



Received: April 19, 2020

Revised: May 5, 2020 (1st); May 14, 2020 (2nd)

Accepted: May 17, 2020

### Corresponding author:

Jia Lin Jacklyn Yek, MBBS, MRCS, MMED  
Department of Anesthesiology and Intensive Care, Changi General Hospital, 2 Simei Street 3, Singapore 529889  
Tel: +65-9172-2396  
Fax: +65-6290-1693  
Email: [jacklyn.yek@mohh.com.sg](mailto:jacklyn.yek@mohh.com.sg)  
ORCID: <https://orcid.org/0000-0001-9879-0669>

# Perioperative considerations for COVID-19 patients: lessons learned from the pandemic -a case series-

Jia Lin Jacklyn Yek<sup>1</sup>, Sheng Chuu Anne Kiew<sup>1</sup>, James Chi-Yong Ngu<sup>2</sup>, Jimmy Guan Cheng Lim<sup>1</sup>

Departments of <sup>1</sup>Anesthesiology and Intensive Care, <sup>2</sup>General Surgery, Changi General Hospital, Singapore

**Background:** As the coronavirus disease 2019 (COVID-19) pandemic spreads globally, hospitals are rushing to adapt their facilities, which were not designed to deal with infections adequately. Here, we present the management of a suspected COVID-19 patient.

**Case:** A 66-year-old man with a recent travel history, infective symptoms, and chest X-ray was presented to our hospital. Considering his septic condition, we decided to perform an emergency surgery. The patient was given supplemental oxygen through a face mask and transported to an operating theatre on a plastic-covered trolley. An experienced anesthetist performed rapid sequence intubation using a video laryngoscope. Due to the initial presentation of respiratory distress, the patient remained intubated after surgery to avoid re-intubation. Precautions against droplet, contact, and airborne infection were instituted.

**Conclusions:** Our objective was to facilitate surgical management of patients with known or suspected COVID-19 while minimizing the risk of nosocomial transmission to health-care workers and other patients.

**Keywords:** Communication; Coronavirus; COVID-19; Infection control; Pandemics; Perioperative care; Perioperative period; Personal protective equipment.

The first case of coronavirus disease 2019 (COVID-19) in Singapore was confirmed on January 23, 2020. On February 7, 2020, Singapore raised the Disease Outbreak Response System Condition alert level to orange, indicating that the disease was severe and easily transmissible. Subsequently, a global pandemic was declared by the World Health Organization on March 11, 2020. Patients with COVID-19 are not only at a risk of developing acute hypoxemic respiratory failure, but also acute cardiac injury and multiorgan failure [1] requiring ventilation therapy and admission to intensive care unit. In addition to the stress of being in an emergency surgical condition, patients with concurrent COVID-19 infections are likely to present with severe physiological derangements.

COVID-19 is known to have high infectivity with an estimated reproduction number (Ro) of 2.2–3.6 [2]. Ro is a measure of the transmission potential of an epidemic, defined as the number of infections caused by an index case within a population with no pre-existing immunity [3]. In the past, the majority of Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) cases were associated with nosocomial transmission in hospitals as well as with aerosol-generating procedures [4]. In particular, intubation and surgery are associated with significant exposure of healthcare workers to patients' bodily fluids [4,5]. The use of electrocautery, application of surgical energy devices [6], and evacuation of pneumoperitoneum during laparoscopic procedures [7] have been associated with bioaerosol generation. Laparoscopic procedures are

© The Korean Society of Anesthesiologists, 2020

© This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

also associated with viral release under high pressure. Hence, careful execution of infection control measures is necessary to prevent nosocomial transmission to other patients and health-care workers [8].

This paper describes the perioperative anesthetic and surgical considerations and hospital facility preparations for infection control undertaken to prepare for a potential surge in confirmed or suspected COVID-19 patients requiring surgery.

