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Learning experience on sentinel cases of COVID-19 at a public healthcare institution: sharing on operating room processes

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has rapidly evolved with more than 3 million cases and 232,000 deaths reported as of 1 May 2020.⁽¹⁾ As part of transmission containment and preservation of the health of frontline medical staff, every city and hospital has to implement and develop control measures within each operating complex for staff safety. Sengkang General Hospital (SKH) was commissioned on August 2018. It has a total of 1,400 beds, and serves a surrounding population of 900,000. To date, 600 acute beds, 13 operating rooms (OR), 15 intensive care unit (ICU) beds and 25 high dependency beds are in service. At full capacity, the hospital expects to function with almost 30 ORs, 80 high dependency beds and 40 ICU beds.

THE SARS EXPERIENCE

Many of the early measures implemented since the COVID-19 outbreak were derived from our experience with severe acute respiratory syndrome (SARS). For respiratory viruses, droplets and close-human contact are the main modes of transmission, with fomites and faecal-oral route also documented.^(2,3) In particular, aerosol-generating procedures may potentially transmit infections and can occur most commonly during tracheal intubation.^(4,5) When the SARS epidemic was reported, a high rate of transmission was noted among healthcare workers (HCW), ranging from 46% in Hong Kong to 63% in Hanoi, Vietnam.⁽⁶⁾ In Singapore, 41% of the 238 SARS patients were HCW and five eventually died from the disease.⁽⁷⁾ Among the HCW who contracted SARS were 13 doctors, including an intensivist, and two doctors died. The disease was only contained with strict adherence to infection control practices. In Singapore, two hospitals reported changes in their practices in the OR during SARS.^(3,8) Components included reorganisation and physical modification of the OR, improving infection control practices and staff training on personal protection. In one centre, 41 surgeries were

performed, of which 15 were tracheostomies (high-risk patients). Altogether, 124 HCW had direct contact with SARS patients with zero transmission within the OR complex.⁽³⁾

Singapore confirmed its first case of COVID-19 on 23 January 2020,⁽⁹⁾ and SKH confirmed its first case admission on 26 January 2020.⁽¹⁰⁾ In Singapore, local transmission was subsequently reported on 4 February 2020⁽¹¹⁾ and the Disease Outbreak Response System Condition (DORSCON) alert level was raised to Orange on 7 February 2020.⁽¹²⁾ This classification indicates that within Singapore, the disease spreads easily from person to person, but it is not widely spread and is being contained.⁽¹²⁾ As of 1 May 2020, SKH has managed 411 COVID-19 patients.

This article aims to describe the protocols and workflows in the setup of the OR for COVID-19 patients, as well as discuss the guidelines and staff preparation processes. These processes were validated after operations on COVID-19 positive cases were performed.

STAKEHOLDERS IN THE DECISION-MAKING PROCESS

The Division of Surgery and Hyperacute Care, including the service heads from general surgery, orthopaedics, urology, otolaryngology, anaesthesiology and operation theatre services, led by the Chairman of the Medical Board and Chief Executive Officer of the hospital, was involved in numerous discussions regarding the conceptualisation of the OR protocols. Their role was also to align the hospital's policy with the prevailing international guidelines and policies of the Ministry of Health.

Key considerations included ensuring that the OR protocols facilitate rapid responsiveness of the hospital to the disease outbreak, preserving the safety of healthcare staff and patients, and ensuring the availability of personal protective equipment (PPE).^(13,14) After a general over-arching protocol was disseminated, the various heads of subspecialties were encouraged to detail their subspecialty-specific protocols to suit their practice and patients.⁽¹⁵⁾

PRESSURE-CONTROLLED OPERATING ROOM

In general, a standard OR is equipped with laminar flow and designed to have positive pressure relative to the induction room. In SKH, there is a unique sterile core that is shared among 2–4 ORs, where the pressure is more positive relative to the OR. In the OR, there are usually at least 25–40 air exchanges per hour, which rapidly reduces any viral pathogens. For airborne diseases, a pressure-controlled OR is recommended to prevent dissemination of virus beyond the OR.⁽¹⁶⁻¹⁸⁾ This OR in SKH, known as Isolation OR 3.4 (ISO3.4), has lower differential negative atmospheric pressures relative to the outside of the OR. It is equipped with four low-level exhausts. In our design configuration (Fig. 1), there is a gentle gradient from the sterile core preparation room (35 Pa), sterile core ante room, OR (25 Pa) and induction room (≤ -2.5 Pa) to the scrub room (≤ -2.5 Pa). All doors leading to the OR have electronic locks that can be controlled from touch control panel within the OR. In our protocol, there is only one entry point via the scrub room and one exit via the induction room. The layout of the OR is shown in Fig. 2.

