patients with acute respiratory distress syndrome. Am J Respir Crit Care Med. 2013;15(12):1428–33, 188.

18. Bellani G, Messa C, Guerra L, Spagnolli E, Foti G, Patroniti N, et al. Lungs of patients with acute respiratory distress syndrome show diffuse inflammation in normally aerated regions: a [18F]-fluoro-2-deoxy-D-glucose PET/CT study. Crit Care Med. 2009;37(7):2216–22.

19. Nyrén S, Mure M, Jacobsson H, Larsson SA, Lindahl SG. Pulmonary perfusion is more uniform in the prone than in the supine position: scintigraphy in healthy humans. J Appl Physiol (1985). 1999;86(4):1135–41.

20. Ippolito D, Pecorelli A, Maino C, Capodaglio C, Mariani I, Giandola T, et al. Diagnostic impact of bedside chest X-ray features of 2019 novel coronavirus in the routine admission at the emergency department: case series from Lombardy region. Eur J Radiol. 2020;129:109092.

21. Ippolito M, Vitale F, Accurso G, Iozzo P, Gregoretti C, Giarratano A, et al. Medical masks and respirators for the protection of healthcare workers from SARS-CoV-2 and other viruses. Pumonology. 2020;26(4):204–12.

Schifino G [a,b,*], de Grauw A.J. [a,b], Daniele F [a,b], Comellini V [a], Fasano L [a], Pisani L [a,b]

a Respiratory and Critical Care Unit, University Hospital St. Orsola-Malpighi, Bologna, Italy
b Respiratory and Critical Care, Sant'Orsola Malpighi Hospital, Alma Mater Studiorum, Department of Specialistic, Diagnostic and Experimental Medicine (DIMES), University of Bologna, Bologna, Italy

* Corresponding author.
E-mail address: lara.pisani@aosp.bo.it (G. Schifino).

29 May 2020

# Wearing of medical mask over the high-flow nasal cannula for safer oxygen therapy in the COVID-19 era

*To the Editor*

The emergence of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) and its associated respiratory disease, coronavirus disease 2019 (COVID-19), has imposed social and medical burdens worldwide. Up to 12% of patients with SARS-CoV-2 infection required intensive care unit admission. Among them, 60-70% had acute hypoxic respiratory failure.[1]

High-flow nasal cannula (HFNC) oxygen therapy is the generally prescribed respiratory therapy for acute hypoxic respiratory failure. This therapy might help limit the need for invasive mechanical ventilation (IMV) and prevent the occurrence of associated adverse events such as ventilator-associated pneumonia in COVID-19 patients.[2] However, administration of HFNC oxygen therapy in COVID-19 patients remains controversial, owing to uncertainties regarding the potential risk of viral transmission to healthcare workers, as this therapy is considered as an aerosol-generating procedure.[3] Indeed, IMV can be selected when low-flow oxygen therapy through a nasal canula fails and a shortage of ventilators is a medical and social problem in regions particularly hard-hit by this pandemic. Therefore, a safe and effective respiratory management for COVID-19 patients should be urgently established.

Recent practical recommendations for COVID-19 patients indicate the use of a medical mask over the HFNC device to limit particle dispersion due to exhaled gas flow.[4,5] These recommendations are partially supported by two previous experimental studies that indirectly examined exhaled breath by visualizing airflow movement using smoke[6] and computational fluid dynamic (CFD) simulation.[7] However, to the best of our knowledge, there is no direct evidence that this strategy could reduce the risk of SARS-CoV-2 transmission to healthcare workers in clinical settings due to the technical difficulty in direct visualization of particle dispersion. Here we present an experimental trial with a novel fine particle visualization system, which allowed evaluating whether particle dispersion from coughing while on HFNC oxygen could be suppressed by an appropriately placed medical mask.

We ran six scenarios with a healthy volunteer with nasal cannula at 3 L/min and 21% fraction of inspired oxygen (room air) delivered at 40 L/min 37°C via HFNC (AIRVO™ 2 device with an Optiflow™ nasal interface [Fisher & Paykel, Auckland, New Zealand]). The volunteer was in a sitting position (seat height: 45 cm), and the evaluation was performed with and without wearing a standard medical mask. Particle dispersion was visualized by a video camera set at 29.97 frames per second (Eye Scope). This system used a light emitting diode (wavelength 400-410 nm; Parallel Eye D), which permitted a visualization of particle $\geq 1\,\mu m$ in diameter. Images obtained were reconstructed as videos using commercial software (Particle Eye). Equipment described above depended on Shin Nippon Air Technologies (Tokyo, Japan).

First, we identified exhaled particles dispersed from coughing in the absence of either nasal cannula, HFNC, or a mask, which reached a horizontal distance of 57 cm (Fig. 1A and supplemental video A). Second, exhaled particles were dispersed from coughing in a similar fashion when using nasal cannula (Fig. 1B and supplemental video B) and HFNC (Fig. 1C and supplemental video C), which reached a horizontal distance of 62 cm and 59 cm, respectively. Notably, when the volunteer wore a standard medical mask, no exhaled particles were detected from coughing either without (Fig. 1D and supplemental video D) or with concurrent nasal cannula (Fig. 1E and supplemental video E) or HFNC therapy (Fig. 1F and supplemental video F).

