Operational Strategies to Prevent COVID-19 spread in Radiology: Experience from a Singapore Radiology Department after SARS

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PII: S1546-1440(20)30306-9
DOI: https://doi.org/10.1016/j.jacr.2020.03.027
Reference: JACR 5155

To appear in: Journal of the American College of Radiology

Received Date: 11 March 2020
Revised Date: 23 March 2020
Accepted Date: 25 March 2020

Please cite this article as: Goh Y, Chua W, Lee JKT, Leng Ang BW, Liang CR, Tan CA, Wen Choong DA, Hoon HX, Leong Ong MK, Quek ST, Operational Strategies to Prevent COVID-19 spread in Radiology: Experience from a Singapore Radiology Department after SARS, Journal of the American College of Radiology (2020), doi: https://doi.org/10.1016/j.jacr.2020.03.027.

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(1) Substantially contributed to the conception or design of the work.
(2) Writing and/or revision of the manuscript, and
(3) Approved the final version of the manuscript
(4) Be accountable for the manuscript's contents

Source of Support: NIL

Statement of Data Integrity: The author(s) declare(s) that they had full access to all of the data in this study and the author(s) take(s) complete responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of Interest: The authors declare no conflict of interest

Acknowledgments: NIL
SUMMARY STATEMENT

Harnessing on experience and lessons from SARS outbreak in Singapore in 2003, the authors would like to share operational guidelines and strategies implemented in our practice to reduce the risk of COVID-19 transmission and mitigate the impact of possible intra-department staff transmission.
ABSTRACT

As COVID-19 infection spreads globally, the demand for chest imaging will inevitably rise with an accompanying increase in risk of disease transmission to frontline radiology staff. Radiology departments should implement strict infection control measures and robust operational plans to minimise disease transmission and mitigate potential impact of possible staff infection. In this article, the authors share several operational guidelines and strategies implemented in our practice to reduce spread of COVID-19 while maintaining clinical and educational needs of a teaching hospital.

SUMMARY STATEMENT

Harnessing on experience and lessons from SARS outbreak in Singapore in 2003, the authors would like to share operational guidelines and strategies implemented in our practice to reduce the risk of COVID-19 transmission and mitigate the impact of possible intra-department staff transmission.

TAKE HOME POINTS

• Radiology departments should ensure adequate portable imaging capabilities, manpower demands and personal protective equipment (PPE) stock in this time of outbreak.

• Strict infection control practices, heightened levels of hygiene and rigorous cleaning are essential in reducing spread of COVID-19.

• Physical and temporal staff segregations with deliberate limitation of staff-to-staff interactions play a role in reducing disease spread while maintaining hospital services.

KEY WORDS

COVID-19, Operational Strategies, Radiology
The novel coronavirus (COVID-19) outbreak was declared a Public Health Emergency of International Concern by the World Health Organization (WHO) on 30 January 2020 [1]. As of 22 Mar 2020, there were 306,893 reported cases worldwide with 13,026 deaths. COVID-19 spreads mainly via respiratory droplets and contact transmission [2, 3], resulting in varying degrees of lower respiratory tract symptoms. Radiology hence plays a key role in the management of COVID-19 infection with the use of chest X-ray (CXR) and Computed Tomography (CT) [4] in screening, diagnosis and prognostication of disease [2, 3, 5-7].

As a new condition, a number of papers have been recently published [2-7] to familiarize radiologists with its imaging appearance but few have dealt with the more practical operational challenges faced [8-11]. With an anticipated worldwide increase in COVID-19 cases, the demand for chest imaging will inevitably rise with an accompanying increase in exposure and risk of disease transmission to frontline radiology staff. Harnessing on our experience and lessons from SARS (Severe Acute Respiratory Syndrome) outbreak in Singapore in 2003, the authors would like to share the operational guidelines and strategies implemented in our practice to reduce the risk of COVID-19 transmission (i.e. patient-to-patient, patient-to-staff) and to mitigate the impact of possible intra-department staff transmission. While these strategies may not be directly applicable to all institutions due to inherent social, cultural, geographical and economic differences, the authors believe the underlying principles and rationale of implemented strategies remain relevant and can be adopted or modified by other institutions for their practice in dealing with the current COVID-19 outbreak.

