JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Coronavirus Pandemic

How did we protect ourselves during intubation for a COVID-19 patient in the context of PPE shortage?

Sheng Zhang[1], Yingxin Lin[1], Yanyan Li[1], Weixing Zhang[1], Qing Feng[1], Hua Luo[1]

[1] *Department of Critical Care Medicine, Peking University Shenzhen Hospital, Shenzhen, China*

Abstract

Beginning in 2019, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) rapidly resulted in a worldwide pandemic. Many patients with coronavirus disease-19 (COVID-19) require invasive ventilation due to severe respiratory failure. However, many medical hospitals experienced shortages of personal protective equipment, increasing the risk of healthcare workers contracting an infection. However, we report a case of acute respiratory distress syndrome during the early stage of COVID-19 treated at a university hospital outside of Wuhan, China. We described the optimization of healthcare worker personal protection and a procedure for airway management in the context of insufficient personal protective equipment. This report may provide a reference for resource-limited settings in low- and middle-income countries, even countries where healthcare systems have been overwhelmed by the pandemic.

Key words: SARS-CoV-2; COVID-19; high-risk aerosol-generating medical procedures; intubation; personal protective equipment.

J Infect Dev Ctries 2021; 15(12):1808-1812. doi:10.3855/jidc.13279

(Received 15 June 2020 – Accepted 17 May 2021)

Introduction

Beginning in 2019 severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) rapidly resulted in a worldwide pandemic, and millions of persons have contracted coronavirus disease-19 (COVID-19) resulting in the most severe public health event of modern times [1]. So far, there have been more than 150 million confirmed cases of COVID-19 worldwide, and the outbreak has been brought under control in China and the number of new cases is declining in most parts of the world, but increases in both cases and deaths of COVID-19 have been noted in South-East Asia and the Western Pacific [2]. In these regions the safety of healthcare workers (HCWs) is a priority to prevent the collapse of healthcare systems and transmission of the disease from hospital to communities.

SARS-CoV-2 is transmitted by respiratory droplets and close contact with an infected individual [1]. Because of close contact with infected patients HCWs are at high risk of becoming infected, particularly during high-risk aerosol-generating medical procedures (AGMPs) such as endotracheal intubation [3]. Data from the Chinese Center for Disease Control and Prevention (CDC) has indicated that, 14% of confirmed cases of COVID-19 have suffered severe pneumonia [4]. Adequate personal protective equipment (PPE) should be used during intubation. However, it is unclear how to prevent infection of HCWs during AGMPs when the supply of PPE is insufficient. Herein, we describe a method of endotracheal intubation and initiation of mechanical ventilation in the absence of a power air purifying respirator (PAPR) in a patient with COVID-19 and acute respiratory distress syndrome (ARDS) (Figure 1).

Case report

On January 13, 2020, a 63-year-old male presented to our emergency department with complaint of a cough for 5 days, shortness of breath on exertion, and an intermittent fever with a maximum temperature of 38.4 °C. He disclosed that he had returned to Shenzhen on January 2 after traveling to visit friends in Wuhan, China. On illness day 4, chest computed tomography displayed bronchiectasis and bilateral pneumonia (Supplementary Figure 1).

In the emergency department body temperature was 36.5 °C, heart rate was 72 beats per minute (bpm), blood pressure (BP) was 114/70 mmHg, respiratory rate was 32 breaths per minute, and his, oxygen saturation breathing ambient air was 88%. With rapidly progressing respiratory failure, he was admitted to the intensive care unit (ICU) in the early morning of January 14. Laboratory evaluations showed a normal

Figure 1. Timeline of disease course from ICU admission.

ICU Day Jan 14 00:20am – Jan 15 6:00am 2020

Time in ICU	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h-19h	20h	21h-29h	30h
HR (bpm*)	72	78	76	80	84	80	85	90	100	130	148	145-130	124	120	110
RR (bpm#)	32	26	27	29	30	32	32	35	36	40	16	16	18	18	18
Saturation (%)	88	96	96	97	96	96	93	91	88	87	85	86-89	91	92	95
Respiratory support	High-flow nasal cannula								NPPV		Invasive mechanical ventilation				
PPE	N95 mask + Goggles + Waterproof gown + Gloves + Hand hygiene + Shower														
											Closed tracheal suction catheter + bacteria/virus filter				
											Intubation at 10:00	CVC BAL	PP	Prelimiinary diagnosis	Transfer at 6:00

*: beats per minute; #: breathes per minute; HR: heart rate; RR: respiratory rate, NPPV: non-invasive positive pression ventilation; PPE: personal protective equipment; CVC: central vena catheterization; BAL: bronchoalveolar lavage; PP: prone position.

white blood cell (WBC) count (4.36×10^9/L) and decreased lymphocytes (0.45×10^9/L). Hisprocalcitonin level (0.18 ng/mL) and C-reactive protein (CRP; 36.2 mg/L) was increased slightly, and his D-dimer level was markedly increased to 2.89 mg/L (normal range 0-0.50 mg/L), his oxygenation index was 186. Other laboratory studies and coagulation indices were normal (Supplementary Table 1).

