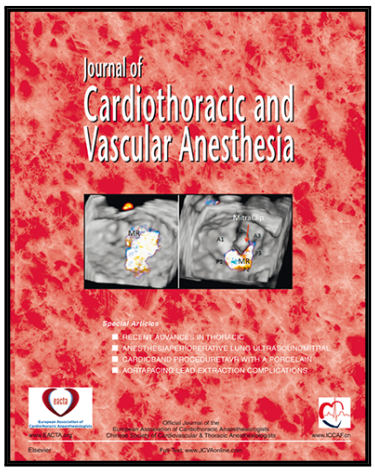
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.



Response and Operating Room Preparation for the COVID-19 Outbreak: A Perspective from the National Heart Centre Singapore

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PII: S1053-0770(20)30300-1
DOI: https://doi.org/10.1053/j.jvca.2020.03.050
Reference: YJCAN 5833

To appear in: *Journal of Cardiothoracic and Vascular Anesthesia*

Please cite this article as: Dr Zihui Tan , Dr Priscilla Hui Yi Phoon , Ling Antonia Zeng Dr , Fu Jing , Lim Xiao Ting , Teing Ee Tan Dr , Kenny Wei-Tsen Loh Dr , Goh Meng Huat Dr , Response and Operating Room Preparation for the COVID-19 Outbreak: A Perspective from the National Heart Centre Singapore, *Journal of Cardiothoracic and Vascular Anesthesia* (2020), doi: https://doi.org/10.1053/j.jvca.2020.03.050

Response and Operating Room Preparation for the COVID-19 Outbreak: A Perspective from the National Heart Centre Singapore

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There is no conflict of interest or funding received for the writing of this article.

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Abstract

The outbreak of COVID-19, a respiratory disease from a novel coronavirus that was first detected in Wuhan City, Hubei Province, China is now a public health emergency and fast approaching a pandemic. Singapore, as a major international transportation hub in Asia, is one of the worst hit countries of COVID-19. With the advent of local transmission of cases, we share our preparation and response planning for the operating room from the National Heart Centre Singapore, the largest cardiothoracic tertiary center in Singapore. Protection of staff and patients, environmental concerns as well as other logistic and equipment issues must be considered.

Introduction

A cluster of novel acute respiratory disease presenting with a broad clinical spectrum, now known to be caused by the coronavirus (SARS-CoV2), was first detected in Wuhan, Hubei Province, and reported to the World Health Organization (WHO) Country Office in China on December 31, 2019.[1–7] Current evidence suggests a zoonotic source of human transmission, likely arising from illegal wildlife trade in the Huanan Seafood Wholesale Market.[3,5] On February 11, 2020, the WHO renamed the disease coronavirus disease 2019 (COVID-19).[8] Since then, COVID-19 has spread rapidly from Wuhan to many other countries worldwide given the ease of both viral transmission and global air travel, prompting the lockdown of several cities in the Hubei province by Chinese authorities.[9] Despite the aggressive containment measures by China, the disease has now affected 168 countries with over 200,000 confirmed cases and a death toll exceeding 8000.[10] In light of the worsening global situation, the WHO declared the COVID-19 a pandemic on March 11, 2020.[11]

Singapore, being the main transportation hub and a popular tourist destination for mainland Chinese in South-East Asia[12], had the highest number of COVID-19 confirmed cases outside of China in the early stages of the outbreak.[13] The first imported case from China was reported on January 23, 2020[14] and the first locally transmitted case on February 4, 2020.[15] Within 2 weeks after the first case hit the shores, Singapore raised its Disease Outbreak Response System Condition (DORSCON) level to Orange, prompting additional precautionary measures nationwide.[16] The DORSCON framework was drafted after the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003 and serves as a guide for the

country's response to pandemics.[17] It was last declared Orange in the H1N1 outbreak in 2009.[18]

Unlike in the SARS outbreak where Tan Tock Seng Hospital (TTSH) was designated to manage all SARS-infected patients[19], all government and privately-owned hospitals in Singapore presently have their individual infectious disease units with isolation ward capabilities to manage highly infectious patients.[20,21] The National Heart Centre Singapore (NHCS) was opened in 2014 and is the largest adult cardiothoracic tertiary center in Singapore.[22] This article aims to outline the guidelines and modifications to operating room (OR) preparation for the management of COVID-19 suspected or confirmed patients coming for emergency cardiac surgery in NHCS.

