High-flow nasal-oxygenation-assisted fibreoptic tracheal intubation in critically ill patients with COVID-19 pneumonia: a prospective randomised controlled trial

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Editor—Since December 2019, cases of pneumonia caused by the coronavirus disease 2019 (COVID-19) have been reported in Wuhan, Hubei Province, China. Coronavirus disease 2019 has spread rapidly around the globe, including Asia, North America, Europe, and Africa.[1] The 2019 novel coronavirus is likely similar to Middle East respiratory syndrome coronavirus and severe acute respiratory syndrome coronavirus. They belong to the Betacoronavirus genus and can cause severe respiratory disease, including acute respiratory distress syndrome, pulmonary oedema, and respiratory failure.[2] Tracheal intubation for invasive mechanical ventilation is the mainstay therapy to correct hypoxaemia. Preoxygenation with the standard bag-valve mask oxygenation followed by rapid-sequence intubation has been proposed in non-severely hypoxaemic critically ill patients requiring tracheal intubation to reduce the risk of aspiration and desaturation. However, a previous study reported that 23% of patients had Spo_2 <90% during intubation.[3]

Thus far, more than 80000 cases of COVID-19 have been confirmed in China. Person-to-person transmission of COVID-19 has been described, including in many healthcare workers.[4,5] Rapid-sequence fibreoptic bronchoscopic tracheal intubation in patients with COVID-19 pneumonia may reduce the risk of viral spread. We evaluated the efficacy and safety of high-flow nasal oxygenation (HFNO) during fibreoptic bronchoscopic intubation in critically ill patients with COVID-19 pneumonia compared with standard mask oxygenation (SMO).

This study was approved by the ethics committee of the General Hospital of Central Theatre Command and registered at http://www.chictr.org/cn/ (registration number: ChiCTR2000029658). Inclusion criteria were adults (aged >18 yr), with clinically-confirmed COVID-19 pneumonia and hypoxaemia (defined as the ratio of arterial oxygen tension [Pao_2] to inspiratory oxygen fraction [Fio_2] <300 mm Hg), and requiring intubation in the ICU. Patients were randomly allocated to the HFNO group or the SMO group.

Patients were placed in the head-up supine position and oxygen was administered for 4 min, either via high-flow nasal cannula (AIRVO™ 2; Fisher & Paykel Healthcare, Auckland, New Zealand) at 50 L min^{-1} with heated and humidified oxygen at 37°C, or by standard bag-valve mask at 15 L min^{-1}. All patients were then instructed to take deep breaths before general anaesthesia was induced with propofol 1.5–2.5 mg kg^{-1} and neuromuscular block was initiated with rocuronium 1 mg kg^{-1}. One minute after administration of rocuronium, fibreoptic tracheal intubation was attempted by one of six anaesthesiologists experienced in fibreoptic intubation. Each anaesthesiologist intubated sequences of 10 patients who were evenly divided into the two groups.

A 4.5 mm fibreoptic bronchoscope (UE Medical Company Ltd, Zhejiang, China) loaded with a lubricated reinforced Parker Flex-Tip® tracheal tube (Well Lead Medical Company Ltd., Guangzhou, China) was inserted until the carina was visualised, and the tube was advanced over the bronchoscope into the trachea. During attempts at tracheal intubation, HFNO was maintained for the HFNO group, whereas no oxygen was administered for the SMO group. After removal of the bronchoscope, successful intubation was confirmed by capnography. If Spo_2 <90% occurred during intubation, bronchoscopy was terminated and face-mask ventilation was initiated to correct desaturation. The primary endpoint was the total time of intubation, defined as the sum of the time spent from the beginning of bronchoscopy until proper tracheal tube placement was confirmed. The secondary endpoints included the lowest Spo_2 during intubation, incidence of mask ventilation for Spo_2 <90%, Pao_2/Fio_2 before intubation, incidence of Spo_2 <80% during intubation, incidence of minimum Spo_2 >95% during intubation, and 7 day mortality.