Because the patient was potentially contagious, he was placed in an isolated single room ; negative pressure room was not available but the window was kept open for ventilation. All healthcare workers (including an attending physician, a resident and 2 nurses) in the room wore PPE (waterproof gown, gloves, goggles, hair cover, and the N95 masks). After 7 hours of nasal high-flow oxygen therapy, his oxygen saturation gradually decreased to 91% and he developed a dry cough. Non-invasive pressure ventilation (NPPV) was begun, but his oxygen saturation did not improve. Thus, the decision was made to perform endotracheal intubation and mechanical ventilation.. After medications, mask, suction, and intubation equipment were prepared, our team used an improved rapid sequence intubation strategy to perform the endotracheal intubation (Figure 1). The attending physician then performed successful intubation using a video laryngoscope after a failed attempt by the resident, and the whole process was accomplished within 8 minutes. A closed tracheal suction system was used during ventilation with deep analgesia and sedation, and filters were installed on the exhaust valve of the ventilator (Figure 2). All works took a shower after the operation.

Subsequently, an internal jugular vein catheter was placed, bronchoalveolar lavage was performed, and ventilation was performed with the patient in the prone position. On January 15, 2020, the local CDC preliminary confirmed that the patient's bronchoalveolar lavage fluid specimen was positive for SARS-CoV-2 by a real-time reverse transcription

Figure 2. Precaution of aerosol generation and diffusion.

A: Closed mask and dual-circuit for pre-oxygenation; B: Personal protective equipment and intubation using video laryngoscope; C: Closed tracheal suction system; D: The black arrow is ventilator exhalation valve with bacteria/virus filter.

polymerase chain reaction (rRT-PCR) assay. He was immediately transferred to the appointed local medical center for COVID-19 patients. Unfortunately, he died on February 16, 2020.

Among his close contacts, his wife was diagnosed as COVID-19 on January 24, 2020. None of the healthcare workers caring for the patient contracted.

Discussion

This was the first patient with severe who was intubated in Shenzhen. SARS-CoV-2 is highly communicable, and the reproductive rate is greater than that of SARS coronavirus [5]. AGMPs performed on patients with an acute SARS-CoV-2 respiratory infection are thought to substantially increase the risk of HCWs becoming infected [6]. Thus, adequate PPE is necessary to protect HCWs but there are critical supply shortages of PPE in both low-income and high-income countries [7], which endangers the safety of the frontline workers. Our case is unique in that we successfully protected ourselves from infection by the measures to reduce aerosol-generation before a diagnosis of COVID-19 was made.

SARS-CoV-2 is transmitted by close personal contact and larger 'respiratory droplets' to smaller 'aerosols' exhaled through the mouth or nose [8]. Aerosol transmission can occur in specific situations during medical procedures such as bag-mask ventilation, endotracheal intubation, tracheostomy and cricothyrotomy [8]. HCWs can become infected by the virus contacting through mucous membranes or entering the respiratory tract [9]. PPE recommendations from international organizations are largely consistent; but PPE use is not [10]. The basic PPE for the very high risk AGMPs recommended by different guidelines includes a hair cover, N95 mask (or FFP2 or FFP3), gloves, waterproof gown, and eye protection (goggles and/or face shield) [8,11-13]. Apart from South Africa and South Korea [14,15], the use of a PAPR is not mandatory in most countries, and if impossible, an N95 mask or equivalent respirator is considered as an alternative during intubation[16-18]. The World Health Organization (WHO) does not make a clear recommendation for the use of a respirator [8]. There are some controversies over whether a neck covering is required when performing high-risk AGMPs. The potential for contamination at the wrist (despite a single pair of gloves) and the neck have been reported during airway management [19,20]. Although contamination at the neck or wrist does not necessarily lead to infection, given the increased risk of transmission during high-risk AGMPs it has been proposed that a neck cover and a second pair of gloves be used, [3]. If neck cover are unavailable, some barrier devices could be adopted to limit the exposure of HCWs to the virus [21]. In our case, we replaced certain protective measures with sufficient hand hygiene and a shower after the procedure. Therefore, we advocate that healthcare workers have access to shower facilities after directly participating in a high-risk AGMP particularly in the context of a shortage of PPE.