National Heart Centre Singapore

The NHCS is located within the Outram campus of the Singapore General Hospital (SGH) and is connected to the main SGH building via a link bridge. It houses 6 operating rooms, of which 4 are dedicated to cardiothoracic surgeries. Since 2014, all elective cardiac surgeries have been performed within the NHCS operating complex and transported across the link bridge to the cardiothoracic intensive care unit (CTICU) in SGH post-operatively if intensive care is required. However, emergency surgeries done after-office hours are performed within the major operating complex in SGH.

When news of the COVID-19 outbreak surfaced in January 2020, hospitals in Singapore were immediately placed on high alert for suspected and confirmed cases. Elective surgeries were

reduced to allow for potential surges in admissions requiring hospital beds. General wards were cleared and designated as isolation wards. All non-urgent training, meetings, conferences and leave were cancelled. Visitor numbers were reduced and all visitors were required to be screened prior to entry.

Healthcare Workers

Personal Protection

The Infectious Disease and Occupational Health departments stepped up infection control measures and conducted N95 mask fitting sessions across all departments. Powered air-purifying respirator (PAPR) training was provided for healthcare workers (HCW) working in potential high-risk areas. Staff surveillance and temperature recording via the Ministry of Health (MOH) platform was required twice a day. Frequent OR simulations were conducted to allow members of the surgical team familiarize themselves with the use of PAPR and infection control workflow.

Staff Deployment

In line with the heightened alert, healthcare staff movement between the various healthcare institutions in Singapore was restricted. Measures were also taken to prevent OR cross contamination between HCW. This included dividing staff members into teams such that if one team was accidentally exposed to an undiagnosed COVID-19 patient, team members would be taken out of the elective roster until they were cleared. In addition, the Department of Perfusion also allocated dedicated personnel to manage both the intensive care unit (ICU) and OR separately. Besides providing services in NHCS, perfusionists also

support the Extracorporeal Membrane Oxygenation (ECMO) services in both SGH and the National Centre for Infectious Diseases (NCID). An ECMO support team, made up of 2 perfusionists, 1 cardiothoracic surgeon and an intensivist, is rostered to the NCID, while a second team will provide similar support for COVID-19 patients admitted to SGH.

OR Modifications

Once DORSCON Orange alert was activated, elective surgeries within NHCS were immediately reduced to 3 elective surgical lists from 4. All suspected or confirmed COVID-19 cases were assigned to be performed in a dedicated smaller operating complex located away from the main operating complex. The COVID-19 designated operating complex consists of 3 operating rooms located in the main SGH building but separated from the main operating complex to avoid patient and OR cross contamination. Each OR has its own separate humidity, laminar airflow and air conditioning systems.

Droplet precautions

The mode of transmission for SARS-CoV-2 appears to be droplet in nature and not airborne.[23] Hence, adherence to droplet precautions, proper environmental hygiene and sound infection control practices are indicated.[23] The Centre for Disease Control and Prevention (CDC) recommends that airborne infection isolation rooms (AIIR) be reserved only for patients undergoing aerosol-generating procedures.[23] These rooms are negative-pressure areas and are recommended for airborne infections as they prevent micro-organisms from escaping into hallways and corridors.[24] After the SARS outbreak in Hong Kong, the United Christian Hospital successfully converted 1 of their positive-pressure OR

into a negative-pressure OR for surgical patients with airborne infections.[25] Likewise in Singapore during the SARS outbreak, negative-pressure rooms were created by attaching exhaust fans with high efficiency particulate air (HEPA) filters to windows.

Currently, all COVID-19 confirmed patients in Singapore are admitted to negative-pressure isolation rooms in isolation wards. Ideally, all COVID-19 suspected or confirmed patients should be operated in a negative-pressure OR to reduce contamination of adjoining corridors or rooms. However, both the NHCS and SGH lack such a facility. To address this issue, OR doors must remain closed for at least 10 minutes after intubation or extubation for the HEPA filters to remove 99% of the particulate air matter since the OR air change rate is approximately 25 times per hour.[26]

As SARS-CoV-2 is spread by droplet transmission, it is important that coughing during intubation and extubation be reduced to a minimum so as to reduce contamination of near surfaces as the at-risk area is within 2 meters.[27] There should be minimal movement in and out of the OR whilst the operation is ongoing. If need be, the smallest door is used for entry or exit.

Equipment

The anesthetic work environment and its surfaces are at high risk for harboring droplets which can serve as virus reservoirs if proper decontamination processes are not taken. As such, the use of disposable equipment where possible is favored. The main anesthetic drug trolley is kept in the induction room outside the OR and anesthetists are encouraged to

bring the necessary drugs required in a sterile disposable tray into the OR prior to patient arrival. To circumvent problems associated with working in an unfamiliar environment, pre-packed intravenous and invasive line insertion sets were created. Ice packs used for surface cooling during deep hypothermic circulatory arrest were also changed to disposable ones. If a difficult airway is anticipated, the GlideScope® AVL video laryngoscope system (Verathon Medical Inc., Bothell, WA, USA) with its disposable blade is preferred over the C-MAC video laryngoscope (Karl Storz, Tutlingen, Germany) which we unfortunately did not purchase disposable blades for. The GlideScope also has a larger screen size compared to other brands of video laryngoscopes. This is of importance when vision and depth perception may be impaired with the use of eye goggles or PAPR.

