Received: 2 March 2021 | Revised: 13 May 2021 | Accepted: 7 July 2021

DOI: 10.1111/nmo.14227

TECHNICAL NOTE

Neurogastroenterology & Motility NGM WILEY

The effect of an air purifier on aerosol generation measurements during clinical motility testing

Wout Verbeure[1] | Annelies Geeraerts[1] | I-Hsuan Huang[1,2] | Lien Timmermans[3] | Joran Tóth[1] | Hannelore Geysen[1] | Louise Cools[1] | Florencia Carbone[1,3] | Jolien Schol[1] | Herman Devriese[4] | Rico Haesaerts[3] | Hideki Mori[1] | Tim Vanuytsel[1,3] | Jan Tack[1,3]

[1]Translational Research Center for Gastrointestinal Disorders, KU Leuven, Leuven, Belgium

[2]Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan

[3]Neurogastroenterology and motility, University Hospitals Leuven, Leuven, Belgium

[4]Prevention and Environment, University Hospitals Leuven, Leuven, Belgium

Correspondence
Jan Tack, Translational Research Center for Gastrointestinal Diseases (TARGID), University of Leuven/University Hospital Gasthuisberg, O&N I – bus 701, Herestraat 49, B-3000 Leuven, Belgium.
Email: jan.tack@kuleuven.be

Funding information
Tim Vanuytsel is a senior clinical investigator of the Flanders Research Foundation (FWO Vlaanderen), and Jan Tack is supported by a Methusalem grant of KU Leuven.

Abstract

Background: Aerosol spread is key to interpret the risk of viral contamination during clinical procedures such as esophageal high-resolution manometry (HRM). Installing an air purifier seems a legitimate strategy, but this has recently been questioned.

Methods: Patients undergoing an HRM procedure at the Leuven University Hospital were included in this clinical study. All subjects had to wear a surgical mask which was only lowered beneath the nose during the placement and removal of the nasogastric catheter. The number of aerosol particles was measured by a Lasair® II Particle Counter to obtain data about different particles sizes: 0.3; 0.5; 1.0; 3.0; 5.0; and 10.0 μm. Measurements were done immediately before the placement and the removal of the HRM catheter, and one and 5 min after. A portable air purifier with high-efficiency particle air filters was installed in the hospital room.

Key Results: Thirteen patients underwent a manometry examination. The amount of 0.3 μm-sized particles was unaffected during the whole procedure. The larger particle sizes (1.0; 3.0; 5.0; and 10.0 μm) decreased when the catheter was positioned, but not 0.5 μm. During the HRM measurements itself, these numbers decreased further. Yet, 1 min after catheter removal a significant elevation of particles was seen, which did not recover within 5 min.

Conclusions & Interferences: Based on this study, there is no evidence that filtration systems reduce aerosol particles properly during a clinical investigation.

KEYWORDS
aerosol, air purifier, COVID19, nasogastric intubation

1 | INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak drastically changed our view of the world and forced us to adjust safety measures considering viral spread during clinical research. Here, the focus lays on dealing with the airborne transmission, for example, aerosol particles.[1] Respiratory pathogens can remain in the air for 3 h in a room without proper ventilation.[2] To secure the safety of healthcare workers (HCWs) and patients, hospitals have installed air purifiers to reduce particle spread. A recent South Korean pilot study questioned the efficacy of these purifiers and even warned for several drawbacks.[3] In a recent study, no increased risk or aerosol and droplet spread were observed when positioning and removing a nasogastric catheter, in the absence of an air purifier. In the current study, we evaluated the effect of an air purifier on aerosol spread during esophageal high-resolution manometry (HRM).

2 | METHODS

This study protocol was approved by the Ethics Committee of the Leuven University Hospital, Belgium and performed in full accordance with the declaration of Helsinki. The study is published in clinicaltrials.gov with reference number NCT04687488.

Patients—with a negative COVID-19 reverse transcriptase-polymerase chain reaction test during the preceding 36 h—undergoing an esophageal HRM at the Leuven University Hospital were invited to participate. Patients were requested to wear a mask covering the mouth during nasogastric intubation and removal. The HRM measurements (between positioning and removal) take in general 35 min to perform. The HRM was conducted with a 2.7 mm diameter solid-state catheter (Unisensor, Attikon, Switzerland).

