Published in final edited form as:

J Addict Med. 2020 December ; 14(6): 446–450. doi:10.1097/ADM.0000000000000634.

THE CLINICAL ASSESSMENT OF VAPING EXPOSURE

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Abstract

Vaping, the inhalation of a nicotine or tetra hydrocannabinol (THC), cannabidiol (CBD), or non-drug infused solution delivered by vaping devices, is a growing phenomenon across many segments of the US population. Complications associated with vaping are newly emerging and relatively unstudied; little guidance exists on how clinicians may best elicit information related to vaping practices and associated medical problems. This publication, therefore, provides physicians and other treatment clinicians with direction for obtaining the medical history that can guide clinical decision-making for patients at risk for adverse effects associated with vaping.

Keywords

vaping; nicotine; THC; CBD; treatment

Introduction

Vaping, the inhalation of a nicotine or tetrahydrocannabinol (THC), cannabidiol (CBD), or non-drug infused solution delivered by vaping devices, is a growing phenomenon across many segments of the US population.[1,2] Vaping has been marketed as a safer alternative than smoking cigarettes, but safety data are lacking. The new phenomenon of vaping is changing the culture of nicotine and marijuana use. Because vaping devices do not combust plant matter and therefore lack the characteristic odor of burning tobacco or marijuana, discrete or surreptitious use can occur in almost any location, promoting use and making indoor smoking bans and other health-promoting restrictions challenging to enforce.[3] The

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popularity of vaping has eclipsed that of cigarette smoking; adolescents have been particularly affected by the epidemic, with 3.6 million middle and high school students reporting e-cigarette use in 2018.[1] Complications associated with vaping are newly emerging and not yet well studied.[4] Respiratory manifestations range from mild respiratory symptoms to fulminant respiratory failure culminating in death.[5] Other complications include patterns of behavioral dysregulation related to high delivered concentration of nicotine and THC similar to other addictive substances.[6,7] Despite striking increases in the incidence of vaping in the US and the number of adverse events associated with it, little guidance exists on how to best adapt history-taking during the clinical encounter to elicit information related to vaping practices. Accurate recording of the quantity, frequency, dosage, type and duration of vaping exposure can help develop treatment plans and has the potential to help allied fields such as pathology and epidemiology in understanding acute toxicities as well as in assessing potential cumulative effects. The clinical process of assessing vaping use can also support vaping cessation efforts. Accordingly, we propose a coherent approach to obtaining the patient history component to help clinicians assess the breadth, frequency, and severity of vaping in patients.

Definitions

- **Vaping devices** consist of a power source, an electronic heating element, and a reservoir containing a liquid to be aerosolized. These devices use heat to aerosolize nicotine or THC solutions (called an “e-liquid”) in a process referred to as “heat not burn”.[3]
- **Cartridges (or ‘pods’)** are purchased with premade liquids that typically contain substances such as nicotine, stabilizing compounds, flavorings, and other chemicals. Empty cartridges can also be to be filled with homemade, custom blends of chemicals. These are often referred to as vaping solutions, e-juice, or juice.
- **JUUL** is a vaping device for the delivery of nicotine. When introduced in 2015, JUUL (San Francisco, CA, USA) revolutionized the vaping industry by commercializing a vaping liquid that contained twice the nicotine concentration (5%) of previous 1–2% nicotine formulations.[3] Addiction is central to the JUUL business model.[3] Accordingly, high nicotine devices such as JUUL deliver nicotine at far higher concentrations than combustible cigarettes.[3]
- **Nicotine or nicotine salt** is used in vaping solutions to deliver nicotine to the brain, resulting in the characteristic rewarding experience. Compared to combustible cigarettes, nicotine concentrations are higher in these solutions. Nicotine salts used in newer vaping devices such as JUUL are much less noxious to airways than cigarettes and allow more vaping as well as delivery of much higher concentrations of nicotine.[3] The use of nicotine salts therefore alters the pharmacokinetic profile of inhaled nicotine; individuals can inhale larger amounts of the drug more rapidly than combustible cigarettes, achieve higher blood and brain concentrations of nicotine and, presumably, develop nicotine dependence more rapidly.[3]

