Short-term effect of e-cigarette and tobacco smoke on ventilation and perfusion in the lung: Assessment with functional MRI and lung function measurements

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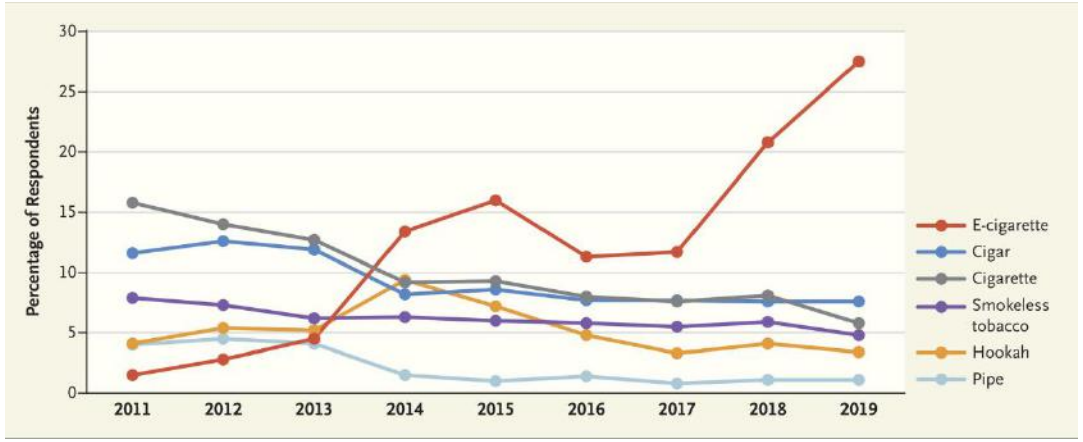
Introduction

- Current use of e-cigarette or vaping products increased by 900% among U.S. middle and high school students between 2011 and 2015 (1)
- In 2019, more than 5.2 million young people in the United States reported current use (2)
- Inhaling nicotine-free e-cigarette aerosol transiently impacted endothelial function in healthy nonsmokers (3)
- E-cigarettes have been reported to cause some subtle, acute changes in pulmonary function (4)



Current Tobacco Product Use among U.S. High School Students, 2011 to 2019.

1 The EVALI and Youth Vaping Epidemics — Implications for Public Health King, Ph.D. et al. NEJM
2 Cullen KA, Gentzke AS, Sawdey MD, et al. e-Cigarette use among youth in the United States, 2019. JAMA 2019 November 5
3 Acute Effects of Electronic Cigarette Aerosol Inhalation on Vascular Function Detected at Quantitative MRI Caporale et al. Radiology
4 Vardavas CI, Anagnostopoulos N, Kougias M, Evangelopoulou V, Connolly GN, Behrakis PK. Short-term pulmonary effects of using an electronic cigarette: impact on respiratory flow resistance, impedance, and exhaled nitric oxide. Chest 2012;141:1400-1406

Aims

Examine the acute effect of e-cigarette and tobacco smoke on lung ventilation and perfusion with MRI and lung function tests

Methods

- **Sub-study of ESTxENDS trial (RCT assessing efficacy, safety and toxicology of Electronic Nicotine Delivery Systems (ENDS) as an aid for smoking cessation)** (1)

- **Unblinded, monocentric (University Hospital Bern, Switzerland)**

- **<u>Participants</u>**

Control group:

- 9 former smokers; mean (sd) age : 43 (12), females, males (4/5)

Intervention group:

- 13 ENDS user; mean (sd) age: 41 (12), females, males (4/9)
- 12 tobacco smokers (TS); mean (sd) age: 42 (14), females, males (4/8)

1 Clinicaltrials.gov registration number: NCT03589989

Methods Study design

MRI protocol

- 1.5T Magnetom Aera (Siemens Healthineers, Germany)
- No sedation, no contrast agent was applied
- Functional scans:

➢ **Perfusion defects ratio (R_Q)** – ratio between volume with impaired Q and the whole lung volume