---

*Abbreviations:* CFD, computational fluid dynamic; COVID-19, coronavirus disease 2019; HFNC, high-flow nasal cannula; IMV, invasive mechanical ventilation; SARS-CoV-2, severe acute respiratory syndrome-coronavirus-2.
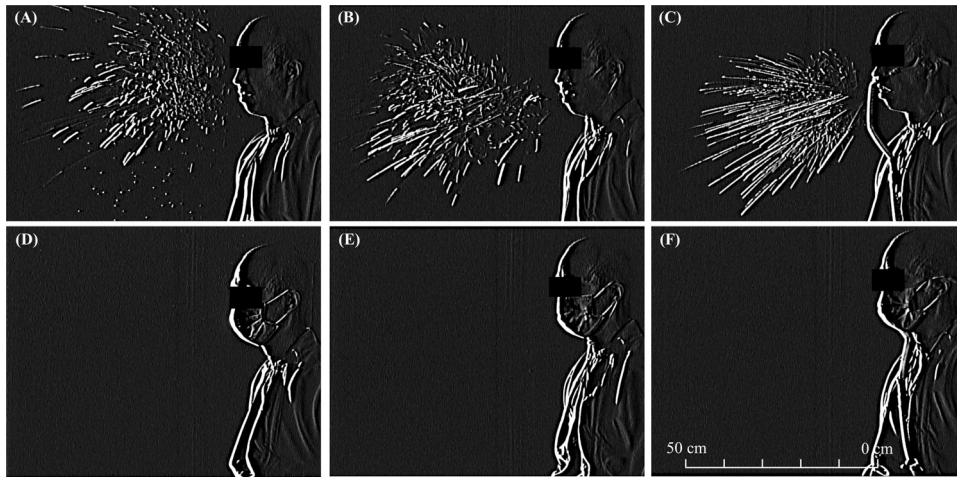
**Figure 1** Photographs of droplet dispersion after cough when not utilizing (A) and utilizing supplemental oxygen via nasal cannula (B) and HFNC (C) and with an appropriately placed medical mask when not utilizing (D) and utilizing supplemental oxygen delivered by nasal cannula (E) and HFNC (F).

HFNC = high-flow nasal cannula.

This report substantially increases our understanding on the droplet dispersion risk during HFNC therapy. Wearing a medical mask over HFNC device almost completely suppressed particle dispersion induced by coughing. Our findings are first direct evidence that wearing a medical mask will be a useful manner in administering HFNC oxygen therapy and strongly support the recommendation as described above. Moreover, the present direct visualization of the suppressive effect of the medical mask *in vivo* further extends a previous CFD simulation by Leonard et al. who showed that the hypothetical medical mask captured 83.2% of particles (0.1-100 $\mu$m) during high-velocity nasal insufflation at 40 L/min.[7]

Despite the advanced technology, we and Leonard et al. could not visualize or simulate particles of <0.1 $\mu$m. Whether these small particles (aerosols) could be sources of transmission of SARS-CoV-2, remains unclear. Further studies are needed to evaluate whether HFNC oxygen therapy could increase risk of SARS-CoV-2 transmission to healthcare workers and whether wearing a medical mask under HFNC oxygen therapy could reduce this risk in clinical settings.

The visual evidence presented here should be shared with all care-givers wearing personal protective equipment to encourage the use of HFNC oxygen therapy for managing hypoxic COVID-19 patients. Hopefully, this method helps overcome this disastrous pandemic situation worldwide.

## Conflict of interest

## Financial conflicts

## Acknowledgements

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pulmoe.2020.10.009.

## References

1. Phua J, Weng L, Ling L, Egi M, Lim CM, Divatia JV, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. Lancet Respir Med. 2020;8:506–17.

2. Agarwal A, Basmaji J, Muttalib F, Granton D, Chaudhuri D, Chetan D, et al. High-flow nasal cannula for acute hypoxemic respiratory failure in patients with COVID-19: Systematic reviews of effectiveness and its risks of aerosolization, dispersion, and infection transmission. Can J Anaesth. 2020;67:1217–48.

3. Brewster Dj, Chrimes N, Do Tb, Fraser K, Groombridge Cj, Higgs A, et al. Consensus statement: safe airway society principles of airway management and tracheal intubation specific to the COVID-19 adult patient group. Med J Aust. 2020;212:472–81.

4. Respiratory care committee of Chinese Thoracic Society [Expert consensus on preventing nosocomial transmission during respiratory care for critically ill patients infected by 2019 novel coronavirus pneumonia] [article in Chinese]. Zhonghua Jie He He Hu Xi Za Zhi. 2020;17:E020.