## Case Report

We obtained written informed consent from the patient. A 66-year-old man with a history of Type II diabetes mellitus, hypertension, and hyperlipidemia, was presented to our hospital with a one-day history of acute shortness of breath, cough, and fever. Further, he had a recent travel history to Batam, Indonesia.

His vitals were as follows: temperature 38.0°C, blood pressure 130/70 mmHg, pulse 140 bpm, respiratory rate of 25 per minute. His oxygen saturation was 92% on room air, and he was promptly placed on a 40% Venturi mask. Physical examination revealed bilateral crepitations and a 20 × 20 cm back carbuncle.

Blood investigations revealed a white blood cell count of 31000/μl, a hemoglobin level of 11.5 g/dl, a lactate level of 5.92 mmol/L, and a pro-brain natriuretic peptide level of 731 pg/ml. Arterial blood gas in supplemental oxygen showed a pH level of 7.42, pCO<sub>2</sub> of 35.1 mmHg and pO<sub>2</sub> of 91.9 mmHg with a PaO<sub>2</sub>/FiO<sub>2</sub> ratio of 230. A chest X-ray (CXR) revealed bilateral diffuse pulmonary infiltrates.

After discussion, the anesthesia and the surgical teams concluded that the patient required saucerization of the carbuncle for sepsis control, and surgery could not be delayed till the COVID-19 swab results were revealed as the patient was acutely septic. Initially, our hospital conducted COVID-19 diagnostic tests only twice a day, and it would have taken another 6 hours to determine the results of this patient's swab test. Since his recent travel history, infective symptoms, and CXR made him a possible COVID-19 suspect, additional infection control precautions had to be taken.

Prior to the transfer, a team huddle was performed to ensure that all members were aware of the sequences and their roles in the transportation of the patient to the operating theatre (OT). The patient was transported on a plastic-covered trolley while receiving supplemental oxygen through a face mask (Fig. 1A). Signages were posted to specify the transportation route, and security personnel were deployed to divert human traffic during patient transfer. Upon entering the OT, the plastic cover on the trolley was removed and discarded into a biohazard bag.

An airway trolley was placed in the OT, and a C-Mac video la-

ryngoscope with disposable blade was chosen as the first-line airway equipment. Before the surgery was started, the anesthetist assembled all the drugs and equipment required for the procedure on a tray to minimize contact with the drug trolley during the surgery. Whenever additional drugs were required, hand cleansing and glove changing were performed before handling the drug trolley.