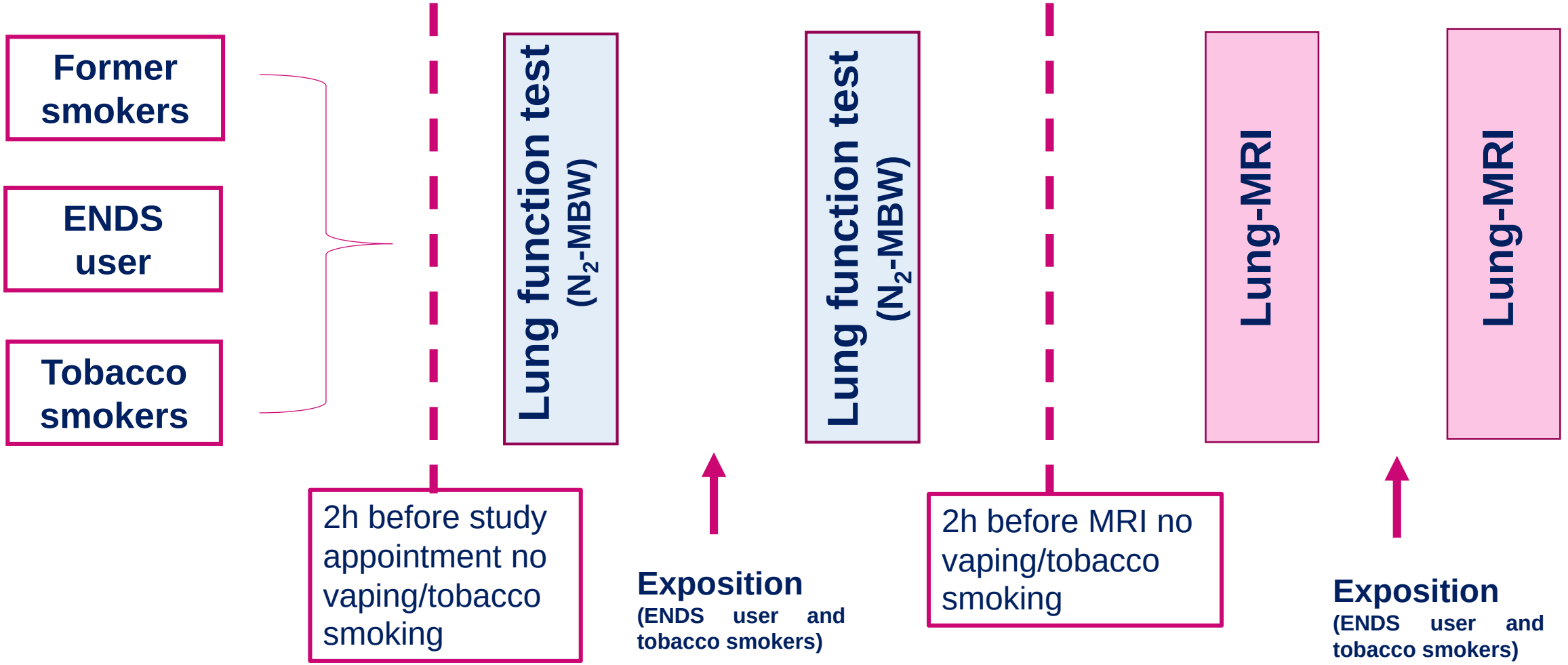
➢ **Ventilation defects ratio (R_{FV})** – ratio between volume with impaired FV and the whole lung volume

Lung function testing:

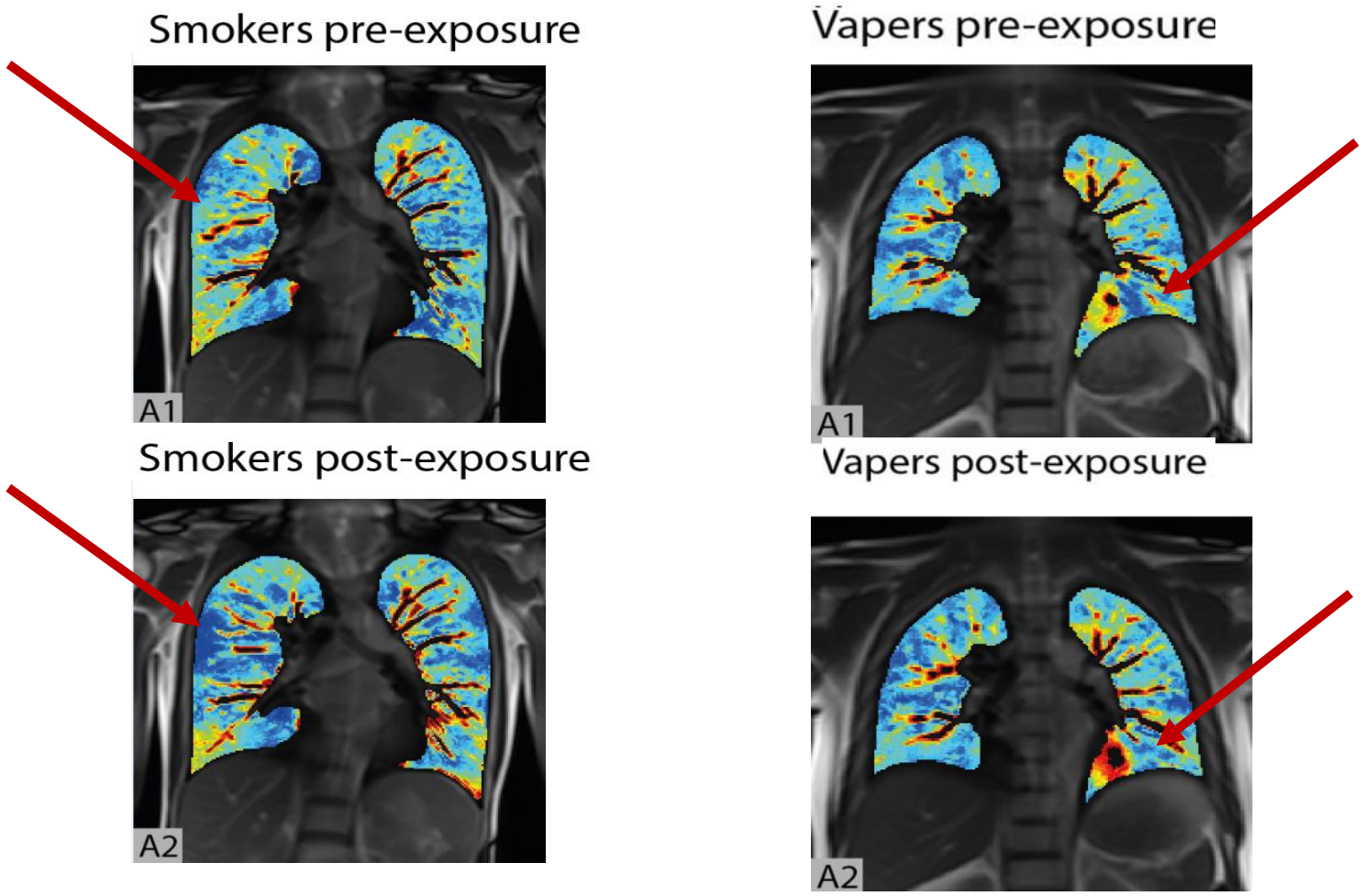
➢ **Lung clearance index (LCI)-** assessment of ventilation inhomogeneity

Methods Study design

Measurements (on the same day)