- **Dab pens** are small easily concealable vaping devices that are used with highly concentrated THC-containing oil-based solutions. Dab pens are designed to deliver more highly concentrated THC than most other forms of THC delivery.
- **Tricks** are acts that involve the inhalation and release of vapor that are intended to entertain and impress. Successfully performed tricks (eg, Ghost inhale, French inhale, Dragon, Waterfall, among others) are touted by online influencers as conveying social capital upon the performer.[8]
- **Mod builds** are modifications made to commercial vaping devices to alter their performance characteristics. Information about ways to perform tricks and mod builds are available online, particularly YouTube.[9]
- **E-cigarette or Vaping Associated Lung Injury (EVALI)—**Lung injury associated with vaping in which the patient had 1) a history of vaping or dabbing (inhalation of vaporized marijuana concentrates) within 90 days before symptom onset; 2) imaging studies demonstrating lung injury; 3) absence of evidence of infection or infection not thought to be the sole cause of lung injury, or infectious testing not performed; and 4) absence of alternative plausible diagnoses.[2]
- **Additives** are materials added to vaping solution that vary by product and manufacturer.[10] Many vaping solutions contain chemicals with pronounced toxicity such as flavoring agents (e.g., diacetyl), volatile organic compounds (e.g., benzene), heavy metals (e.g., nickel, tin, lead), vitamin E acetate, polyethylene glycol, and medium chain triglycerides.[10] Homemade solutions or modified commercial products can contain any soluble drug or chemical.[10]

Vaping nicotine

The delivery of nicotine using vaping devices is distinct from that of combustible cigarettes.

Adolescents may not understand what vaping devices are intended to do: administer drugs through pulmonary routes of delivery.[11] Whereas recognition that cigarettes deliver nicotine is broad, over 60% of adolescents do not understand that JUUL devices are nicotine delivery devices.[11,12] Whereas the size, nicotine content, rate of combustion, and amount of daily use of traditional cigarettes are established, comparable standardization of products has not occurred in the vaping industry where each puff from a vaping device delivers a variable dose of nicotine and other materials. The common metric to assess traditional cigarette smoking exposure is pack-years, the number of packs/day multiplied by the number of exposure years. This lifetime exposure estimate is highly relevant for two reasons; first, the low concentration of nicotine delivered by cigarette smoking makes acute poisoning unlikely; second, the main harms from smoking combustible tobacco are dose related and accumulate over time. Unfortunately, no measure of cumulative exposure that parallels the pack/day metric has been developed for vaping. Furthermore, unlike smoking tobacco or marijuana cigarettes, vaping both nicotine and THC can result in acute toxicity (e.g., hallucinations and psychosis from vaping marijuana, gastrointestinal symptoms of nausea and vomiting from nicotine inhalation) due to the very high concentrations of drugs that can be delivered.[13,14] Finally, because vaping can cause fulminant lung disease due to chemicals

in the vaping fluid, specific information about the source of the vaping fluid is critical, particularly among patients presenting with respiratory symptoms.[4] When assessing vaping, therefore, lifetime measures alone are insufficient to generate a complete understanding of health risks associated with the behavior.

The clinical evaluation of vaping nicotine mimics the assessment for tobacco use; the general approach is presented in Table 1. While nearly all individuals addicted to nicotine ingest larger amounts of nicotine than intended, develop tolerance, and exhibit abstinence symptoms upon cessation of use, a notable difference is that many individuals who vape, particularly adolescents, present with behavioral dysregulation characterized by stealing, lying, increased aggression and irritability. While social factors may exacerbate nicotine use and confound attributing behavioral dysregulation to vaping, these derangements often culminate in a functional decline in scholastic performance that is unusual among cigarette users.[14] These symptoms are believed to be related to the direct impact of high-dose nicotine on the central nervous system.[3,14] Changes in behavior including more frequent and severe arguments, disinhibition, disturbed psychosocial functioning, irrational behavior, and declining school performance are measures of behavioral dysregulation consistent with nicotine use disorder from vaping.