PPE is only one part of a larger system to protect HCWs and other patients from COVID-19 transmission [10]. All guidelines recommend a rapid sequence induction using a video laryngoscope by the most experienced doctor and avoiding awake intubation, using a neuromuscular-blocking drug, and small tidal volumes if manual ventilation is required [13-16,18,22]. In our patient was administered a fast-acting sedative and analgesic to suppress cough and the gag reflex in advance, because mechanical stimulation during tracheal intubation can cause a severe cough [23]. Since the beginning of the SARS pandemic, NPPV has been considered a cause of spreading aerosol droplets during induction of anesthesia and an independent risk factor for super-spreader nosocomial outbreaks affecting many HCWs in Hong Kong and Guangzhou, China [24]. Sufficient sedation and analgesia can limit aerosol droplet generation by inhibiting cough, and our patient was calm and without any cough throughout the procedure. We also used closed mask ventilation, a dual-circuit and small tidal volume (6ml/kg) for pre-oxygenation to reduce gas leakage (Figure 2). Although most of the recommendations discouraged positive pressure ventilation for pre-oxygenation [11, 18], almost of all the patients who require IPPV are already receiving NPPV due to severe hypoxemia. Atidal volume > 6 mL/kg is associated with increased risk for nosocomial infection during intubation [23]. Therefore, a closed circuit and small tidal volume (< 6 mL/kg) may be optimal strategy for minimizing virus-containing aerosol droplets. Our procedure also included administration of a fast-acting neuromuscular blocker to inhibit respiration, and the use of a video laryngoscope to avoid the operator from being close to the patient's mouth. Being in close proximity to the patient's mouth during intubation has been shown to increase the risk of contracting an infection [9]. In addition, the use of a fast-acting neuromuscular blocker and a video laryngoscope can result in a higher first-attempt success and thus a lower transmission rate. Lastly, we used a closed tracheal suction system during mechanical ventilation and a bacteria/virus filter on the

exhaust valve of the ventilator to reduce the risk of airborne transmission.

Conclusions

Until now, there has been no direct evidence that any combination of PPE used during a high-risk AGMP has an advantage over any other. A basic principles for protection during a high-risk AGMP are followed while the exact combination of PPE components is likely not most important. During the pandemic period in China, none of HCWs outside Hubei were reported to have contracted the virus and we have learned that many Chinese doctors adopted similar principles for protection described in this report. We recognize the limitations of this single case report, and understand that additional studies are necessary to determine how best to protect HCWs.

Acknowledgements

The authors thanks Bin Huang, Cong Zhou, Yunliang Tu, Zheng Yi and Shuping Ding for performing the intubation. The author also thanks Shaolin Chen and Yinfeng Li for providing data.

Author contributions

HL and WZ designed and conceived this study. YL and QF collected the data. SZ, YL, YL, QF ,and HL contributed to data analysis andinterpretation; SZ and YL wrote the manuscript. All authors provided critical review and approved the final manuscript.