As the COVID-19 designated operating complex is a distance away from both the operating complexes in SGH and NHCS, a work plan was drawn up detailing the required surgical, perfusion and anesthetic equipment as well as their locations to facilitate procurement during emergencies. Spare equipment was obtained and stored in the COVID-19 designated operating complex as much as possible to minimize delays and suboptimal use of manpower.

Simulation

A team of cardiothoracic anesthetists, surgeons, perfusionists and nurses carried out a simulation as per the workflow developed during SARS. In 2003, Room 3 within the COVID-19 designated operating complex was the designated SARS-OR. However, during the simulation, it was found that Room 3 could no longer accommodate the required

equipment necessary for cardiothoracic surgeries. The alternative suggestion was to use Room 1 which was more spacious (Figure 1). A second simulation was subsequently conducted.

All relevant equipment that may potentially be used during cardiac surgery was brought into Room 1. This included the cardiopulmonary bypass (CPB) machine, transesophageal echocardiography (TEE) machine, intra-aortic balloon pump (IABP), cerebral oximetry, Belmont® Rapid Infuser, autologous cell saver, defibrillator and a simplified drug trolley. A mock patient on an ICU bed with an IABP in-situ was transferred into the OR to ensure that there was adequate room for transfer onto the operating table, along with the surgical scrub nurses setting up and preparing their instrument trolley simultaneously.

All healthcare personnel took turns to perform their daily duties with N95 masks and PAPR on normal patients (Figure 2). This allowed us to identify potential problems, raise awareness and improve systems workflow. For example, the surgical team experienced difficulty in donning the PAPR over their headlights. Reflections from the face shield also affected their vision and depth perception. Issues with battery life were also brought to attention. It was found that having a mirror in the room helped with checking that protective gear was worn properly. In addition, communication between the anesthetic team wearing PAPR and the 'clean' runner stationed outside the OR was found to be hindered at times. Written communication via pen and paper was suggested as an alternative.

Due to unfamiliarity with the Isolation operating complex, planned doffing and undoffing areas for PAPR were demarcated and signposted (Figures 3 and 4). OR doors were also closed to ensure restricted HCW movement and avoid OR cross contamination. In addition, senior anesthesiologists were appointed as COVID-coordinators to help coordinate manpower and facilitate workflow while allowing the main anesthetic team to concentrate oon patient care. Potential routes from the isolation ICU to the OR were also discussed and finalized by the Division of Anesthesiology. Dedicated lifts for the use of COVID-19 suspected or confirmed patients have been assessed to be wide enough to accommodate a bed, equipment and accompanying HCW.

At the end of a COVID-19 suspected or confirmed case, all plastic covers over non-disposable equipment will be disposed of. Surfaces will be wiped down followed by terminal cleaning by environment service staff (ESS). This is performed using sodium hypochlorite 1000ppm followed by treatment with hydrogen peroxide vaporization (HPV) or ultraviolet radiation (UVC) where HPV is not feasible. All soiled instruments are to be placed in double orange biohazard bags, cable tied and transferred onto security trucks where staff members from the sterile supplies unit (SSU) will be activated for collection. All medical devices including PAPR will be wiped down with hospital-approved disinfectant wipes within the OR. Any unused consumables and drugs brought into the OR will be discarded. The turnaround time for OR decontamination is about 4 hours. All HCW involved in patient care will be recorded for contact tracing purposes and have to shower and change into clean attire before resuming regular duties. A summary of OR considerations can be found in Figure 5.

Patient Care

The Division of Anesthesiology in SGH formed clinical care, infection control and manpower allocation workgroups at the beginning of the COVID-19 outbreak to develop guidelines for the clinical management of suspected or confirmed patients.[20,28] Guidelines and updates on what constitute aerosol generating procedures were also regularly updated.

Discussion

The SARS outbreak infected 238 people and killed 33 in Singapore in 2003. Two in five of those infected were HCW.[29] At that time, hospitals were overwhelmed and resources such as N95 masks and gloves were scarce.[30] Have we learnt our lesson from the previous epidemic?