Aerosol quantification was performed using the Lasair® II particle Counter (Particle Measuring Systems, Inc., Unites States), and six sizing channels were measured: 0.3 μm, 0.5 μm, 1.0 μm, 3.0 μm, 5.0 μm, and 10 μm. A tube connected to the particle counter was placed within 10 cm from the mouth of the patient and every measurement was the result of 1-min counting. The particle counter was calibrated at the beginning of each motility session. Particles were measured at three time points for both positioning and removal: right before; 1 min after and 5 min after probe handling (Figure 1).

A portable air purifier (City M Air Purifier; Camfil, Sweden) with high-efficiency particulate air (HEPA) filters was installed on the floor and stayed active 24/7. The room has a surface of 20 m^2, which is within range for a proper functioning of the device. It was set up to move 56 cubic feet of air per minute.

2.1 | Statistical analysis

Aerosol particle data (particles-per-cubic-meter) are presented as mean ± SD. SAS University Edition Software (SAS Institute, Cary, NC, USA) was used for all the analyses. Data were logarithmically transformed for repeated one-way ANOVA with stepdown Bonferonni adjustments for multiple testing. Significance was set at $p < 0.05$.

3 | RESULTS

Log number of aerosol particles are presented in Figure 2. After the installation of the air purifier in the motility room, 13 patients underwent an HRM examination.

Key points

- The coronavirus and other respiratory pathogens spread via aerosol particles. These cause an increased risk for healthcare workers and patients in hospitals.
- Intubation and removal of nasogastric catheters do not increase the number of aerosol particles, without air purifier.
- The installation of an air purifier with HEPA filter is linked with increased aerosol measurements during catheter removal.
- The recommendations of the European Society for Neurogastroenterology and Motility should always be respected in this specific clinical setting.

3.1 | Aerosol particles during catheter positioning

There was no significant difference in the number of small-sized particles (0.3 and 0.5 μm) before and after catheter positioning ($p = 0.94$ and $p = 0.77$, respectively). Five minutes after placement, values remained unchanged ($p = 0.25$ and $p = 0.75$, respectively). For the particles with sizes 1.0; 3.0; 5.0; and 10.0, the number of aerosol particles decreased 1 min after the placement ($p < 0.0001$ for all comparisons) and stayed low until at least 5 min after ($p = 0.0001$; $p < 0.0001$; $p < 0.0001$; and $p < 0.0001$ in ascending particle size order).

3.2 | Aerosol particles during HRM examination

The number of floating 0.3 μm and 0.5 μm particles did not change during the examination; however, the bigger-sized particles decreased in this 35 min period ($p = 0.51$; $p = 0.70$; $p = 0.0006$, $p = 0.0016$, $p = 0.0015$; and $p = 0.0048$, in ascending order of particle size).

3.3 | Aerosol particles during catheter removal

There was no additional 0.3 μm sized particle generation, 1 min after removal ($p = 0.13$), which remained unchanged after 5 min ($p = 0.13$). The number of 0.5 μm sized particles was not significantly increased after 1 min ($p = 0.06$). After 5 min, the amount increased compared with the value before the removal ($p = 0.002$). The bigger particles 1.0; 3.0; 5.0; and 10.0 μm increased significantly within the first minute after removal ($p = 0.0007$; $p < 0.0001$; $p = 0.0005$; and $p = 0.0013$ in ascending particle size order) and did not decrease again within 5 min ($p = 0.34$; $p = 0.47$; $p = 0.66$ and $p = 0.82$ in ascending particle size order).