References

1. Contini C, Caselli E, Martini F, Maritati M, Torreggiani E, Seraceni S, Vesce F, Perri P, Rizzo L, Tognon M (2020) COVID-19 Is a multifaceted challenging pandemic which needs urgent public health interventions. Microorganisms 8: 1228.
2. World Health Organization (WHO) (2021) Coronavirus (COVID-19) dashboard. Global situation (live). Available: https://covid19.who.int. Accessed: 27 April 2021.
3. Lockhart SL, Duggan LV, Wax RS, Saad S, Grocott HP (2020) Personal protective equipment (PPE) for both anesthesiologists and other airway managers: principles and practice during the COVID-19 pandemic. Can J Anaesth 67: 1005-1015.
4. Wu Z, McGoogan JM (2020) Characteristics of and important lessons from the Coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 323: 1239-1242.
5. Liu Y, Gayle AA, Wilder-Smith A, Rocklöv J (2020) The reproductive number of COVID-19 is higher compared to SARS coronavirus. J Travel Med 27: taaa021.
6. El-Boghdadly K, Wong DJN, Owen R, Neuman MD, Pocock S, Carlisle JB, Johnstone C, Andruszkiewicz P, Baker PA, Biccard BM, Bryson GL, Chan MTV, Cheng MH, Chin KJ, Coburn M, Jonsson Fagerlund M, Myatra SN, Myles PS, O'Sullivan E, Pasin L, Shamim F, van Klei WA, Ahmad I (2020) Risks to healthcare workers following tracheal intubation of patients with COVID-19: a prospective international multicentre cohort study. Anaesthesia 75: 1437-1447.
7. Ranney ML, Griffeth V, Jha AK (2020) Critical supply shortages - The need for ventilators and personal protective equipment during the Covid-19 pandemic. N Engl J Med 382: e41.
8. World Health Organization (WHO) (2021) COVID-19: occupational health and safety for health workers. Available: https://www.who.int/publications/i/item/WHO-2019-nCoV-HCW_advice-2021.1. Accessed: 30 Apirl 2021.
9. Fowler RA, Guest CB, Lapinsky SE, Sibbald WJ, Louie M, Tang P, Simor AE, Stewart TE (2004) Transmission of severe acute respiratory syndrome during intubation and mechanical ventilation. Am J Respir Crit Care Med 169: 1198-1202.
10. Cook TM (2020) Personal protective equipment during the coronavirus disease (COVID) 2019 pandemic - a narrative review. Anaesthesia 75: 920-927.
11. Wax RS, Christian MD (2020) Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. Can J Anaesth 67: 568-576.
12. Alhazzani W, Møller MH, Arabi YM, Loeb M, Gong MN, Fan E, Oczkowski S, Levy MM, Derde L, Dzierba A, Du B, Aboodi M, Wunsch H, Cecconi M, Koh Y, Chertow DS, Maitland K, Alshamsi F, Belley-Cote E, Greco M, Laundy M, Morgan JS, Kesecioglu J, McGeer A, Mermel L, Mammen MJ, Alexander PE, Arrington A, Centofanti JE, Citerio G, Baw B, Memish ZA, Hammond N, Hayden FG, Evans L, Rhodes A (2020) Surviving sepsis campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). Crit Care Med 48: e440-440e469.
13. Malhotra N, Joshi M, Datta R, Bajwa S, Mehdiratta L (2020) Indian Society of Anaesthesiologists (ISA National) advisory and position statement regarding COVID-19. Indian J Anaesth 64: 259-263.
14. South African Society of Anesthesiologists (SASA) (2020) SASA Covid-19 Update. Available: https://sasacovid19.com/. Accessed: 30 April 2021.
15. Kim HJ, Ko JS, Seo H, Kim TY (2020) Guidelines for the control and prevention of coronavirus disease (COVID-19) transmission in surgical and anesthetic settings. Korean J Anesthesiol 73: 271-274.
16. Australian Society of Anaesthetists (ASA) (2021) COVID-19 updates. Available: https://asa.org.au/covid-19-updates/. Accessed: 30 April 2021.
17. National Institutes of Health (NIH) (2020) COVID-19 treatment guidelines. Infection control. Available: https://www.covid19treatmentguidelines.nih.gov/critical-care/infection-control/. Accessed: 30 April 2021.
18. Critical care committee of Chinese Association of Chest Physician, Respiratory and critical care group of Chinese Thoracic Society, Respiratory care group of Chinese Thoracic Society (2020) Conventional respiratory support therapy for Severe Acute Respiratory Infections (SARI): Clinical indications and nosocomial infection prevention and control. Zhonghua Jie He He Hu Xi Za Zhi 43: 189-194. [Article in CHinese]
19. Feldman O, Meir M, Shavit D, Idelman R, Shavit I (2020) Exposure to a surrogate measure of contamination from simulated patients by emergency department personnel

wearing personal protective equipment. JAMA 323: 2091-2093.
20. Canelli R, Connor CW, Gonzalez M, Nozari A, Ortega R (2020) Barrier enclosure during endotracheal intubation. N Engl J Med 382: 1957-1958.
21. Simpson JP, Wong DN, Verco L, Carter R, Dzidowski M, Chan PY (2020) Measurement of airborne particle exposure during simulated tracheal intubation using various proposed aerosol containment devices during the COVID-19 pandemic. Anaesthesia 75: 1587-1595.
22. Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A (2020) Consensus guidelines for managing the airway in patients with COVID-19: guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists. Anaesthesia 75: 785-799.
23. Caputo KM, Byrick R, Chapman MG, Orser BJ, Orser BA (2006) Intubation of SARS patients: infection and perspectives of healthcare workers. Can J Anaesth 53: 122-129.
24. Yu IT, Xie ZH, Tsoi KK, Chiu YL, Lok SW, Tang XP, Hui DS, Lee N, Li YM, Huang ZT, Liu T, Wong TW, Zhong NS, Sung JJ (2007) Why did outbreaks of severe acute respiratory syndrome occur in some hospital wards but not in others. Clin Infect Dis 44: 1017-1025.