Sample size was calculated using PASS (version 10.0, NCSS Statistical Software; NCSS LLC, Kaysville, UT, USA) based on total time of intubation. We estimated that 27 patients per group would be needed. Assuming the potential patient dropout, 30 patients were required in each group for a total sample size of 60 patients. Of 79 participants screened for eligibility, 19 participants met the exclusion criteria and 60 patients were recruited for the study. One patient was excluded for improving before the start of bronchoscopic intubation, and one patient withdrew consent in the HFNO group (Supplementary Fig. S1). Baseline characteristics were similar between groups (Table 1). Intubation time was significantly shorter in the HFNO (69 [inter-quartile range {IQR}: 62.2–74.0] s) than in the SMO group (76 [68.0–90.5] s; P=0.005). Compared with the SMO group, the HFNO group had a greater minimum Spo_2 during tracheal intubation (94% [IQR:

Table 1 General characteristics and outcomes of patients. Data shown as mean (standard deviation), median [inter-quartile range], or *n* (%). Continuous data were compared using independent-sample *t*-test or Mann–Whitney *U*-test. Proportions were analysed using Fisher's exact test or χ^2 test. HFNO, high-flow nasal oxygenation; SMO, standard mask oxygenation.

Characteristic	Group HFNO	Group SMO	*P*-value
Patients, *n*	28	30	
Sex, M/F	14/14	19/11	
Age (yr)	64.3 (11.6)	67.1 (9.9)	
Weight (kg)	66.9 (9.4)	70.3 (9.1)	
Height (cm)	165.5 (8.7)	167.0 (7.8)	
Ventilatory frequency	26.8 (5.9)	27.7 (5.3)	
Co-morbidities, *n* (%)			
Hypertension	16 (57.1)	19 (63.3)	
Diabetes mellitus	3 (10.7)	2 (6.7)	
Cardiovascular disease	8 (28.6)	10 (33.3)	
Primary and secondary outcomes			
Pao_2/Fio_2 before intubation	139.5 [118.3; 162.3]	128.5 [121.5; 136.3]	0.225
Total time to intubation (s)	68.5 [62.2; 74.0]	76.0 [68.0; 90.5]	0.005
Lowest Spo_2 during intubation	94.0 [92.1; 95.8]	91.2 [86.3; 93.0]	0.001
Mask ventilation for Spo_2 <90%, *n* (%)	1 (3.6)	8 (26.7)	0.015
Percentage of minimum Spo_2 >95% during intubation, *n* (%)	8 (28.6)	3 (10)	0.071
Percentage of Spo_2 <80% during intubation, *n* (%)	0 (0)	2 (6.7)	0.164

92.1–95.8] *vs* 91% [86.3–93.0]; $P=0.001$) and a lower incidence of rescue face-mask ventilation (4% *vs* 27%; $P=0.015$). There was no significant difference in the proportion of patients with minimum Spo_2 >95% during intubation, in the incidence of Spo_2 <80% during intubation, or in the incidence of 7 day mortality.

High-flow nasal oxygenation is effective in preventing hypoxaemia, but there has been no study of its efficacy during attempts at fibreoptic intubation in the ICU. High-flow nasal oxygenation generates positive airway pressure and can increase end-expiratory lung volume, thereby improving oxygenation.[6,7] Our results show that the lowest Spo_2 was higher in the HFNO group than the SMO group, and that HFNO shortened the duration of intubation. The reasons for this are not clear, but one possibility is that interruption of attempts at tracheal intubation to carry out rescue face-mask ventilation was less frequently required in the HFNO group.

