

RESEARCH LETTER

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# The application of an oxygen mask, without supplemental oxygen, improved oxygenation in patients with severe COVID-19 already treated with high-flow nasal cannula

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*Trial registration* ClinicalTrials, NCT04794400 Registered 12 March 2021—Retrospectively registered, <https://clinicaltrials.gov/ct2/show/NCT04794400>

Hypoxemia is the clinical hallmark of severe COVID-19 infection, and guidelines suggest using high-flow nasal cannula (HFNC) when conventional oxygen therapy fails [1, 2]. In late 2020, we observed that oxygenation could be improved in some patients by applying a mask (e.g. a nebulisation mask or simple oxygen mask) to ongoing HFNC. This procedure has quickly become a clinical routine at our hospital, and in this study, we aim to assess its effect.

The study was performed at Skåne university hospital in Malmö, Sweden. Eligibility criteria were (1) COVID-19 infection, (2) HFNC treatment, and (3) estimated PaO<sub>2</sub>/FiO<sub>2</sub> ratio of  $\leq 13$  kPa ( $\sim 97.5$  mmHg). Baseline measurements, including arterial blood gases (ABG), were taken without mask. Then, a simple oxygen mask was applied over nose and mouth for 30 min, without supplemental oxygen, followed by another ABG. Patients maintained position and HFNC settings throughout the procedure, which was monitored by a study physician. After mask

removal, SpO<sub>2</sub> was recorded upon reaching steady state and participants could continue using the mask at their doctor's discretion. The primary outcome was change in SaO<sub>2</sub>, with hypothesis testing through a paired t test. Secondary outcomes included changes in PaCO<sub>2</sub>, SpO<sub>2</sub> and respiratory rate.

Eighteen patients were included, see Table 1. SaO<sub>2</sub> (%) was higher in all patients after 30 min with mask than at baseline, mean difference: 5.1% (95%CI 3.0–7.2%), see Fig. 1a. There was a trend towards increased PaCO<sub>2</sub>, mean difference: 0.15 (95%CI – 0.03 to 0.34) kPa, see Fig. 1b. SpO<sub>2</sub> increased with mask and decreased after mask removal, see Fig. 1c. Mean respiratory rate was 22.4 with mask, compared to 24.6 at baseline, mean difference: – 2.2, (95%CI – 0.2 to – 4.2).

Thus, this small study confirmed the observation that oxygenation improved when a mask was added to HFNC. PaCO<sub>2</sub> increased slightly, possibly due to a lower respiratory rate, but without hypercapnia. No other side effects or complications were observed during this short-term study. The decline of SpO<sub>2</sub> after mask removal suggested an intervention effect, although SpO<sub>2</sub> did not fully reach baseline levels. The underlying mechanism was not studied, but we hypothesise that the mask

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**Table 1** Patient and infection characteristics at the time of inclusion

	N = 18
Age	69 (61–75)
Male sex	13 (72%)
Smoking history	10 (56%)
Diabetes	3 (17%)
Hypertension	11 (61%)
Chronic pulmonary disease	4 (22%)
Immunosuppression	3 (17%)
Charlson index $\geq$ 2 points	6 (33%)
Body mass index	
< 25	3 (17%)
25–30	8 (44%)
30–35	1 (6%)
35 +	6 (33%)
Infection characteristics	
Symptom duration, days	13 (10–14)
Respiratory rate/minute	24 (21–28)
Heart rate/minute	69.5 (64–87)
MAP, mmHg	90 (84–103)
PaO <sub>2</sub> , kPa/mmHg	8.1 (7.0–8.8) / 61 (53–66)
Estimated P/F ratio, kPa/mmHg	9.8 (8.4–10.5) / 74 (63–79)
c-Reactive protein, mg/L	74 (41–111)
Neutrophil/lymphocyte ratio	12 (7–21)
Procalcitonin, $\mu$ g/L	0.2 (0.1–0.3)
Ferritin, $\mu$ g/L	1085 (752–1683)
d-Dimer, mg/L	1.9 (0.8–3.6)
Troponin, ng/L	12 (9–21)
Pro-BNP, ng/L	466 (235–1197)
Creatinine, $\mu$ mol/L	65 (59–73)
Treatment	
Betametasone	18 (100%)
LMWH	18 (100%)
Remdesivir	1 (6%)
Antibiotics	6 (33%)
HFNC flow, L/min	40 (40–40)
FiO <sub>2</sub> , %	82.5% (80–100)
Position (side/back/prone)	9/4/5
HFNC/NIV ceiling of care	4 (22%)

Data are presented as median (IQR) or count (%). For Charlson index, the updated version (Quan 2011) was used

