the size of the pneumothorax. CT chest did not show any evidence of emphysema, blebs, cysts or nodules. Over the next five days, the pneumothorax did not resolve with simple chest tube placement. Thoracic surgery evaluated the patient and she underwent VATS. During examination of the visceral surface, a 2.5 cm by 2.5 cm intact bleb was found and resected. Subsequently, the patient underwent abrasion pleurodesis. Post-operative course was uncomplicated and the chest tube was removed on post-operative day 3. A comparison of CXR at admission and 24 hours after chest tube removal is shown in Fig. 2.

Surgical pathology from bleb and pleura showed normal lung tissue and ruled out catamenial pneumothorax. The patient followed up in the clinic two months later and reported no recurrent symptoms after quitting vaping.

2.3. Case 3

An 18-year-old Caucasian male presented to the ER for sudden onset of cough, nasal congestion, trauma or recent travel. Vital signs upon presentation showed a temperature of 36.4 °C, HR of 68 per minute, BP of 105/61 mmHg, RR of 22 per minute, and oxygen saturation of 94% on room air. Respiratory exam was significant for decreased right-side breath sounds. CXR obtained in the ER demonstrated a large right-sided pneumothorax without evidence of tension. A chest tube was inserted and placed to suction with immediate improvement in symptoms and the patient was monitored on the medicine floor. His pneumothorax resolved within few days. He was offered chemical pleurodesis and/or surgery in alignment with British Thoracic Society (BTS) guidelines. The patient elected for chemical pleurodesis which was completed during the hospital stay. He followed up in the clinic three months later and reported quitting vaping. There has been no recurrence of pneumothorax.

2.4. Case 4

A 35-year-old male presented to the ER for sudden onset of cough, shortness of breath and sharp chest pain in the left shoulder blade and left anterior chest. The pain worsened with cough and deep breathing, but not upon exertion. He had a past medical history of spontaneous pneumothorax eight years ago which was treated with chest tube. CT chest at that time showed right upper lobe blebs, for which no definitive management was followed. He reported social drinking, 7.5 pack/years of smoking and vaping marijuana 3 h prior to presentation. He had no recent fevers, congestion, nasal discharge, travel, trauma, prolonged immobilization, surgery or known sick contacts. He denied any significant occupational exposure. He had no past history of vision changes, heart problems, or joint laxity. In addition, there was no family history of Marfan syndrome. He reported no current medications, cigarette smoking, or alcohol consumption.

Physical examination revealed temperature 36.8 °C, HR 72 per minute, BP 110/62 mmHg, RR 21 per minute, and oxygen saturation of 96% on room air. His height was 190 cm, weight 59 kg and calculated BMI was 16.2 kg/m². Respiratory exam showed decreased right-side breath sounds. CXR in the ER demonstrated a large right-sided pneumothorax with evidence of tension. A chest tube was placed to suction, after which symptoms improved, and the patient was placed under observation. The pneumothorax resolved within the next few days and the chest tube was removed in a stepwise fashion. His presentation at the time was attributed to his body habitus. He was encouraged to quit vaping.

One week after discharge, he presented again to the ER for sudden-onset right-sided pleuritic chest pain and shortness of breath. He reported daily vaping after discharge, but no fever, chills, hemoptysis, cough, nasal congestion trauma or recent travel. Vital signs upon presentation showed a temperature of 36.4 °C, HR of 68 per minute, BP of 105/61 mmHg, RR of 22 per minute, and oxygen saturation of 94% on room air. Respiratory exam was significant for decreased right-side breath sounds. CXR obtained in the ER demonstrated a large right-sided pneumothorax without evidence of tension. A chest tube was inserted and placed to suction with immediate improvement in symptoms and the patient was monitored on the medicine floor. His pneumothorax resolved within few days. He was offered chemical pleurodesis and/or surgery in alignment with British Thoracic Society (BTS) guidelines. The patient elected for chemical pleurodesis which was completed during the hospital stay. He followed up in the clinic three months later and reported quitting vaping. There has been no recurrence of pneumothorax.
of Marfan syndrome or lung disease.