INSTITUTIONAL GUIDELINE FOR PERIOPERATIVE MANAGEMENT OF COVID-19 CASES

The COVID-19 pandemic is evolving, and patient screening guidelines and criteria will keep changing. To simplify decision-making, the workflow to determine the criteria for use of the ISO3.4 is shown in Fig. 3. Surgeries performed in the ISO3.4 include all positive COVID-19 cases, and emergency cases with symptoms that fulfilled the national Ministry of Health (MOH) criteria of suspected cases [MOH(+)] with swab results still pending. In the latter category, the emergencies could be urgent time-sensitive surgeries (e.g. limb salvage), or may involve very sick patients whose outcomes would be compromised if surgery is delayed till the swab test results are back. For cases that fulfil the criteria but the initial swab was negative, a repeat swab

is performed, and if confirmed to be negative, surgery will proceed in the routine emergency OR.

As local transmission had been proven in Singapore, all patients with pneumonia have to be managed with caution within the institution. For emergency cases that do not fulfil criteria [MOH(-)], a chest radiograph was mandatory. The presence of pneumonia requires two swabs to be negative before the routine emergency OR can be used. When in doubt, the surgical and anaesthetic team would consult the hospital infectious disease specialists.

All electively scheduled cases are contacted by the admission officers three days before their planned procedures. A checklist is used to screen patients for travel history and symptoms that are suggestive of COVID-19. Elective patients with flu-like symptoms are asked to postpone surgery. These patients may be further referred for review to our infectious disease specialists if they are MOH(+) by criteria.

SPECIFIC INTRA-OPERATIVE PROTOCOLS AND GUIDELINES

Preparation

- Based on the proposed workflow, a detailed team-brief is first conducted to discuss the procedure and to ensure surgical instruments, equipment for airway instrumentation and anaesthetic drugs are readily available. Only selected equipment and drugs should be brought into the OR to reduce the number of items requiring terminal cleaning. Disposable consumables are to be used as much as possible.^(19,20)
- The role of each member of the team is clearly identified.
- Pocket-size action guides are given to circulating nurses and anaesthetic nurses to apprise them of their delegated pre-, intra- and post-surgery duties. The guides include the contact numbers of emergency and essential services. Marker pens and paper on clipboards allow

short messages to be written and displayed through the OR visual panel where the runner outside the OR will be able to read.

- All staff are required to review and revise the donning and doffing of PPE and powered air-purifying respirator (PAPR) protocols.
- This is followed by a hands-on session for all staff. A trolley with step-by-step visual aids is designated for the donning of PPE (Fig. 4). Mirrors are installed on the walls to facilitate the adjustment and application of facemasks/protective eyewear. We also instilled a buddy system during the donning process for personnel to check on each other.

Transfer and Intra-operative management

- Once preparation work is completed, the OR team proceeds to call the ward or ICU where the patient is being cared for. A phone handover about the patient is done at this point. Patients are transported via designated routes to the OR. At the OR entrance, OR personnel (circulating and anaesthetic unit nurses) then transfer the patient directly to the ISO3.4 after confirmation of the patient's identity by hospital protocol
- After handing over the patient to OR personnel, the ward team doffs PPE at a dedicated area with biohazard waste bins and then performs hand hygiene.
- Airway instrumentation: The most experienced anaesthetist present is tasked to manage the airway to improve success rates during the first attempt at intubation.
- Air purification: After the airway is secured, we implement a lockdown of 5 minutes for air scrubbing to allow for adequate air exchanges within the OR to reduce any possible circulating viral load that has been aerosolised. Although the evidence for this practice is not widespread, we chose to lean on the side of caution (Box 1). This process is also done routinely for all patients in the OR complex even before the COVID-19 outbreak.

Box 1: Suggested intubation/extubation protocol for a normal operating room (non-ISO3.4).