Broadly, the strategies can be divided into the following categories:

1. Equipment and manpower
2. Strict infection control practices
3. Team segregation
4. Limitation of staff interaction

STRATEGY #1 – Equipment and Manpower Readiness

Equipment: Portable CXR Machines and Dedicated CT Scanners

The demand for portable CXRs will rise tremendously. Our department experienced a 3-fold increase in portable CXR numbers from the emergency department (EMD) alone with at least 100 portable CXRs performed daily since the start of the outbreak. As such, our department has allocated half of the available portable x-ray machines to EMD to cope with the outbreak.

Similar to the SARS outbreak in 2003, hospital EMDs have set up outdoor extensions or tents (i.e. colloquially termed “fever facility”) with portable digital radiography services to effectively triage patients. The immediate priority is to identify case suspects (i.e. patients with symptoms concerning for COVID19 +/- relevant contact or travel history which are updated daily by local health authorities according to global situation) and manage them separately from low-risk patients to minimize disease transmission. A sample layout of the “fever facility” is shown in Figure 1.

For patients who require imaging depending on protocol or physician’s discretion, portable CXRs are performed in these “fever facilities” to minimize patient transportation and risk of disease spread. In addition, dedicated portable x-ray machines with a separate set of cassettes are allocated for case suspects in isolation areas to reduce cross-contamination with other low-risk patients. Some other hospitals in Singapore had to pre-emptively rent additional portable x-ray units to handle the increased demand [8]. Hence, radiology departments should consider and assess the adequacy of existing portable facilities during this period.

For patients who require CT scans, portable CT scanners can be a potential solution but many institutions could face economic and logistical challenges (i.e. space constraint) during implementation. As an alternative, our department designated a dedicated CT scanner with shortest distance to isolation wards for case suspects to prevent contamination to other CT scanners.
**Manpower**

We also experienced an increase in manpower demand due to a number of factors including: (1) Increased workload in certain modalities (e.g. portable CXRs) with necessary quick turn-around-times, (2) Increased time required to perform procedures for case suspects due to additional precautions required and (3) Limitation of staff cross-coverage due to team segregation strategies (see strategy #3 below).

Radiology departments should ensure manpower adequacy during this period as the situation may potentially worsen and manpower resources could also deplete exponentially if staff infection and quarantine occurs. As such, in Singapore, we have frozen non-essential overseas leave and conference leave for public healthcare workers [8] with financial reimbursements for leave cancellations. Local leave is still granted as staff can be recalled to work quickly if unforeseen circumstances arise.

**Personal Protective Equipment (PPE)**

There is a huge demand for PPE world-wide. Fortunately, we have learnt to stockpile PPE on a national and hospital level from the SARS experience to ensure adequate supply for our frontline staff. This is in line with the pandemic response plan published in 2004 by Singapore Ministry of Health [12], which advised institutes to maintain a 3-6 month stockpile of PPE. Mask-fitting exercises have also been carried out on a regular (~3 yearly) basis to keep staff updated on their mask sizes.

Within the department, equipment is distributed to staff daily at designated sites to ensure accountability and sustainability of PPE stock. Frontline staff (e.g. radiographers) are also updated on the latest policies, via emails or e-learning hospital intranet modules, on handling droplet and contact precaution patients with instructions on the proper donning, use and removal of PPE.

**STRATEGY #2 – Strict Infection Control**

**Strict Adherence to PPE guidelines**
All staff are required to wear surgical masks when on clinical duty. The use of PPE with fluid-resistant characteristics, disposable gloves with coverage over gown cuff, eye protection (including face shields or goggles) and fit-tested N95 or higher face mask is mandatory when handling suspected or confirmed COVID-19 patients [13]. Our department also advocates the double glove practice with the outermost layer of gloves changed between every patient. The inner layer of gloves are not removed when cleaning surfaces that had patient contact to minimize the risk of contact transmission [14].