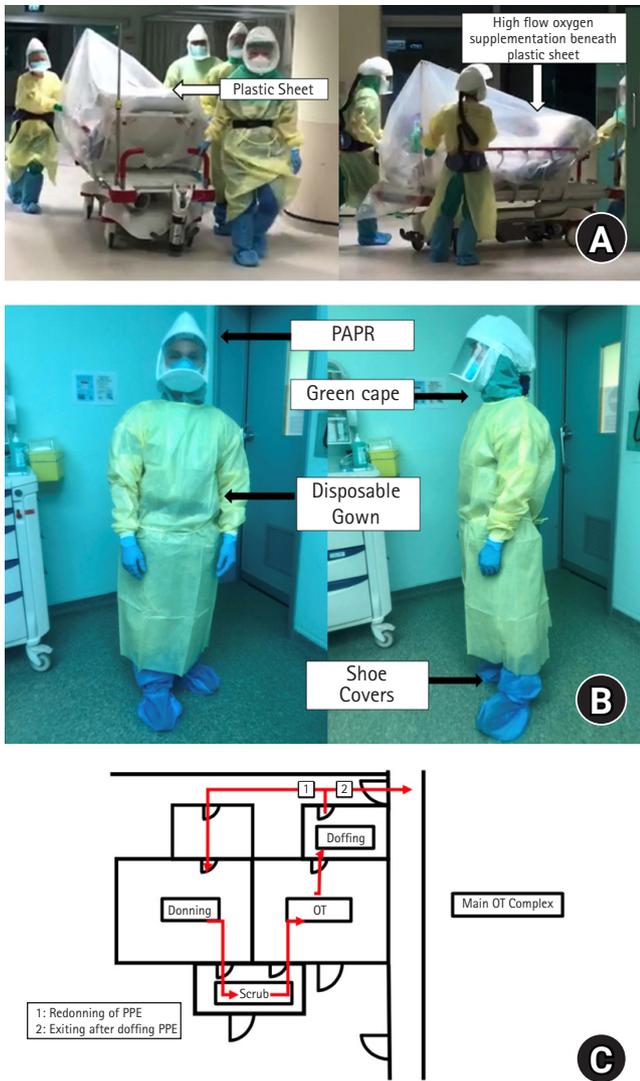
An adequate preoxygenation of 8 vital capacity over 1 minute, achieving an FiO<sub>2</sub> of 0.80, and modified rapid sequence induction was our preferred induction technique. Induction agents including 2–3 mg/kg of propofol, 1–2 mg/kg of succinylcholine, and 1–2 μg/kg fentanyl were administered, and mask ventilation was avoided. We ensured that sufficient muscle paralysis was achieved after loss of consciousness before intubation. Thereafter, the airway was secured by the most senior anesthetist using a video laryngoscope, as it was believed that this process had a higher probability of success in the first attempt. Moreover, it avoided repeated instrumentation of the airway. General anesthesia was maintained with desflurane, and mechanical ventilation with a tidal volume of 7 ml/kg was instituted as the patient's lung compliance and oxygenation were normal. As the patient was in respiratory distress on presentation, we decided to keep him intubated to avoid re-intubation.

Fortunately, the patient was tested negative for COVID-19.

## Discussion

During a global pandemic, the importance of minimizing nosocomial transmission cannot be overemphasized. Medical workers have accounted for 3.8% of the total number of COVID-19 cases in mainland China [8]. Anesthetists and other perioperative care providers are particularly at risk during airway management and other procedures performed on patients with COVID-19. Hence, it is crucial to design disease outbreak response measures in conjunction with the surgical, nursing, and allied health staff.

For confirmed or high suspicion cases, identified by the presence of symptoms with CXR changes, the minimum personal protective equipment (PPE) should be powered air-purifying respirator (PAPR). Personnel such as surgeons, anesthetists, and their assistants who are likely to be in contact with droplets, aerosol or bodily fluids, should wear an additional green cape to protect their neck and ears (Fig. 1B). For patients with low suspicion, i.e. asymptomatic but positive contact history, N95 respirators and face shields as well as disposable gowns, are necessary. Within the OT, the number of staff should be limited to a maximum of two senior anesthetists, two anesthesia unit nurses, two surgeons, and two scrub nurses.



**Fig. 1.** Equipment and facility considerations in the peri-operative management of COVID-19 patients. (A) Transport of patient in plastic covering. (B) Example of personal protective equipment. (C) The workflow of the operating theatre complex. PAPR: powered air-purifying respirator; OT: operating theatre; PPE: personal protective equipment.

Understanding the airflow within the OT is crucial in minimizing the risk of infection. As all our operating theatres were designed to only have a positive pressure, we designated an OT located at a separate bank that utilized a separate filter system from the rest of the OT complex. Access from the emergency department was possible via a dedicated route. The pressure in the scrub room was designed to be more positive than the OT and, the workflow was adapted to maintain human traffic in a single direction (Fig. 1C). For example, if a team member was to experience PAPR malfunction during the surgical procedure, he would go through Route 1 (Fig. 1C) to the doff and perform hand hygiene in the doffing room, before re-entering the donning room. Air ex-

change was increased from the default setting of 16–18 to a maximum of 20–23 air exchanges per hour.