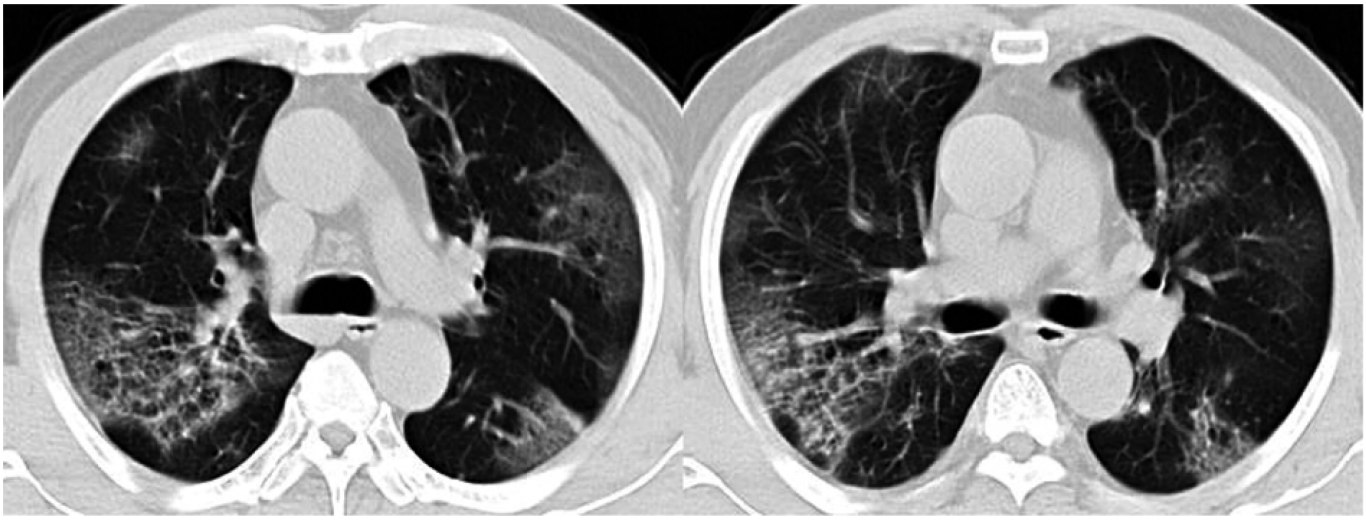
Corresponding author

Hua Luo, MD
Deputy Chief of Critical Care Medicine, Peking University Shenzhen Hospital, 518036, Shenzhen, China
Phone: +86-13828731408
Email: zalion@163.com

Conflict of interests: No conflict of interests is declared.

Annex – Supplementary Items

Supplementary Figure 1. Chest computed tomography. January 12, 2020 (Illness Day 4) displayed multiple ground-glass opacity and crazy-paving sign.



Supplementary Table 1. Clinical laboratory results before ICU.

Measure	Reference Range	Pre-ICU
White-cell count (10^9/L)	3.5-9.5	4.36
Absolute neutrophils count (10^9/L)	1.8-6.3	3.6
Absolute lymphocyte count (10^9/L)	1.1-3.2	0.45
Absolute eosinophil count (10^9/L)	0.02-0.52	0.00
Platelet count (10^9/L)	125-350	126
Hemoglobin (g/L)	130-175	154
Na^+ (mmol/L)	137-145	130
K^+ (mmol/L)	3.5-5.1	3.65
Glucose (mmol/L)	3.6-6.1	6.03
PH	7.35-7.45	7.47
PCO2 (mmHg)	35-45	28.3
PO2 (mmHg)	80-100	69.5
Creatinine (umol/L)	58-110	101
Blood urea nitrogen (mmol/L)	2.5-7.1	7.78
Alanine transaminase (U/L)	9-66	58
Total bilirubin (umol/L)	8.5-29.2	18.6
Albumin (g/L)	35-50	37.9
D-Dimer (mg/L)	0-0.5	2.89
Prothrombin time (sec)	11.00-15.00	14.3
International normalized ratio (INR)	0.80-1.20	1.11
Fibrinogen (g/L)	2.00-4.00	3.81
Procalcitonin (ng/ml)	< 0.05	0.18
C-reactive protein (mg/L)	< 10	36.2
Lactic acid (mmol/L)	0.7-2.1	1.15
Cardiac troponin T (ng/ml)	< 0.014	1.550