1. Intubation to be performed only with anaesthetist, one surgical doctor and anaesthetic unit (AU) nurse present in the OR. (Note: surgeon to wear N95 if assisting in intubation)
2. All personnel in the OR during intubation should be with N95 and eye protection.
3. Surgical team complete 'Sign-in', then vacate OR; only anaesthetic team to remain in OR during intubation/aerosol-generating procedure.
4. Anaesthetist to announce "Clear OR, intubation now" to vacate personnel out of OR during intubation. No vendors allowed in OR till support is required.
5. For all non-laparoscopic surgeries: the surgical team must wait 5 min after intubation to allow clean scrub of air. (Note: The OR performs 25 cycles of air exchange per hour; 100% clean air will be circulated in OR within 2.5 min; the 5 min allowance will ensure 2 cycles of air exchange are performed). Operation to proceed with surgical masks.
6. Extubation to be done only with anaesthetist team in OR. Anaesthetist to announce "Clear OR, extubation now" to initiate extubation. The rest of the surgical team to vacate the OR.
7. Anaesthetist to announce "Extubation complete" after patient is full extubated. The rest of the surgical team to wait 5 min after extubation before entering OR.
8. For all elective and emergency laparoscopic surgeries: All staff in laparoscopic surgeries to be in N95 throughout the case and can remain in OR during intubation and extubation.
9. Doors (OR main door and scrub door) are locked at induction of anaesthesia and will remain so until 15 min after deflation of pneumoperitoneum; circulating nurse to start timer countdown for 15 min. Doors to remain closed until 15 min is up.
10. Upon **final deflation** of pneumoperitoneum, circulating nurse to start timer countdown for 15 min. Doors to remain closed until 15 min is up.
11. During extubation, staff in N95 can remain. OR doors to remain closed till 5 min after end of extubation.

- Runner (anaesthetic unit and scrub): A runner who holds on to the Voice over Internet Phone for communication with the OR team is stationed outside the OR if additional drugs, supplies and equipment are needed. Additional supplies are placed on a trolley that is left in the ante room for the OR team to retrieve. This is done similarly if there are any blood or pathology specimens (frozen section) to be brought out. All specimens are double-

bagged and placed in a leak-proof container. The runner dons full PPE with N95 mask when entering the ante room.

- To address the concerns of aerosolisation during laparoscopy, additional time has been allocated to the procedural time to account for the evacuation of the pneumoperitoneum. This allows a complete 20 minutes of air exchange upon completion of surgery and extubation.

Postoperative

- All personnel exiting the OR are to discard their used gowns and gloves in the induction room. Hand hygiene is performed before exiting the induction room. Doffing of the PAPR is performed outside the OR. PAPR masks are sent to the Central Sterile Supply Unit for thermal disinfection. The patient is allowed to recover and is monitored in the OR before being sent back to the ward. All documentations are performed electronically. Prior to patient's discharge from the OR, a phone handover is performed between the ward nurse and the OR nurse taking care of the patient.
- There is a minimum of one hour between cases to allow for transfer, and thorough decontamination of the entire OR, including all surfaces, cables, monitors, machines and tables. Unused items are all assumed to be contaminated and are discarded. Used instruments are placed in the closed cart system and transported via the central disposal lift linked directly to the Central Sterile Supply Unit decontamination zone.

FULL DRESS REHEARSAL

Full dress rehearsals (FDRs) are important for testing the workflow and to uncover any problems that are not apparent during planning,^(21,22) including coordination issues,

environment limitations, communication difficulties and whether OR staff are adequately supported.

After the abovementioned OR protocols were conceptualised, two FDRs were first conducted with the elective procedures. All surgeons, anaesthesiologists, surgical and anaesthesia registrars and medical officers, and OR nursing staff familiarised themselves with the ISO3.4 setup. Subsequently, further FDRs were performed by various specialties in the ISO3.4. In particular, the ear, nose and throat (ENT) specialists performed the early FDRs in the initial phase in preparation for a possible need for tracheostomy procedures. Separate FDRs were performed in the endoscopy centre, which also had a negative pressure endoscopy suite. These FDRs enabled all general surgeons and gastroenterologists to be familiar with the workflows, in view of the possibility of aerosolisation during endoscopic procedures.⁽²³⁾

Through the FDRs, we were able to fine-tune processes, including identification of the important points that were protocolised. One critical identified area was the importance of having a buddy system for the donning and doffing of PPE to ensure that all steps are executed correctly.

