


Smoking Mechanics and Impact on Smoking Cessation: Two Cases of Smoking Lapse Status Post Lung Transplantation

Panagis Galiatsatos^{1,2} , Princess Ekpo², Raiza Schreiber^{1,2}, Lindsay Barker³ and Pali Shah^{1,3}

¹Division of Pulmonary and Critical Care Medicine, Johns Hopkins School of Medicine, Baltimore, MD, USA. ²Tobacco Treatment Clinic, Johns Hopkins Bayview Medical Center, Baltimore, MD, USA. ³Office of Transplantation, Johns Hopkins Hospital, Baltimore, MD, USA.

Tobacco Use Insights
Volume 15: 1–4
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DOI: 10.1177/1179173X211069634



ABSTRACT

BACKGROUND: Smoking behavior includes mechanisms taken on by persons to adjust for certain characteristic changes of cigarettes. However, as lung function declines due to lung-specific diseases, it is unclear how mechanical smoking behavior changes affect persons who smoke. We review two cases of patients who stopped smoking prior to and then subsequently resumed smoking after lung transplantation.

METHODS: A retrospective review of two patients who were recipients of lung transplantation and sustained from cigarette usage prior to transplantation.

RESULTS: Patient A was a 54-year-old woman who received a double lung transplant secondary to chronic obstructive pulmonary disease (COPD) in October 2017. She had stopped smoking cigarettes in July 2015 (FEV1 .56 L). Patient B was a 40-year-old man who received a double lung transplantation due to sarcoidosis in January 2015. He stopped smoking cigarettes in February 2012 (FEV1 1.15 L). Post-transplant, Patient A resumed smoking on March 2018 where her FEV1 was at 2.12 L (5 months post-transplantation), and Patient B resumed smoking in April 2017 where his FEV1 was 2.37 L (26 months post-transplantation).

CONCLUSION: We report on two patients who resumed smoking after lung transplantation. While variations of smoking mechanics have been identified as a function of nicotine yield and type of cigarette, it lung mechanics may play a role in active smoking as well. Therefore, proper screening for tobacco usage post-lung transplantation should be considered a priority in order to preserve transplanted lungs.

KEYWORDS: Lung transplant, smoking cessation, tobacco dependence, relapse, smoking topography

TYPE: Case Report

DECLARATION OF CONFLICTING INTERESTS: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FUNDING: The authors received no financial support for the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Panagis Galiatsatos, Division of Pulmonary and Critical Care Medicine, Johns Hopkins School of Medicine, 4940 Eastern Avenue, 4th Floor, Asthma and Allergy Building, Baltimore, MD 21224, USA. Email: pgaliat1@jhmi.edu

Introduction

Smoking behavior is distinct, highly complex, and dynamic.¹ Smoking topography attempts to characterize an individual's smoking behavior holistically, addressing cigarette properties, smoking mechanics, and triggers.^{2–4} Topography parameters have been utilized to exhibit the compensatory smoking behavior resulting from cigarette brand-switching. Participants regulated their nicotine intake by smoking more of the low-yield cigarettes in comparison to the high-yield cigarettes.^{5–7} It remains unclear, though, what part of smoking topography is a significant driver in consumption rate and/or abstinence for certain populations of active smokers.

Smoking mechanics is a part of smoking topography involving parameters for puffing, inhalation, and exhalation.^{3,4} The inhalation and exhalation parameters of smoking mechanics depend, in part, on the condition of airways and lung tissue. Airway strength can be

measured with forced expiratory volume (FEV1) and forced vital capacity (FVC). While smoking has been shown to reduce variables such as FEV1,^{8,9} it is unclear if such changes impact smoking continuation and/or cessation or overall smoking topography. It is possible that patients with diminished lung function may smoke less of a cigarette due to mechanical limitations, suggesting an interplay between smoking mechanics and lung health.

Lung transplantation is currently a treatment option for those with end-stage lung diseases.¹⁰ For lung transplant candidates, active smoking is a contraindication to transplant, and many centers recommend a period of abstinence from smoking prior to waitlisting.^{11,12} Around 40% are active smokers before approaching lung transplantation candidacy.¹³ Unfortunately, smoking cessation therapy compliance of transplant recipients is low, with 10–40% relapsing post-lung transplantation.^{13,14} The role of smoking mechanics in



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successful smoking cessation and smoking relapse in post-lung transplant patients has yet to be determined.

In this study, we present the cases of two patients with tobacco dependence who received lung transplants after maintaining smoking abstinence, though relapsed to tobacco usage after transplantation. We discuss in detail how changes in their lung function affected their smoking mechanics and may have impacted their relapse to smoking.

Methods

For both patients, we collected several variables to better understand their smoking phenotype. This included brand of cigarette, smoking topography (variables of smoking mechanics such as puff duration, inhalation duration, and puffs per cigarette),³ and triggers to smoking. Further, we identified the age that they began to smoke consistently (defined as daily use of cigarettes) as well prior quit attempt strategies and duration of abstinence from smoking. The study was approved by Institutional Review Board at Johns Hopkins School of Medicine (IRB00282725) and all actions undertaken by the authors were in accordance with the Declaration of Helsinki, along with written consent for both patients.