The number of floating aerosol particles at the end of the experiment (5 min after catheter removal) never reached significantly

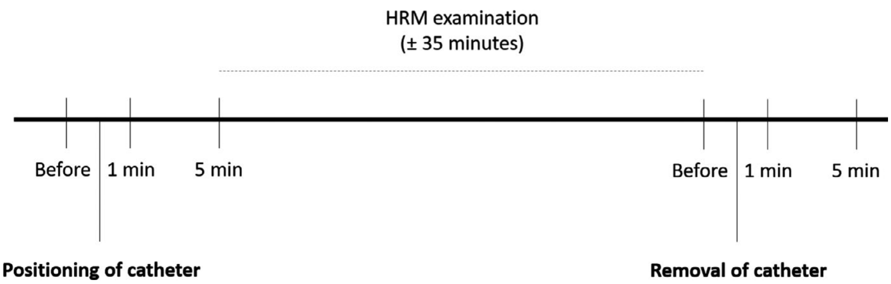

FIGURE 1 Timeline of the esophageal HRM (high-resolution manometry) examination. Aerosol particles are measured at three time points for both the positioning and removal of the catheter: before, 1 min after, and 5 min after. The duration of the examination is in average 35 min

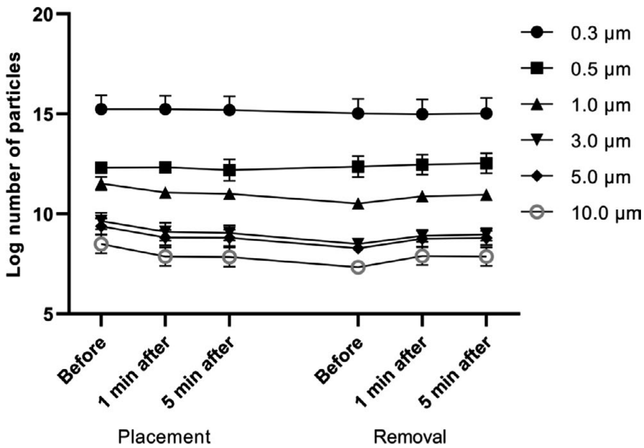

FIGURE 2 The number of aerosol particles for different sizes (0.3; 0.5; 1.0; 3.0; 5.0; and 10.0 μm) during a complete esophageal HRM examination with air purifier ($n = 13$). Number of particles are presented in a logarithmic scale. Data are presented as mean±SD. Abbreviation: HRM, high-resolution manometry

higher levels compared with the start of the examination (before placement of catheter). Actually, all bigger-sized particles were still significantly lower in number ($p = 1.00$; $p = 1.00$; $p < 0.0001$; $p < 0.0001$; $p < 0.0001$; and $p = 0.0012$ in ascending particle size order).

4 | DISCUSSION

Since the COVID-19 outbreak, awareness for pathogen spread via aerosol has grown. All options to reduce the number of airborne particles are being explored, ranging from wearing mouth masks, limiting the number of people inside a room to optimization of room ventilation. In a dental clinical study, the use of an air purifier showed a reduced exposure of airborne droplets and aerosol particles to HCWs when an air cleaner was placed in a suitable position.[4] The U.S. Environmental Protection Agency also suggested that air purifiers can help reduce airborne contaminants via appropriate use.[5] However, currently, the U.S. Centers for Disease Control and Prevention has not provided recommendations to use air purifiers with HEPA filter for decontamination of airborne COVID-19. Furthermore, the use of air purifiers has been questioned as a pilot study observed increased local air flow when a test amount of aerosols and droplets were released near the exhaust outlets.[3]

In a recent study, we found that the placement and removal of an HRM catheter or a 24 h multichannel intraluminal impedance-pH monitoring probe, with a number of precautionary measures, do not increase the number of floating aerosol particles of any size, and only results in little droplet spread in the patient's environment.[6] This study was performed without the presence of a purifier in the room. Here, the efficiency of aerosol reduction by an air purifier was evaluated during an HRM examination.

During the placement of the catheter, there is no difference in aerosol particle levels with or without purifier. The 0.3 and 0.5 μm remained unchanged, and the heavier particles dropped in numbers. Without purifier, no increase in particles has been seen after catheter removal.[6] After the device's installation, an elevation for particle sizes 0.5; 1.0; 3.0; 5.0; and 10.0 μm occurred after probe removal. The hospital safety measures oblige to keep the examination room doors open between visits and closed when the patient enters. With the HRM examination taking on average 35 min to be finished, enough time might pass by for the purifier to filter the number of particles. This is confirmed in our study for particles sizes 1.0; 3.0; 5.0; and 10.0 μm, but not for 0.3 and 0.5 μm. Such reduction during the examination had not been observed in our study without the purifier.[6] We suggest two plausible explanations: 1) lower numbers of particles right before catheter removal makes a small increase after more noticeable or 2) there is an actual increase of particle spread by the presence of the purifier. In any case, the increased amount of particles does never reach significantly higher levels compared with the moment the patient entered the room.