Since the SARS outbreak, hospitals in Singapore have beefed up their infection control standards as well as management capabilities. The NCID with its state-of-the-art technology opened its doors in September 2019 for this very purpose.[31] However, many of the current HCW have not personally been through the SARS outbreak as it had occurred more than a decade ago. The implementation of such measures on the ground has therefore been challenging for many of us. HCW across all departments have been sent to assist in the increased workload in the emergency department and isolation wards. Junior doctors are being excluded from operating in order to reduce patient contact. Surgeons have had to work with lesser assistants in the OR.

We have also heard and read of colleagues who have sacrificed their time and lives during the SARS outbreak. Airway manipulation during anesthesia and other aerosol generating

procedures like sternotomy and TEE insertions are all high-risk activities that we do on a daily basis. Although the calling to serve our community has never wavered, we want to provide the best level of care without compromising on personal safety.

Being a tertiary center for cardiothoracic referrals from other healthcare institutions has also posed unique challenges due to the potential risk of transferring an undiagnosed COVID-19 patient. This was a lesson learnt during SARS and in the early stages of the COVID-19 outbreak. Workflow and inter-hospital transfers need to be developed to reduce such risks. Currently, patients are only allowed to be transferred over to NHCS after consultation with an Infectious Disease specialist as well as the Heads of Departments of both Cardiology and Cardiothoracic Surgery.

The advent of social media and the internet has allowed information, both true and false, to spread quickly and easily. This can be seen as an advantage but may also result in confusion and panic when incorrect information is being disseminated. To combat fake news and maintain transparent risk communication, the SGH Senior Management has provided its staff daily updates regarding the current situation and introduced measures in line with MOH. The Division of Anesthesiology has also formed workgroups providing regular updates on infection control and care of patients with suspected and confirmed COVID-19 disease. Having such information at hand has provided a sense of calmness on the ground.

New plans are being made and updated as the situation unfolds with everybody on the ground adapting to new changes each day. People have stepped up when quarantine orders or leaves of absence were taken by their colleagues. Leave was cancelled voluntarily. Senior

colleagues were there to guide us along the way and their advice was crucial as they had first-hand experience of the SARS outbreak and were key to how rapidly workflows and guidelines were being implemented. Senior management personnel were also mindful that hospital services have expanded since SARS and that the cardiothoracic service required a larger operating space compared to before. It was to their credit that the change from Room 3 to Room 1 happened within 2 days of feedback. Personal goggles and thermometers were supplied on short notice after suggestions were made. Teamwork, good communication across all departments and willingness to listen are key components to maintaining good patient care even in times of crisis.

Thankfully, although COVID-19 seems extremely infectious, it does not seem to be as deadly compared to SARS at the moment. There have been no reported cases of local transmission from patients to HCW at the time of writing.

Although we have not performed surgery on any COVID-19 suspected or confirmed cases, we anticipate potential cases in the near future given the second wave of infections coming from returning travelers.[32] Through this article, we hope to be able to document some of the thought processes and difficulties that we went through and potentially help others that may find themselves in a similar situation.

Conclusion

In a difficult time, such as this COVID-19 outbreak, there is limited time for elaborate planning and training. Despite the uncertainty and fear when the disease first appeared, we

took on the challenges that were thrown at us one at a time. A clear direction from our leaders, confidence in our training, great teamwork and spirit without compromising on personal safety, played key roles to the rapid formulation of crisis plans and workflow.

Acknowledgement

We would like to thank all members of the SGH cardiothoracic anesthesia team, surgeons, nurses and perfusionists in NHCS for their ideas and suggestions, as well as our anesthetic technician, Johari Bin Katijo, for his excellent input and assistance.

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Figure 1.

Figure 2.

Figure 3.

Figure 4.

Figure 5: Summary of OR considerations for COVID-19 suspected or confirmed patients (PAPR: Powered air purifying respirator ESS: environment service staff)

Preoperative

- Check your PAPR in isolation OT
- Team brief (surgeon, anesthesiologist, nurse, perfusionist)
- Machine and equipment check including slave monitor for perfusionist
- Prepare drugs in advance as induction room is out of bounds once case has started
- COVID Co-ordinator to lead efforts

Intraoperative

- Full PAPR throughout
- All personnel to stay outside OR during intubation
- Ensure adequate paralysis, no cuff leak, low gas flows and airway management by the most experienced anesthesiologist
- 'Clean' nurse ready to obtain additional drugs or equipment outside OR
- At the end of the case, for transfer of intubated patients, ensure ETT is clamped and transport ventilator is switched off before disconnection from OR ventilator

Postoperative

- Handover to isolation ICU team
- Appropriate degowning of PAPR
- Activate ESS for terminal cleaning
- Contact tracing form
- Shower before resuming normal activities