Screening for smoking cessation at our institution takes on both self-report and laboratory data. Specifically, we screen for urine nicotine and cotinine. If the patient is using nicotine replacement therapies (NRT) to assist in smoking cessation, then we screen for anabasine to assure the nicotine and cotinine are from an NRT source and not tobacco products.¹⁵ Pre-transplantation, the aforementioned laboratory data is monitored until the patient achieves a status of 6-months smoke-free. For patients who are post-lung transplant, since there are no active international guidelines suggesting how to monitor for smoking relapse,¹⁶ at our institution we continue to assess smoking status with self-reports and with the aforementioned smoking-related biomarkers. These biomarkers are ordered at the discretion of the transplant team in conjunction with clinical assessments of the patient.

We collected data on their pulmonary-specific morbidity, as well as any other morbidity that would influence the patient's tobacco dependence (e.g., major depressive disorder and general anxiety disorder). In regards to the patient's pulmonary-specific morbidity, we documented management strategies prior to pre-transplantation, pulmonary function testing, and management of tobacco dependence. Post-transplantation, we collected data on ongoing management of the patient's tobacco dependence and pulmonary function testing. Finally, we selected patients who relapsed into smoking post-lung transplant and, after confirmation of their smoking resumption, were enrolled into the Tobacco Treatment Clinic at the Johns Hopkins University School of Medicine.

Results

Patient A

Patient A is a 54-year-old woman status post a double lung transplant secondary to chronic obstructive pulmonary disease

Table 1. Patient characteristics and smoking topography.

	PATIENT A	PATIENT B
FEV1* (time of smoking cessation)	.56 L (21%)	1.15 L (35%)
Smoking history		
Age of smoking onset	14 years old	12 years old
Cigarette preference	Marlboro reds	Newport slims
Packs per year	80	30
Smoking topography		
Puff duration	Long	Long
Inhalation hold	Long	Long
Puffs per cigarette	>5	>5
Cigarettes per day	10–15	15–20
Quit strategy	Varenicline	Avoidance
FEV1 (time of smoking relapse)	2.12 (70%)	2.37 (72%)
Relapse time	5-months	26-months
Post-transplant		

*FEV1 = Forced expiratory volume, 1-second.

(COPD). The date of transplant was October 2017. Her COPD was considered a GOLD Class D given her exacerbation history, and was managed with an inhaled long-acting muscarinic antagonist, inhaled corticosteroid, inhaled long-acting beta2 agonists, as well as chronic macrolide (azithromycin), and an as needed short-acting beta2 agonist inhalers and nebulizers. She also underwent pulmonary rehabilitation for her COPD management as well. Given the inability to improve her symptoms as well as her overall prognosis, the patient began to pursue candidacy for lung transplantation.

Patient A quit smoking in 2015, with an FEV1 at the time of .56 L (21% predicted). She used varenicline to help with her smoking cessation strategy in 2015. She discussed that she has been smoking since the age of 15, and smoked consistently a pack of cigarettes a day, if not more, up until her early 40s. When she was diagnosed with COPD in 2004, she found herself frequenting hospitalizations and outpatient clinics due to exacerbations, often making it difficult to smoke given her "breathlessness." She discussed her smoking mechanics as long puffs, deep inhalations, as well as taking more than 5 puffs per cigarette (Table 1). Her choice of cigarette usage is Marlboro Reds, smoking a pack or more a day. She identified triggers to smoking as stress and anxiety, specific places (e.g., bathrooms of her home and her car), and after food. She never attempted to quit in the past, but did have periods without smoking, often due to COPD-related health issues. For the purpose of obtain a lung transplant, she was started on varenicline, using the medication for 6-weeks in total, stopping in July 2015 and receiving a transplant in 2017.

Patient A discussed a lapse in smoking at 5-months post-transplantation after identification of a positive urine nicotine and cotinine level, sent at the discretion of the transplant team given a decline of lung function on pulmonary function testing.

The patient highlighted that stress at that time influenced significantly the need to re-engage with smoking. The ability to smoke in the manner she was accustomed to (long puffs, long inhalation) reaffirmed as well a “satisfaction” gain from smoking. At the time of relapse, her FEV1 had increased to 2.12 L, an over 200% increase in FEV1 from the patient’s prior baseline when she began to abstain from cigarettes.

Patient B

Patient B is a 40-year-old man status post a double lung transplant secondary to sarcoidosis. The date of transplant was January 2015. The impact of sarcoidosis on the patient’s lungs was severe, with pre-transplant imaging identifying extensive central bronchiectasis, interstitial lung disease present with predominance near hila and upper lobes. Further, there was a cavitary lesion in the right upper lobe as well. Patient B was managed mainly with prednisone and short-acting beta agonist inhalers, though he had frequent hospitalizations for his sarcoidosis and resulting pulmonary symptoms of dyspnea. As his disease progressed, he discussed his ability to breathe was a challenge, even at rest, coupled with excessive sputum production. Both of these symptoms impaired his ability to smoke, ultimately resulting in his abstinence transition.