Physical examination showed height 183 cm, weight 77.6 kg and BMI 23.2 kg/m². Vital signs were HR 109 per minute, BP 128/89 mm Hg, RR 20 per minute, saturating 96% on room air. Physical examination revealed decreased breath sounds on the left. Remainder of physical exam was unremarkable. CXR showed large left pneumothorax, at least 50% in size, with slight mediastinal shift to the right. Chest tube was placed to suction which resulted in full expansion of lungs within a day. Patient was discharged two days later after removal of chest tube.

One week later, during an outpatient evaluation, his primary care physician noticed decreased breath sounds on the left as compared to the right. The patient reported shortness of breath on exertion for three days. On presentation to the ER, vital signs were BP 153/105 mm Hg, HR 81 per minute, RR 16 per minute and oxygen saturation of 98% on room air. CXR showed complete collapse of the left lung with mediastinal shift to the right and evidence of tension. The patient was placed on 2L oxygen. A chest tube was inserted and placed to suction. High resolution CT chest showed multiple bullae in both upper lobes with patchy infiltrates throughout the left lung likely representing areas of atelectasis/pneumonitis. The patient was treated with amoxicillin-clavulanate for possible community acquired pneumonia. Repeat CT chest with contrast five days later demonstrated complete resolution of left-sided opacities. His pneumothorax resolved fully with chest tube and he was subsequently discharged. Later, he underwent left-sided VATS, bullectomy and talc pleurodesis. He tolerated the procedure well without any complications. Chest tube was kept on suction for 48 hours post-surgery and removed on post-operative day 2. Biopsy of bullae showed emphysematous bulla/blebs and respiratory bronchiolitis. A comparison of CXR at admission for left-sided pneumothorax and complete resolution of pneumothorax after undergoing VATS is shown in Fig. 3.

The patient followed up in the clinic two weeks later and had no evidence of recurrent pneumothorax. He underwent right sided VATS, blebectomy and talc pleurodesis six weeks later. He tolerated the procedure well.

Table 1 summarizes our 4 cases [5].

3. Discussion

Given the temporal association of vaping to the onset of respiratory symptoms caused by spontaneous pneumothoraces, we attributed vaping as the culprit of this new suggested entity, VASP, in our case series. The exact underlying pathophysiology of VASP is yet to be fully elucidated, though it is likely multifactorial in origin [6]. We hypothesize that using electronic cigarettes increases the likelihood of developing pneumothorax via inhalation of toxins and different breathing mechanics employed by patients as discussed below.

Inhaled flavored chemicals may contain various toxins such as diacetyl and 2,3 pentadiene which can impair the transcriptional profile of genes regulating lung development.
of primary human bronchial epithelial cells and phenotypically lead to impaired ciliogenesis [7]. Furthermore, electronic cigarettes can alter gene expression within the innate immune system of the airways, impairing ciliogenesis [7]. Furthermore, electronic cigarettes can alter gene expression within the innate immune system of the airways, impairing ciliogenesis [7].

When vaping, people utilize different breathing patterns to allow adequate delivery of vaporized content which may influence the development of VASP. Patterns employing the Valsalva maneuver such as deep inhalation and forceful exhalation can further elevate positive resistance such as a water pipe or pod-based e-cigarettes simulates a muller maneuver, thus generating a high negative intrathoracic pressure, which can lead to development of a spontaneous pneumothorax [10].

Alveolar damage due to inhaled toxins resulting in bleb formation

Fig. 4. Various postulated pathophysiologic processes resulting in VASP. VASP: Vaping-associated spontaneous pneumothorax.

Our study findings are consistent with prior reports in the literature which suggest that VASP requires tube thoracostomy in 85% of cases and has a recurrence rate of 57%, requiring surgical intervention regardless of presence of blebs as summarized in Table 2 [11–16].

In contrast to VASP, primary SP-PTX management is variable and depends on patient and clinical characteristics. It can be managed conservatively with supplemental oxygen if the size of PTX is less than 3 cm [17]. However, recent studies have shown that a conservative approach might be non-inferior to interventional treatment even in cases with moderate to large spontaneous pneumothorax [18]. Unlike VASP, primary SP-PTX is noted to have a lower recurrence rate than VASP at 25–50% with the risk being higher in patients with blebs >1 cm in size, which often demands surgical intervention [17,19].