5. Ferioli M, Cisternino C, Leo V, Pisani L, Palange P, Nava S. Protecting healthcare workers from SARS-CoV-2 infection: practical indications. Eur Respir Rev. 2020;29:200068.
6. Hui DS, Chow BK, Lo T, Tsang OTY, Ko FW, Ng SS, et al. Exhaled air dispersion during high-flow nasal cannula therapy versus CPAP via different masks. Eur Respir J. 2019;53:1802339.
7. Leonard S, Atwood CW Jr, Walsh BK, DeBellis RJ, Dungan GC, Strasser W, et al. Preliminary findings on control of dispersion of aerosols and droplets during high-velocity nasal insufflation therapy using a simple surgical mask: implications for the high-flow nasal cannula. Chest. 2020;158:1046−9.

S. Hamada[a], N. Tanabe[b,*], H. Inoue[c], T. Hirai[b]

[a] Department of Advanced Medicine for Respiratory Failure, Graduate School of Medicine, Kyoto University, Kyoto, Japan
[b] Department of Respiratory Medicine, Graduate School of Medicine, Kyoto University, Kyoto, Japan
[c] Department of Medicine, Division of Respiratory Medicine and Allergology, Showa University School of Medicine, Tokyo, Japan

* Corresponding author at: Department of Respiratory Medicine, Graduate School of Medicine, Kyoto University, 54 Shogoin Kawahara-cho, Sakyo-ku, Kyoto, 606-8507, Japan.
E-mail addresses: sh1124@kuhp.kyoto-u.ac.jp (S. Hamada), ntana@kuhp.kyoto-u.ac.jp (N. Tanabe), hiyumi2001@gmail.com (H. Inoue), t_hirai@kuhp.kyoto-u.ac.jp (T. Hirai).

28 July 2020

# COVID-19 does not stop good practice in smoking cessation: Safe use of CO analyzer for smokers in the Covid era

Smoking has been proven to be an important risk factor for disease severity and worse outcomes in Covid-19, the disease caused by SARS-CoV-2.[1]

The World Health Organization (WHO) recommends not smoking in order to reduce the risk of harm caused by the disease and warns against reports that tobacco or nicotine could benefit Covid-19 as they do not provide sufficient evidence for this statement.[2] In our practice at the Anti-smoking Center of the National Cancer Institute of Milan, the smoker's assessment has proved particularly useful, in particular, for this purpose, we use carbon monoxide (CO) measure in the exhaled breath.

Starting from June 2020 it was possible, keeping the distance between patients and the use of personal protection devices, to resume the activity of the antismoking center, but the Covid-19 situation has posed non-emergency labs with the question of how to proceed with clinical tests safely while avoiding virus transmission among patients[3]; so, we addressed the problem of safe CO measurement.

The level of carboxyhemoglobin in the blood can be determined by measuring the exhaled CO through an instrument that provides the CO value in parts per million (ppm). This type of measurement is then configured as an extremely useful tool in smoking cessation assessment, to enhance motivation to quit and for follow-up of smoking cessation programs.

One of the major company for CO analyzers is Bedfont Scientific Ltd with its main product ''Smokerlyzer™'', a portable instrument with research and education aims. The model we have available in our antismoking centre is a Micro⁺ Smokerlyzer™ model purchased in 2012. It is composed of the electronic device (Fig. 1a), the fitting provided with an antibacterial filter (Fig. 1b) which lasts 30 days and the disposable mouthpieces (Fig. 1c). For the latest models Bedfont has produced disposable antibacterial filters, but our model is not compatible.

To safely use the CO analyzer, we thought of substituting the fitting with an antibacterial filter with a new one, specially created (Fig. 1d). This fitting, designed with the help of our clinical engineering department, was made of a plastic polymer and printed via a 3D printer. The size of the fitting (section and length) was calculated to make minimum modifications in order not to change significantly the
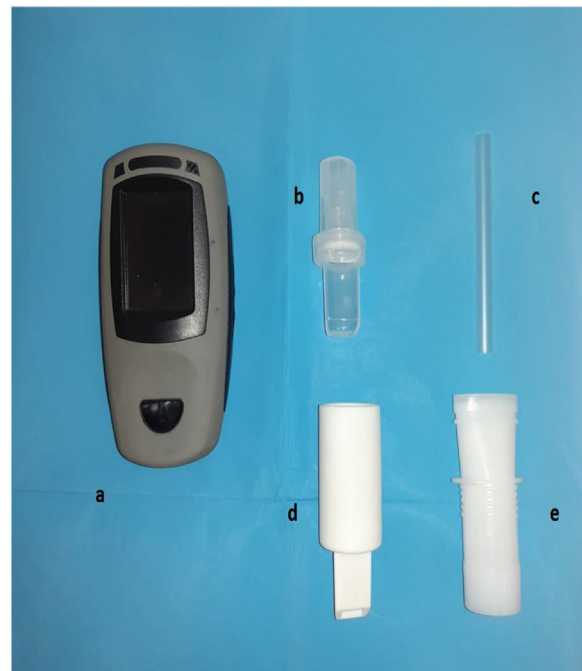


**Figure 1**  Smokerlyzer's components: electronic device (a); original fitting (b); disposable mouthpieces (c); fitting specially created (d); disposable spirometry mouthpieces (e).