In the initial stages of an assessment, we recommend that clinicians focus on objective information. Particularly among patients presenting for evaluation of acute respiratory illness, learning the sources of vaping liquid including the name of the manufacturer and product, the addition of substances by the user of the end product and whether the commercial product or delivery system was altered provides important information. Queries about the experience of acute toxicity (e.g., hallucinations and psychosis from vaping marijuana, gastrointestinal symptoms of nausea and vomiting from nicotine inhalation) are a useful component of the clinical assessment.[14] To make an estimate of lifetime exposure, we recommend asking age of initiation, frequency of use, number of pods used per day, and associated symptoms such as signs of nicotine toxicity. The DSM-5 criteria can establish a diagnosis of nicotine use disorder.[15] Withdrawal symptoms, including the development of depressed mood, sleep disturbance, irritability, anxiety, and increased hunger, are common upon abstinence from nicotine. Assessing whether patients have used vaping devices to a greater extent than was intended, impact on physical activity, quit attempts, as well as the motivation for them all point to a detrimental impact on day-to-day functioning while exploring ambivalence. Generally, adolescents can report accurately whether more frequent vaping is needed to achieve desired effects; determining the number of cartridges or pods used over time can help identify the presence of the neuroadaptive phenomenon of tolerance.[16] We also recommend identifying the frequency and intensity of cravings. Asking about the extent to which e-cigarette users also smoke traditional cigarettes or use other tobacco products can be particularly important for making decisions regarding initiating nicotine replacement therapy.

Clinicians should be aware of potential differences in responses from adults or adolescents in the assessment of vaping. For example, adolescents may not recognize the impact of nicotine on their behavior and, instead attribute recurrent, severe behavioral dysregulation to interpersonal or interfamilial conflict that characterize adolescence instead of their drug use.

To distinguish between typical adolescence and the impact of nicotine use disorder, clinical assessment of adolescent vaping should therefore focus on increased frequency of use and include surrogate measures such as amount of money and resources directed toward obtaining vaping solutions, devices, and cartridges. Furthermore, vaping devices carry less stigma than cigarettes, adolescents recognize that parental discomfort with vaping often makes use of e-cigarettes a stigmatized behavior. Understanding the extent to which adolescents use these products outside of the house, including in school, or try to hide their vaping, is therefore important in understanding the problems, and in particular the interpersonal conflict, associated with nicotine use. Whereas adult patients may recognize a need to decrease cigarette use, adolescents, with limitations in executive function and greater impulsivity typical of the age group, may not register that nicotine use has become problematic.

Vaping cannabis

The use of THC is not new; what is new is the scale, scope, and variety of new and more concentrated cannabis products fostered by commercialization of marijuana.[17,18] Because vaping avoids the characteristic smell of burning marijuana, inhalation of THC by vaping can be highly discreet; as the social contexts surrounding THC use have made it more overt and less stigmatized, use of the drug, particularly by vaping, has grown.[19] The amount of THC that some users vape can be dramatic, reaching up 50 mg THC inhaled in a single session, with a total consumption of up to 700mg per day; in comparison, a typical “joint” of marijuana delivers approximately 12mg inhaled THC (Monte A, personal communication, 2019). As with nicotine, the more rapidly delivery of THC to the brain by vaping compared to combustible and edible products dramatically alters the clinical presentation, such as increased incidence of hallucinosis or psychotic reactions.[17]

Assessment of behaviors related to the vaping of cannabis is complex, not only because of the large number of THC-containing products manufactured by an industry that remains largely unregulated, but also because of the growth of ‘grey market’ cannabis vaping products coupled with homemade vaping liquids of unknown and variable chemical compositions. Even the method individuals can use to inhale THC is complex; in addition to e-cigarette and “dab pens”, vaporizers can deliver THC from cannabis flower, shatter (a hard, translucent concentrate of THC similar in texture to glass), or wax (a sticky, highly viscous concentrate of cannabis oils that holds its form after cooling). Some users increase the concentration of THC delivered by “dripping” where THC solutions are applied directly to heating coil to produce a vapor to be inhaled.[20] As the frequency of use and dose of inhaled THC have increased, so too have the incidence of clinical conditions associated with problematic cannabis use such as cannabis hyperemesis syndrome as well as mental health and behavioral disorders.[21]

As with the assessment of nicotine vaping, identifying where THC vaping products were purchased, the product name, and the manufacturer, if available, can provide useful information, particularly for patients who present to an emergency department of evaluation of acute respiratory symptoms.[2] When evaluating users who experiment with custom or homemade vaping solutions, clinicians should obtain sources of information about methods

used to make these products; review of online tutorials, for example, can help define method of preparation, identify the chemicals used in vaping solutions (e.g., extraction solvents, heating, distillation, flavorings), and reveal other individualized aspects of cannabis vaping.