4. Conclusion

In summary, our case series proposes the novel disease process “VASP” to the literature. We suggest that vaping cessation and early interventional treatment including tube thoracostomy and surgical treatment is necessary in most cases to prevent recurrences, and may improve quality of life and limit health care cost. Mass education regarding the hazards of vaping through various social platforms may assist in curbing this epidemic and mitigating health care issues related

Table 1: Demographics and relevant clinical course of our case series.

|                     | Case 1            | Case 2            | Case 3            | Case 4            |
|---------------------|-------------------|-------------------|-------------------|-------------------|
| Age                 | 19                | 20                | 18                | 35                |
| Gender              | Male              | Female            | Male              | Male              |
| Race                | Asian             | Caucasian         | Caucasian         | African American  |
| BMI/Height          | 20.5/182 cm       | 15.4/170 cm       | 16.2/190 cm       | 23.2/183 cm       |
| Cigarette smoking   | None              | None              | None              | 7.5 pack years    |
| Type of vaping      | Marijuana         | Marijuana         | Marijuana         | Marijuana         |
| Other recreational drugs | None          | None              | None              | None              |
| Laterality of Pneumothorax | Left        | Right             | Right             | Left              |
| Hemodynamic instability* | No             | No                | No                | No                |
| Tension physiology on imaging* | No            | Yes               | Yes               | Yes               |
| Parenchymal abnormality on imaging | Bilateral apical blebs on CT chest without contrast | No | No | Multiple upper lobe bullae*
| Treatment of Pneumothorax | 100% Oxygen    | Chest tube, VATS, blebs resection, abrasion pleurodesis | Chest tube, Chemical pleurodesis, VATS, mechanical pleurodesis | Chest tube
| Length of hospital stay | 2 days*         | 11 days           | 5 days            | 3 days            |
| Recurrent Pneumothorax | No              | No                | Yes*              | Yes*              |
| Pathology           | Blebs and emphysematous changes | No | No | Blebs and Respiratory bronchiolitis |

BMI = Body Mass Index, VATS = Video Assisted Thoracoscopic Surgery, RR = Respiratory Rate, CT = Computed Tomography.

* Hemodynamic stability defined per ACCP guidelines: respiratory rate <24/minute, heart rate >60/minute, <120/minute, normal blood pressure, oxygen saturation >90%, ability to speak in full sentences.

* Indicated by mediastinal shift, ipsilateral increased intercostal spaces, depression of diaphragm.

* Patient was offered chest tube placement but refused; complete resolution of pneumothorax took 24 days.

* Multiple bilateral upper lobe bullae were noted on HRCT on second presentation.

* Patient underwent chemical pleurodesis after first recurrence and VATS with mechanical pleurodesis after second recurrence.
Table 2
Summarizes prior available literature on VASP.

| Case | Laterality | Treatment | Recurrence | Laterality | Treatment |
|------|------------|-----------|------------|------------|-----------|
| 1    | Right      | Chest tube placement followed by bleb removal and right-sided parietal pleurectomy through video assisted thoracic surgery | No | NA | NA |
| 2    | Left       | Supportive NC O2 | No | NA | NA |
| 3    | Right      | Chest tube placement | Yes | Right | Chest tube placement, offered pleurodesis but refused Chest tube placement followed by VATS and mechanical pleurectomy |
| 4    | Left       | Chest tube placement | Yes | Left | No |
| 5    | Right      | Chest tube placement | Yes | Right | Chest tube placement followed by VATS, bleb resection, and pleurodesis |
| 6    | Right      | Chest tube placement resulted in no resolution hence VATS was performed and blebs resection, thoracoscopic pleurectomy, and talc pleurodesis was performed | No | NA | NA |
| 7    | Left       | Chest tube placement followed by VATS, pleurodesis, bleb resection | Yes | Right | Contralateral recurrence: Underwent Bleb resection and pleurodesis |

NA: Not applicable, NC: Nasal canula, VATS: Video-assisted thoracoscopic surgery.

to this national crisis.

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Author's contribution

OA was involved in study conception and design, AN drafted the manuscript, and RK acquired data. AA, OA, AN, and RK completed critical revision of the manuscript and AA served as expert on the study.

Declaration of competing interest

The other authors report no conflicts of interest.

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