Based on our observation, utilization of portable HEPA purifiers for COVID-19 should be considered with caution in a clinical setting. These cannot be installed to convey a false feeling of safety, and other safety measures should be respected at all times. Further large-scale clinical trials to investigate this aspect are required.

DISCLOSURES

Tim Vanuytsel has given Scientific Advice to Takeda, VectivBio, Shire, Dr. Falk Pharma, Tramedico, Truvion, and Zealand Pharma and has served on the Speaker bureau for Abbott, Kyowa Kirin, Menarini, Takeda, Tramedico, and Truvion. Jan Tack has given Scientific advice to AlfaWassermann, Allergan, Christian Hansen, Danone, Grünenthal, Ironwood, Janssen, Kiowa Kirin, Menarini, Mylan, Neutec, Novartis, Noventure, Nutricia, Shionogi, Shire, Takeda, Theravance, Tramedico, Truvion, Tsumura, Zealand, and Zeria pharmaceuticals and has served on the Speaker bureau for Abbott,

Allergan, AstraZeneca, Janssen, Kyowa Kirin, Menarini, Mylan, Novartis, Shire, Takeda, Truvion, and Zeria.

AUTHOR CONTRIBUTIONS

WV, AG, IH, LT, JT, HG, LC, JS, RH and HM performed the experiments; WV analyzed the data; WV, AG, FC, HD, TV and JT designed the research study; WV wrote the manuscript. All authors edited and revised the manuscript.

ORCID

Wout Verbeure https://orcid.org/0000-0001-9934-4636
Annelies Geeraerts https://orcid.org/0000-0003-4941-3263
I-Hsuan Huang https://orcid.org/0000-0002-9390-6180
Hannelore Geysen https://orcid.org/0000-0001-8960-932X
Florencia Carbone https://orcid.org/0000-0003-1790-7904
Jolien Schol https://orcid.org/0000-0003-0537-969X
Hideki Mori https://orcid.org/0000-0001-8830-4671
Tim Vanuytsel https://orcid.org/0000-0001-8728-0903
Jan Tack https://orcid.org/0000-0002-3206-6704

REFERENCES

1. Tack J, Vanuytsel T, Serra J, et al. European Society for neurogastroenterology and motility recommendations for conducting gastrointestinal motility and function testing in the recovery phase of the COVID-19 pandemic. *Neurogastroenterol Motil*. 2020;32(7):e13930.
2. van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. 2020;382(16):1564-1567.
3. Ham S. Prevention of exposure to and spread of COVID-19 using air purifiers: challenges and concerns. *Epidemiol Health*. 2020;42:e2020027.
4. Chen C, Zhao B, Cui W, Dong L, An N, Ouyang X. The effectiveness of an air cleaner in controlling droplet/aerosol particle dispersion emitted from a patient's mouth in the indoor environment of dental clinics. *J R Soc Interface*. 2010;7(48):1105-1118.
5. Agency USEP Will an air cleaner or air purifier help protect me and my family from COVID-19 in my home?: United States goverment; 2020 [updated January 12, 2021. https://www.epa.gov/coronavirus/will-air-cleaner-or-air-purifier-help-protect-me-and-my-family-covid-19-my-home. Accessed February 17, 2021.
6. Verbeure W, Geeraerts A, Huang IH, et al. Aerosol generation and droplet spread during nasogastric intubation in the COVID-19 era. *Gut*. 2020. https://doi.org/10.1136/gutjnl-2020-323836.

How to cite this article: Verbeure W, Geeraerts A, Huang I-H, et al. The effect of an air purifier on aerosol generation measurements during clinical motility testing. *Neurogastroenterology & Motility*. 2022;34:e14227. https://doi.org/10.1111/nmo.14227