Patient B began to smoke at the age of 12. His preferred cigarette choice was Newport Slims, smoking up to a pack of cigarettes a day. He described his smoking mechanics as long puffs with a long inhalation, and would smoke the cigarette completely (Table 1). He identified his triggers to smoke as stress and anxiety, after eating, and certain areas (e.g., in his car). He eventually stopped smoking, identifying while he wanted a lung transplant, he found it difficult to smoke in the manner he preferred. His abstinence was through avoidance and without pharmacological assistance. His last cigarette was in February 2012, with an FEV1 1.15 L at the time.

Patient B resumed smoking in April 2017, and discussed this at a lung transplant office visit. While it was self-reported, it was confirmed with urine nicotine and cotinine levels being positive. He identified stress as the main variable resulting in his lapse to smoking. With his improved lung function, he was able to resume smoking with the lung mechanics that were consistent with his prior usage of cigarettes. He lapsed at 26-months post-lung transplantation. His FEV1 at the time of resuming smoking cigarettes was 2.37 L, more than double of FEV1 at the time of abstinence from smoking.

Discussion

We highlight two patients status post-lung transplantation who relapsed to smoking, with both patients identifying the ability to smoke with improved lung function mechanics contributing to resuming smoking of cigarettes. Other similarities these patients shared was initiation of smoking at a young age (under the age of 18) and variables that result in cravings for cigarettes, specifically that of anxiety and stress. Such findings warrant further discussion

in reaffirming tobacco dependence as a chronic disease whose management should continue in recipients of lung transplant.

The dynamics of smoking mechanics is associated with many unique variables, for both the individual smoking and in regards to the cigarette itself. For instance, the nicotine yield of a cigarette may dictate the puff duration, puff volume per cigarette, and number of puffs per cigarette.⁵ Further, the nicotine itself from cigarette smoke may provide a positive consequence for a person actively smoking.¹⁷ For instance, in anxiety disorders may increase smoking behavior and the risk for nicotine dependence, as cigarettes may be seen as an anxiolytic self-treatment.^{18,19} Both patients’ description of their smoking mechanics, specifically their puff duration and inhalation hold (puff volume), appeared to be impacted by specific external influences (stress and anxiety). When faced with these triggers to smoke in the past, during low FEV1 variables, their inability to smoke in the manner they desired resulted in the ability to pursue abstinence. However, while faced with the same triggers post-transplant, the ability to match their desired smoking mechanics due to the improved FEV1 to the trigger that is driving their craving for nicotine (anxiety and stress) resulted in a lapse to cigarette consumption.

A significant insight into the lapse of smoking by both patients’ status post post-lung transplantation is in how it reaffirms tobacco dependence and nicotine addiction as a chronic disease. For instance, proteins impacting tolerance and craving in nicotine addiction, specifically cAMP response element-binding protein (CREB) and delta fos b, remain elevated after an individual’s last cigarette for a significant amount of time (if not permanent).^{20,21} Both proteins play a significant role in nicotine’s ability to impact the brain’s reward system as well as the conditioning that occurs in regards to person’s compulsion towards smoking.²² Further, if nicotine exposure occurs at a young age, at a time when the prefrontal cortex continues to evolve, epigenetic changes may sensitize the brain to nicotine craving and future and continued use of cigarettes. This is the case for both patients, who began smoking while they were adolescents. Therefore, insight into both active smoking topography as well as past usage of cigarettes (e.g., age of initiation of smoking) may result in an understanding of a smoking phenotype that warrants management both before and after lung transplantation.

Smoking resumption post solid organ transplant is not an uncommon diagnosis in transplant centers. In regards to post-lung transplantation, smoking resumption has been reported from 0 to 10% in the United States to up to 15% at a European transplant center.^{23,24} Smoking cessation and smoking relapse are both complex, with multiple factors contributing to cessation and relapse. Improved lung function is an exceptional outcome for patients after lung transplantation, one that aims to improve a person’s quality of life. However, the challenge with improved lung function is it may also contribute to smoking resumption, a plausible parallel since the opposite, a decreased lung function resulting in smoking cessation, was confirmed in our case series. Therefore, as Hofmann et al.¹⁶ underscore with their conclusion

of smoking resumption in post-transplant patients is likely underestimated,¹⁶ we believe our case series adds to the necessity that monitoring of smoking resumption should be standard of care for post-lung transplantation evaluation.

Tobacco dependence and nicotine addiction are chronic diseases with many factors, both intrinsic and extrinsic, affecting the ability to quit and ultimately become tobacco independent. For patients undergoing lung transplant evaluation, a need to abstain from cigarettes prior to transplant should be met with similar priorities post-transplant. The management, like other chronic diseases, warrants consistent reassessments. We believe the aforementioned cases emphasize the need for international guidelines to offer recommendations on screening for smoking resumption post-lung transplantation and availability of immediate resources to help patients if they should relapse in an effort to preserve transplanted lungs.

ORCID iD

Panagis Galiatsatos  <https://orcid.org/0000-0002-7752-3841>

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