Since COVID-19 can be spread by contact, surface cleansing of the anesthesia workplace is particularly important. In general, coronaviruses can survive on surfaces for up to nine days [9]; but, is susceptible to killing by 62–71% alcohol, 0.5% hydrogen peroxide, or 0.1% sodium hypochlorite [9]. However, routine cleaning of surfaces and interior storage areas of anesthesia machines and carts is very challenging [9,10]. Hence, plastic covers were placed over 'high touch surfaces' such as the anesthesia machine, patient monitor, computer keyboard, mouse, and touch screens, as these have been shown to reduce the bioburden [11]. In addition, the same OT and anesthesia machine have been designated for use for confirmed/suspected COVID-19 cases throughout the pandemic. Each anesthesia circuit is equipped with a high-efficiency particulate air filter. Both the heat and moisture exchanger filters and soda-lime will be changed after each case. The anesthesia machine, patient monitor surfaces, and patient cart were thoroughly cleaned after use. Equipment that had been dedicated to the isolation OT were labeled to avoid inadvertent exchange and cross-contamination.

As the procedure entailed the complete saucerization of a large hyperemic area, the use of diathermy was inevitable. However, the generator was maintained at the lowest necessary setting in order to reduce the amount of plume generated. In addition, the scrub nurse provided close and constant suctioning using a smoke evacuation device to minimize contamination of the OT air. Given the size of the carbuncle, saucerization was performed in quadrants, starting with a cruciate incision across the center of the affected area. As the infected tissue in each quadrant was excised, hemostasis was maintained, and the operative area was packed with gauze. This reduced the aerosolization of the blood in contact with the heated diathermy. Similarly, additional precautions were undertaken during laparoscopic procedures as a part of our institution's COVID-19 workflow; but did not pertain to this case of open surgery.

Aerosols produced during airway management are particularly hazardous to anesthesia providers [12,13]. A systematic review showed that compared to healthcare workers who did not perform aerosol-generating procedures, those who performed tracheal intubation were at a higher risk of contracting SARS (odds ratio: 6.6), as were those who performed non-invasive ventilation (odds ratio: 3.1), tracheotomy (odds ratio: 4.2), and manual ventilation before intubation (odds ratio: 2.8) [13]. In general, coughing and assisted mask ventilation can generate aerosols and hence, were avoided. A C-Mac video laryngoscope was chosen as it not only allows direct visualization like a direct laryngoscope but also

allows the assistant to visualize the airway and facilitate the procedure. Adjuncts like these are useful because visibility is known to be reduced with PPE, and they are crucial to achieve success in intubation in the first attempt since most patients are already in acute hypoxemic respiratory failure with minimal to no respiratory reserve [14]. In addition, such equipment also allows more distance between the operator and the patient's airway and reduces the risk of airborne transmission.

Since we anticipated further respiratory deterioration in the patient, he was kept intubated postoperatively to avoid the risks of re-intubation. The need for emergent intubation limits the time available for donning PPE and increases the likelihood of mistakes in the procedure in increased aerosol exposure. Patients who can be extubated are recovered in the OT till standard Post Anesthetic Discharge Scoring System discharge criteria are achieved. Subsequently, terminal cleaning of the OT is performed and then allowed to ventilate for at least an hour [15].

Since this was the first case experienced by the team, there were several challenges despite having well-designed protocols and processes. Hence, in our opinion all involved healthcare workers should attend briefings and simulations to familiarize themselves with the workflow and avoid inadvertent contamination.

Communication is difficult within PAPR, especially while using a telephone to communicate with people outside the OT. Thus, to circumvent the problem of handwriting misinterpretation, we instituted a 'write and write back' system, similar to the read-back system in a closed-loop communication. Hence, a writing board can be used to communicate with colleagues outside the OT to minimize contact and miscommunication.

In conclusion, organizing surgery for COVID-19 patients requires the involvement, and therefore potential exposure of various healthcare workers. Detailed planning and coordination between departments are required to minimize the risk of disease transmission. It is imperative for the containment measures to be effective yet practical, without hindering patient care, especially during a surgical emergency.

## Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

## Author Contributions

Jacklyn Jia Lin Yek (Conceptualization; Methodology; Writing – original draft; Writing – review & editing)

Anne Sheng Chuu Kiew (Writing – original draft; Writing – re-

view & editing)

James Chi-Yong Ngu (Conceptualization; Methodology; Supervision; Writing – original draft; Writing – review & editing)

Jimmy Guan Cheng Lim (Conceptualization; Project administration; Supervision; Writing – original draft; Writing – review & editing)

## ORCID

Jia Lin Jacklyn Yek, <https://orcid.org/0000-0001-9879-0669>

Sheng Chuu Anne Kiew, <https://orcid.org/0000-0002-0312-0767>

James Chi-Yong Ngu, <https://orcid.org/0000-0001-5233-457X>

Jimmy Guan Cheng Lim, <https://orcid.org/0000-0003-3496-0432>

## References

1. Luo M, Cao S, Wei L, Tang R, Hong S, Liu R, et al. Precautions for intubating patients with COVID-19. *Anesthesiology* 2020; 132: 1616-8.
2. Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. *Lancet* 2020; 395: 689-97.
3. Heesterbeek JA, Dietz K. The concept of  $R_0$  in epidemic theory. *Stat Neerl* 1996; 50: 89-110.
4. Peeri NC, Shrestha N, Rahman MS, Zaki R, Tan Z, Bibi S, et al. The SARS, MERS and novel coronavirus (COVID-19) epidemics, the newest and biggest global health threats: what lessons have we learned? *Int J Epidemiol* 2020; 49: 717-26.
5. Munster VJ, Koopmans M, van Doremalen N, van Riel D, de Wit E. A novel coronavirus emerging in China – key questions for impact assessment. *N Engl J Med* 2020; 382: 692-4.
6. Bröske-Hohlfeld I, Preissler G, Jauch KW, Pitz M, Nowak D, Peters A, et al. Surgical smoke and ultrafine particles. *J Occup Med Toxicol* 2008; 3: 31.
7. Englehardt RK, Nowak BM, Seger MV, Duperier FD. Contamination resulting from aerosolized fluid during laparoscopic surgery. *JSLs* 2014; 18: e2014.00361.
8. Wu Z, McGoogan JM. 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* 2020; 323: 1239-42.
9. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *J Hosp Infect* 2020; 104: 246-51.
10. Munoz-Price LS, Bowdle A, Johnston BL, Bearman G, Camins

- BC, Dellinger EP, et al. Infection prevention in the operating room anesthesia work area. *Infect Control Hosp Epidemiol* 2019; 40: 1-17.
11. Hunter S, Katz D, Goldberg A, Lin HM, Pasricha R, Benesh G, et al. Use of an anaesthesia workstation barrier device to decrease contamination in a simulated operating room. *Br J Anaesth* 2017; 118: 870-5.
  12. Judson SD, Munster VJ. Nosocomial transmission of emerging viruses via aerosol-generating medical procedures. *Viruses* 2019; 11: 940.
  13. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One* 2012; 7: e35797.
  14. Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med* 2020; 8: 475-81.
  15. European Centre for Disease Prevention and Control. Disinfection of environments in healthcare and non-healthcare settings potentially contaminated with SARS-CoV-2. ECDC technical report [Internet]. Stockholm: ECDC; 2020 Mar 26 [cited 2020 Apr 19]. Available from [https://www.ecdc.europa.eu/sites/default/files/documents/Environmental-persistence-of-SARS-CoV\\_2-virus-Options-for-cleaning2020-03-26\\_0.pdf](https://www.ecdc.europa.eu/sites/default/files/documents/Environmental-persistence-of-SARS-CoV_2-virus-Options-for-cleaning2020-03-26_0.pdf).