A recent study of 138 patients showed that healthcare workers comprised 29% of those infected, and suggested rapid human-to-human transmission of COVID-19.[5] As of February 11, 2020, 1716 medical workers were considered laboratory-confirmed COVID-19 infections in China, with six fatal cases. Direct laryngoscopy, inadequate sedation, coughing during laryngoscopy, and manual ventilation are consistently associated with increased risk of transmission as a result of the generation of natural aerosols.[8] Therefore, tracheal intubation and mask ventilation are considered high-risk procedures as they intensify viral spread.[9,10] To reduce tracheal-intubation-induced coughing and subsequent spread of virus, we recommended intubation after rapid-sequence intubation of general anaesthesia using visual fibreoptic bronchoscopy. Although we have no evidence that fibreoptic tracheal intubation can prevent airborne viral transmission from patient to healthcare provider, it may increase the distance between the anaesthesiologist and the patient's airway. The six anaesthesiologists in the current study are currently not infected. According to the results of a recent study, HFNO use in patients with bacterial pneumonia was not associated with an increase in air or surface contamination.[11] In contrast, mask ventilation before tracheal intubation can generate more aerosols.

In conclusion, in critically ill patients with COVID-19 pneumonia, HFNO provided a shorter intubation time and less frequent incidence of desaturation during attempts at fibreoptic tracheal intubation compared with preoxygenation by face-mask ventilation. High-flow nasal oxygenation is potentially useful during rapid-sequence induction and intubation in critically ill patients with COVID-19 pneumonia.

Authors' contributions

Study design: B-XL, C-NW, YC
Study conduct: C-NW, B-XL, L-ZX, BQ
Data collection: B-XL, C-NW, W-HM, K-HL
Data analysis: YC, D-NY
Writing manuscript: C-NW, YC
All authors read and approved the final version of the manuscript.

Declarations of interest

The authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.02.020.

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Tracheal trauma after difficult airway management in morbidly obese patients with COVID-19

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Editor—Since December 2019, a pandemic infection caused by a novel coronavirus responsible for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been spreading globally after the first respiratory cases appeared in Wuhan, Hubei Province, China.[1] In March 2020, Western Europe and France faced a huge number of SARS-CoV-2 cases. The clinical management of the most severe cases requires tracheal intubation with mechanical ventilation. In order to protect against viral transmission, airway management requires several precautions. Therefore, anticipation of difficult airway management to limit the number of attempts and procedures is recommended.

We have had two recent patients with SARS-CoV-2 infection who had airway trauma during tracheal intubation (written consent was obtained from the patients before reporting these cases).

The first case is a 59 yr old woman with a history of morbid obesity (BMI, 41 kg m^{-2}) who was admitted to a tertiary hospital for acute dyspnoea, myalgia, and arthralgia. Initial physical examination revealed the following: heart rate, 90 beats min^{-1}; arterial blood pressure, 120/70 mm Hg; tachypnoea, 30 min^{-1}; fever of 39.2°C; oxygen saturation, 80%; and bilateral dry rales on lung auscultation. Biological investigation showed a white blood count of 8400 mm^{-3}, lymphopaenia of 800 mm^{-3}, and C reactive protein of 230 ng L^{-1}. Blood gas analysis confirmed severe hypoxaemia with a Pa_{O_2} of 7 kPa and respiratory alkalosis (pH 7.5, HCO_3^- 24.8 mM, Pa_{CO_2} 18 kPa). Chest CT was compatible with SARS-CoV-2 infection as it showed bilateral ground-glass like opacities and multiple patchy lung consolidations.[2] Real-time reverse transcriptase–polymerase chain reaction (RT–PCR) of nasopharyngeal swabs was positive for SARS-CoV-2. The initial medical management consisted of high-flow nasal cannula (HFNC) oxygen therapy (100% oxygen) and administration of lopinavir and ritonavir. On Day 2 after admission, the patient's respiratory condition worsened requiring tracheal intubation and mechanical ventilation. Direct laryngoscopy showed a Grade IV view requiring use of a single bougie (Eschmann introducer, Vygon 15 Fr, Vygon, Écouen, France) without successful intubation. Cervical and thoracic subcutaneous emphysema occurred just after the first attempt during face mask ventilation. The trachea was intubated on