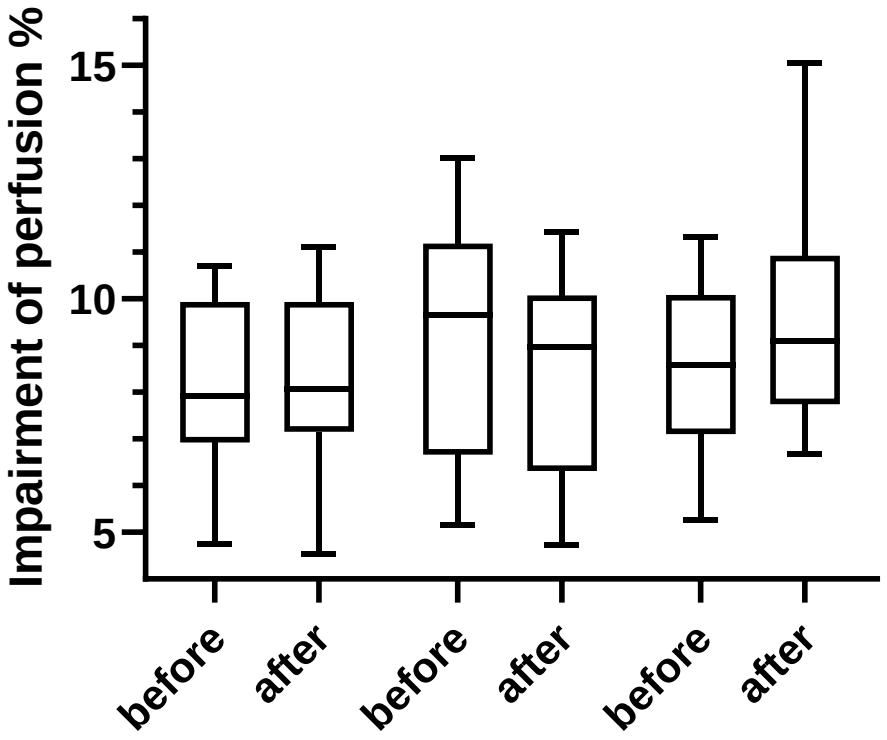


Results



Functional MRI of the lung from two participants before and after tobacco smoking and vaping, respectively.
Example of pulmonary perfusion images obtained using MP MRI in a smoker and vaper before (A1) and after exposure (A2). The images before and after exposure were acquired at corresponding coronal slice locations. Red arrows indicate lung regions with changed regional perfusion after the exposure.

Results



Former smokers **ENDS user** **Tobacco smokers**

Impairment of perfusion (%) in ENDS users and tobacco smokers before and after exposure. Former smokers performed MRI measurements without exposure.

Functional MRI imaging values of study participants before and after exposure			
	Measurement 1	Measurement 2	p-value
Former Smokers*			
Perfusion impairment	7.92 (6.95-9.69)	8.06 (7.61-9.43)	0.44
Ventilation impairment	12.87 (11.91-13.59)	12.51 (12.16-13.57)	0.37
ENDS user			
Perfusion impairment	9.66 (7.13 -10.91)	8.97 (6.9-9.95)	**0.006**
Ventilation impairment	11.75 (11.3-13.4)	12.71 (11.39-13.32	0.38
Tobacco smokers			
Perfusion impairment	8.57 (7.2-9.98)	9.09 (7.84-10.71)	**0.031**
Ventilation impairment	11.86 (9.86-14.22)	12.19 (10.26-13.65)	0.31

Data is presented as median (IQR). Continuous variables between the measurements were compared with Wilcoxon signed rank test. *Former smoker performed all measurements without exposure.

Conclusion

- This pilot study demonstrated **the responsiveness** of R_Q to vaping and tobacco smoking
- Vaping seems to **increase** lung perfusion (as tobacco smoke **decreases lung perfusion**)
- R_Q **correlates** with ventilation inhomogeneity (LCI), a biomarker of small airways disease in TS
- Ventilation inhomogeneity (LCI) was frequently abnormal but not responsive to Vaping or TS
- The clinical relevance of changes in R_Q remains to be determined

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