The age of initiation, frequency of use, and change in cannabis use over time can help identify lifetime exposure; change in cannabis use over time can help identify development of tolerance.[22] Other questions that can be useful for both assessing severity of illness as well as optimizing the effectiveness of interventions include identifying problems related to marijuana use, changes in school or work function, loss of interest in other activities, interpersonal problems with parent, teachers, coaches, or friends, or dangerous use (particularly while driving).[22] Questions about quit attempts can help uncover ambivalence about ongoing THC use and readiness to change. A brief assessment followed by psychoeducation to correct misinformation about THC use, addiction, and adverse effects of use, coupled with advice that choosing not to use is the healthiest option for all adolescents, can serve as an initial brief intervention.[22]

Special considerations: Focused assessments

Certain clinical environments demand more focused assessments of vaping. In particular, emergency department clinicians, with their emphasis on efficient disposition of patients, do not have the time to complete comprehensive evaluations and may reasonably limit their assessments to discriminating between a medical and behavioral workup. Accordingly, the italicized content presented in Table 1, which focuses on the relationship between substance use and respiratory outcomes, may be more realistic for use in emergency settings.

Conclusion

Our understanding of acute and chronic effects of vaping is limited by variations in use patterns (especially since adolescents share vaping products) and extensive overlap of nicotine and THC vaping, particularly in combination with other drug use behaviors. Further complexity comes from rapid changes in the vaping landscape arising from introduction of new vaping brands, vaping liquids, and “knock-off” products; banning of vaping products; expanding THC legalization; and use of “black market” or homemade vaping materials. Finally, proprietary vaping liquid compositions can contain potentially thousands of flavorants, additives, and other chemicals designed to alter the vaping experience; assigning causation of lung injury to a specific chemical is therefore difficult. Our recommendations presented here can help clinicians obtain a detailed history of drug exposure and outcomes from nicotine and THC vaping that can serve as useful guidance until estimates of both lifetime and acute exposure to these drugs can be rigorously established.

Acknowledgments

Sources of Support that Require Acknowledgement/Conflicts of Interest and Sources of Funding:

“Authors must state all possible conflicts of interest in the manuscript, including financial, consultant, institutional and other relationships that might lead to bias or a conflict of interest. If there is no conflict of interest, this should also be explicitly stated as none declared. All sources of funding should be acknowledged in the manuscript.”

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Table 1.

Summary of Vaping Evaluation Recommendations (Content in italics may be appropriate for focused assessment)

Vaping Use History (Ask parent to leave the room and assure confidentiality)

- *Type of substance:*
  - *THC*
  - *CBD*
  - Nicotine
    - 20mg/mL
    - 70mg/mL
    - 2%
    - 7%
  - E juice/liquid only
  - Modified products
  - Home made products including components used, source of products, source of directions for mixing, websites from which information was obtained
- Specific products including brand, name and manufacturer, flavorings used
- Product source
  - Vape shop, convenience store, online, friend, adult
- Age at initiation
  - Reason for initiation
- *Duration of use*
- *Frequency of use*
- *Number of pods or volume used in typical day*
- *Time of last use*
- Product delivery system
  - E-cigarette
  - Juul
  - Pod Vape
  - Vape Pen
  - Box Mod Kit
  - Dab pen
- Method of use including tricks
- *Additional use of other nicotine and THC products*
  - *Cigarettes*
  - *Cigars*
  - *Pipes*
  - *Bongs*
  - *Other inhalants*

Assess for other substance use

Assess for interest in change in habits/quitting

Respiratory Symptom History (If any positive symptoms perform further pulmonary evaluation)

-Acute symptoms

- *Cough, sputum production, chest pain, shortness of breath, dyspnea on exertion, hemoptysis*
- *Note duration and if any of these symptoms correlate with initiation of vaping or change in vaping practices*

-Chronic symptoms and any underlying respiratory past medical history

- *Pneumonia*
- *Bronchitis*
- *Pneumothorax*
- *Hemoptysis*

Screen for Gastroenterology Symptoms

- Abdominal Pain, nausea, vomiting, diarrhea

Screen for Systemic Symptoms

- Fever, chills, weight loss, malaise

Screen for Neuro-behavioral Complications of Vaping

- Changes in mood, aggression, irritability, sleep disturbance, anxiety, fighting, seizure activity
- Disinhibition, psychosis, hallucinations
- Withdrawal symptoms upon cessation of use
- Need to use more to produce desired effects
- Use of more product or more frequently than intended
- Increasing amount of money spent on vaping products
- Changes in activities, physical activity, peer interactions or scholastic performance
- Interpersonal relationship changes
- Risk taking behaviors (e.g. stealing, lying, hiding use, use in school)
- Quit attempts

Screen for Mental Health History

- ADHD/ADD, Anxiety, Depression, other