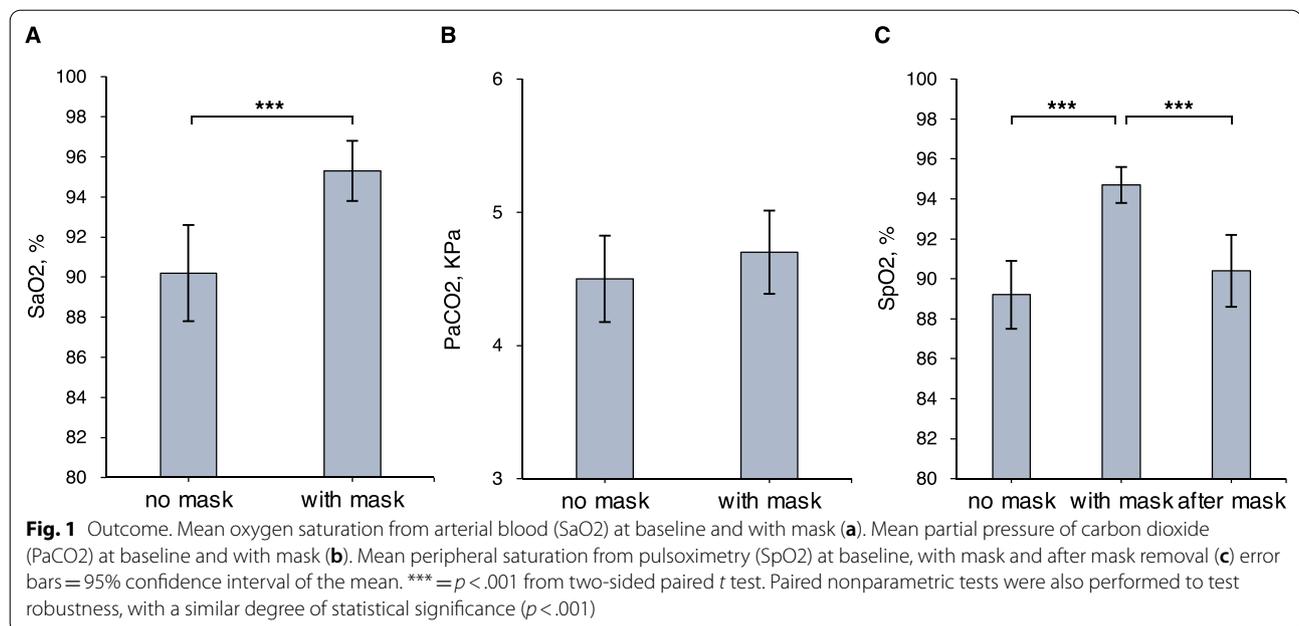
MAP: mean arterial pressure; BNP: brain natriuretic peptide; LMWH: low-molecular weight heparin; HFNC: high-flow nasal cannula; FiO<sub>2</sub>: fraction of inspired oxygen; NIV: non-invasive ventilation

could minimise entrainment of room air, especially when mouth-breathing.

Our HFNC device had a maximum flow rate of 40 L/min. However, the increase in SaO<sub>2</sub> of 5% is in line with the 4% found in a study with a similar design but another HFNC device and a flow rate of 60 L/min [3]. Furthermore, this other study used a surgical mask, suggesting that the observed phenomenon is neither strictly

mask- nor device-dependent. The study populations of these two small studies were quite similar though, and the generalisability of the results must be considered uncertain at this point.

Optimal intubation timing in COVID-19 is debated [4–6]. At our hospital, patients with severe hypoxemia have increasingly been managed for long periods on non-invasive respiratory support, including awake proning. In



this context, the intermittent use of mask + HFNC (alternating with proning, during mobilisation, as a rescue in desaturation episodes, a bridge to intubation or a last resort for patients with ceiling of care) has filled a niche, being less demanding than NIV by face mask, while maintaining benefits of HFNC over conventional oxygen treatment. However, without experienced staff, rigorous monitoring and intubation protocols, adding a mask to HFNC could also delay intubation, putting the patient at risk.

In conclusion, further studies are needed regarding oxygen delivery in severe COVID-19. The results in this study suggest that the addition of a mask to HFNC could improve oxygenation in some patients in the short-term perspective. However, potential long-term risks, including those associated with delaying intubation, must be acknowledged.

#### Acknowledgements

The authors thank Katja Beskow for assistance in data acquisition.

#### Authors' contributions

BD collected the data, analysed data and drafted the manuscript. FR, FM, HH, and JT contributed to conception and design of the study and revised the manuscript. GT conceived the study, monitored data collection, analysed the data and revised the manuscript. All authors read and approved the final manuscript.

#### Funding

The study was funded by the Governmental Funding of Clinical Research within the Health Sciences (ALF). The funding body had no role in the design of the study, collection, analysis, and interpretation of data or in writing the manuscript.

#### Declarations

##### Ethics approval and consent to participate

All patients provided informed consent and the study was approved by the Swedish Ethical Review Authority (2020-07078 and 2021-00834).

##### Consent for publication

Not applicable.

##### Competing interests

The authors declare no competing interests.

##### Availability of data and materials

Data are available on reasonable request to the corresponding author.

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Received: 14 May 2021 Accepted: 19 August 2021

Published online: 28 August 2021

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