APPLICATION OF PROTOCOL IN ACTUAL COVID-19 PATIENTS

On 18 April 2020, SKH performed the first laparoscopic appendicectomy for a COVID-19 positive patient with acute appendicitis with an appendicolith at its base.⁽²⁴⁾ On 29 April 2020, SKH performed an incision and drainage of a perianal abscess in another COVID-19 positive patient. These two cases provided further opportunities for evaluation of the OR processes. Feedback from the surgical and anaesthesiology team was good. Staff were confident of the processes, as they were easy to follow with the provided visual aids and buddy-system cross checking. Both patients recovered well from surgery, and both the surgical teams of nurses and doctors remained healthy. Till date, three more operations have been performed for COVID-

19 infected patients (one laparoscopic cholecystectomy,⁽²⁵⁾ one urological procedure and one orthopaedic procedure).

DISCUSSION

The COVID-19 pandemic is an unprecedented crisis that requires definitive containment measures. Our experience with SARS has left indelible memories of infected HCW and demised colleagues. The lessons learnt have allowed for incorporation into current practices, which we have now enhanced and utilised. While it is ideal to perform surgeries or procedures in negative pressure ORs, there are likely multiple limitations in many hospitals worldwide that have only positive pressure ORs. We have been fortunate that the newly built hospitals in Singapore have purpose-built negative pressure ORs and isolation PACU rooms. However, the older hospitals in Singapore, which are currently undergoing renovation, have retained such limitations. To mitigate this, alternate OR complexes that are separate from the main OR can be identified for COVID-19 patients, thus avoiding contamination of other ORs.⁽¹⁸⁾ Temporary set up of a negative pressure OR could also be performed by modifying two connected ORs with an adequate pressure gradient (≥ 2.5 Pa), as suggested by the US Centers for Disease Control and Prevention guidelines.⁽²⁶⁾ This experience was reported by a South Korean tertiary hospital, which successfully performed six procedures for MERS patients, with zero perioperative transmission.⁽²⁷⁾

One important consideration in our planning is to ensure adequate PPE. PPE is especially vital for all our healthcare workers, as patients without contact history may be asymptomatic carriers of the virus in areas with community transmission. Besides N95 respirators, eye protection is important in all potential aerosol-generating procedures due to the risk of conjunctival inoculation.⁽²⁸⁾ In our hospital, mask fitting and refresher of PPE, as well as the use, maintenance, donning and doffing of the PAPR were conducted by staff from

Infection Control. In our institution, all HCW were mask fitted with the PAPR CleanSpace® HALO™ (CleanSpace Technology Pty Ltd, Artarmon, NSW, Australia). For those who failed N95 fit testing, PAPR CleanSpace® was used instead. This PAPR with face-pieces has a higher Assigned Protection Factor (workplace level respiratory protection) of 50 compared to hooded PAPR with loose-fitted PAPR, which has an Assigned Protection Factor of 25.⁽²⁹⁾ Staff compliance to proper use of the PAPR is perhaps one of the most important factors to allow for re-use of limited mask resources, and thus prevents cross-infections. We also suggested that besides FDRs and adequate instructional charts, a buddy system is necessary, especially for unfamiliar staff, to observe and provide reminders to avoid touching face and mucosal surfaces during doffing. We have found this system especially useful to avoid errors.

The use of PAPR has its limitations. We have observed that communication is often difficult because of the ambient noise from the powered motor, and it also requires the user to exert effort to be heard. Similar to N95 respirators, the tight fit of the PAPR CleanSpace® mask can result in pressure indentations on the face and discomfort. Furthermore, the goggles provided by the institution limits peripheral vision and staff have to modify actions to accommodate this tunnel vision. Some staff may also experience claustrophobia. Fatigue levels could set in quickly and, as such, procedures should be done by the most experienced clinician for speed, efficiency, and avoidance of mistakes due to fatigue.

CONCLUSION

In this pandemic of untold proportions, preparing every hospital to manage potential COVID-19 patients in the OR is critical. Infrastructure modification and familiarisation, infection prevention strategies, clinical recommendations, as well as training of staff in workflows and proper utility of PPE and PAPR, have to commence quickly. These measures are important to reduce the risk of viral transmission to our HCW and other patients.

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FIGURES



Fig. 1 Photographs show the ante room, scrub room and induction room (from left to right).

