High-flow nasal cannula for COVID-19 patients: low risk of bio-aerosol dispersion

To the Editor:

Human-to-human severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission has been established, with >3300 clinicians reported to be infected in China and >1116 clinicians infected in Italy, where 13 882 cases were confirmed by 13 March 2020. Room surfaces in the vicinity of coronavirus disease 2019 (COVID-19) symptomatic patients and clinicians' protective equipment were found to be contaminated [1]. The primary strategy for COVID-19 patients is supportive care, including oxygen therapy for hypoxaemic patients, in which high-flow nasal cannula (HFNC) has been reported to be effective in improving oxygenation. Among patients with acute hypoxaemic respiratory failure, HFNC was proven to avoid intubation compared to conventional oxygen devices [2, 3]. However, there is an important concern that HFNC may increase bio-aerosol dispersion in the environment due to the high gas flow used. The increased dispersion might favour transmission of infectious agents (such as SARS-CoV-2) carried in aerosol droplets generated by the infected patient. This concern is reflected in the limited use of HFNC in the first clinical study reporting 21 patients with COVID-19 in Washington State (USA), where only one patient used HFNC [4]. In contrast, a broad utilisation was observed in the study by Yang *et al.* [5] from Wuhan, China, where 33 out of 52 intensive care unit (ICU) patients were treated with HFNC.

There appears to be an uncertainty and a trend to avoid HFNC among COVID-19 patients in the western world, thus increasing early intubation rates and potentially associated harms such as sedation and prolonged ICU stay but also intubation procedures *per se*, which represent a high-risk situation for viral exposure. Early intubation increases the demand for ventilators, contributing to the critical shortage reported worldwide. Avoiding or delaying invasive mechanical ventilation could substantially reduce immediate demand for ventilators. Thus, we aim to discuss the scientific evidence supporting the risk of HFNC-induced bio-aerosol dispersion in the COVID-19 context.

The utilisation of smoke (an aerosol of solid particles <1 µm) simulation *via* a manikin model by Hui *et al.* [6] and Ip *et al.* [7] provides a direct visualisation of exhaled smoke dispersion. It appears that, when using HFNC, dispersion is greater at 60 L·min^{-1} than at 10 L·min^{-1} [6]. We summarise the results from reported *in vitro* studies with different oxygen devices in table 1 [6, 7]. Interestingly, using the same study method and similar breathing patterns, the exhaled smoke dispersion distance from the manikin with HFNC at 60 L·min^{-1} [6] was similar to the one observed with a simple oxygen mask at 15 L·min^{-1} [7] and even smaller than with other oxygenation devices, particularly non-rebreathing and Venturi masks [7]. While the dispersion of smoke in this model is instructive, especially between interfaces, the particle size of smoke (<1 µm) only represents a small fraction of the mass of bio-aerosol generated by patients naturally. As the aerosol generated by a patient's cough contains particles from 0.1 to 100 µm, clinical studies are required to truly evaluate aerosol dispersion, particularly the aerosol dynamics during physiological exhalation and cough.

Leung *et al.* [8] reported a randomised controlled trial comparing the utilisation of HFNC at 60 L·min^{-1} with an oxygen mask at 8.6±2.2 L·min^{-1} in 19 ICU patients with bacterial pneumonia on the environmental contamination. The patient's room air was sampled and settle plates were placed at 0.4 m and 1.5 m from patients. No significant difference in bacterial counts was reported in the air sample and

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Bio-aerosol dispersion *via* high-flow nasal cannula shows a similar risk to standard oxygen masks. High-flow nasal prongs with a surgical mask on the patient's face might benefit hypoxaemic COVID-19 patients without added risk for the environment. https://bit.ly/34p7Fyy

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TABLE 1 Summary of exhaled smoke dispersion distances with different oxygen devices

Oxygen device	Flow rate L·min^{-1}	Dispersion distance cm	Ref.
HFNC	60	17.2±3.3	[6]
	30	13.0±1.1	[6]
	10	6.5±1.5	[6]
Simple mask	15	11.2±0.7	[7]
	10	9.5±0.6	[7]
Non-rebreathing mask	10	24.6±2.2	[7]
Venturi mask at F_{IO_2} 0.4	6	39.7±1.6	[7]
Venturi mask at F_{IO_2} 0.35	6	27.2±1.1	[7]

Summary of studies evaluating oxygen delivery devices using a high-fidelity human simulator with smoke particles of <1 µm (an aerosol of solid particles). The smoke was illuminated by a laser light-sheet and high-definition video was used to measure dispersion distance away from the manikin. Indicated dispersion distances give an idea of proximity of contaminated bio-aerosols, to which healthcare workers may be directly exposed. HFNC: high-flow nasal cannula; F_{IO_2}: inspiratory oxygen fraction.

settling plates between the two oxygen devices at 1, 2 and 5 days of incubation [8]. These clinical results confirm the *in vitro* smoke experiments.

In vitro and clinical studies have demonstrated that placing a simple surgical protection mask on patients significantly reduces dispersion distance [9] and levels of virus-infected bio-aerosol 20 cm away from patients while coughing [10]. Such a surgical mask can be worn by a patient oxygenated through a nasal cannula (standard nasal cannula or HFNC) but not when using simple, non-rebreathing or Venturi oxygen masks.

Taken together, compared to oxygen therapy with a mask, the utilisation of HFNC does not increase either dispersion or microbiological contamination into the environment. The patient being able to wear a surgical mask on top of HFNC, in order to reduce the aerosol transmission during coughing or sneezing, represents an additional benefit.

However, given the high efficacy of HFNC to oxygenate the patients, closely monitoring the use of HFNC for COVID-19 patients is crucial to avoid any delay in intubation. Monitoring respiratory rates and pulse oximetry, and clinical examination, are essential.

In conclusion, massive numbers of clinicians have been infected during the COVID-19 outbreak, which has raised concerns around implementing aerosol-generating procedures. Consequently, there appears to be a trend to avoid HFNC. The scientific evidence of generation and dispersion of bio-aerosols *via* HFNC summarised here shows a similar risk to standard oxygen masks. HFNC prongs with a surgical mask on the patient's face could thus be a reasonable practice that may benefit hypoxaemic COVID-19 patients and avoid intubation.

Clinicians should consider moving away from the dogma restraining the use of HFNC among COVID-19 patients.

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