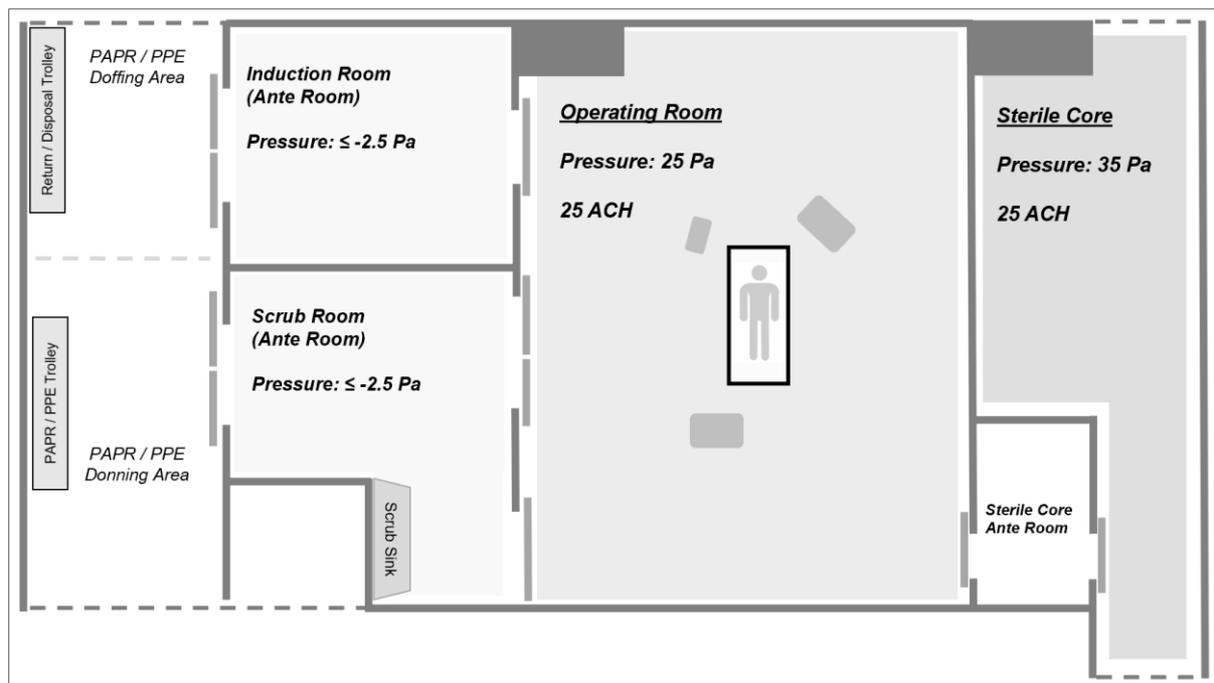


Fig. 2 Floor plan of the pressure-controlled operating room. *PAPR: powered air-purifying respirator; PPE: personal protective equipment*

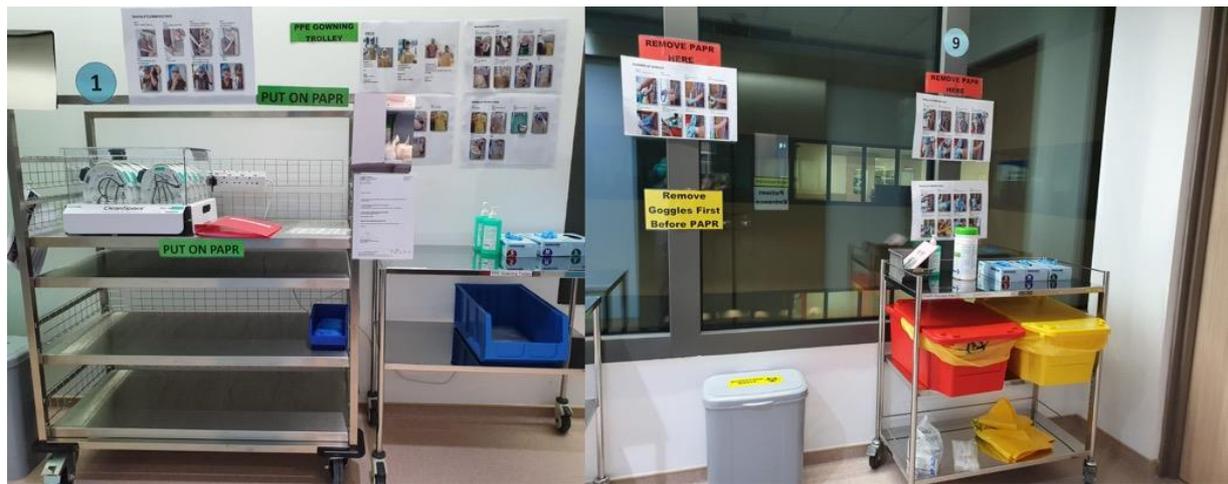


Fig. 4 Photograph shows the donning and doffing stations with visual aids and mirrors.