CT and MRI Scan Protocols for High-Risk Patients

The following guidelines were implemented in our institute to reduce the risk of cross contamination for non-portable modalities, such as CT or MRI. Non-urgent scan requests were postponed until the confirmation of COVID-19 diagnosis. If a scan is deemed urgent, it is scheduled as the last case of the morning or afternoon session on a dedicated scanner, to minimize disease transmission between patients and to allow abundant time for cleaning and airing of room before the next scan. A specific route of transportation is used between the isolation wards and the imaging department. Hospital security is engaged to clear human traffic along this route to minimize exposure or transmission between the patient and the public/staff.

Upon arrival at the scan room, the patient is attended to by two separate radiographers. The radiographer who has direct contact with the patient is designated the “dirty” radiographer; (“dirty” being the colloquial term for “high risk for potential contamination and/or exposure to COVID-19). The “dirty” radiographer performs hand hygiene and dons full PPE with double gloves, and is responsible for (1) positioning patient for scan, (2) moving patient off scanner and (3) cleaning of equipment after scan completion. The “clean” radiographer remains stationed in the scan room to operate the scanner. The separation of clean, dirty (or potentially contaminated) and changing areas are illustrated in Figure 2.

Heightened levels of Hygiene and Cleaning
There had been constant efforts to improve hygiene awareness ever since the SARS outbreak in 2003. For example, departments are regularly assessed on hand hygiene standards by an infection control team and results are used for department appraisals. The COVID-19 outbreak only served to heighten hygiene standards all-round. In addition, temperature monitoring of staff has been instituted. Thermometers were issued to staff so they can record their temperature readings daily. Staff who feel unwell are also advised against coming to work.

Rigorous measures have also been taken to clean and disinfect radiology equipment. Single use disposable plastic sheets are used for lining of CT scan couches for case suspects. After disposal, the surfaces are wiped down with Isopropyl Alcohol 70%. Terminal cleaning of the scan room by housekeeping staff is also carried out by using diluted bleach solution (6mg Chlorine releasing disinfectant tablet to 1000ml of water) to wipe down the machine, walls and floor. As we do not have negative air pressure room for our CT scanner, the scan room is aired for at least 30 minutes to allow the cleaned surfaces to dry adequately before proceeding to scan another patient.

For portable x-ray machines, deep cleaning is performed twice a day using diluted bleach solution to wipe down the machine exteriorly. For parts of the machine that are delicate (e.g. collimators, control console, exposure buttons etc.), Isopropyl Alcohol 70% rather than bleach is used for cleaning after every patient. For detailed guidelines on equipment disinfection, staff should seek advice from their specific equipment vendors.

**STRATEGY #3 - Team Segregation (Physical and Temporal)**

Gaining experience from SARS outbreak in 2003, local radiology departments have adopted team segregation strategies to (1) reduce risk of human-to-human transmission with team quarantine in the event of staff infection while (2) maintaining the capabilities to meet the hospital needs [8]. The department is hence split into independent teams, each comprising of selected individuals with different skillsets (i.e. radiologists, radiographers, nurses etc.) to serve the daily hospital needs. In our institution, we adopted a combination of temporal and physical segregation strategies.
Temporal Segregation

The rationale behind temporal segregation is due to the inherent incubation period of COVID-19. Asymptomatic infected staff may be a potential source of human-to-human transmission at work [15]. With reported potential incubation periods of up to 2 weeks [16] for COVID-19, trial runs of split teams in temporal “2+2” format have been suggested by the Chinese Society of Imaging Technology in an expert consensus article [9]. In this “2+2” format, staff who are at high-risk (e.g. frontline radiographers, sonographers, interventional radiologists etc.) are split into 2 groups. The first group works 2 weeks consecutively while the second group rests and ‘self-quarantines’ at home. A swap-over happens at the end of the 2-week period.

However, this “2+2” format faces many potential challenges in our experience. Firstly, not all radiology departments can afford for many of its staff to be self-quarantined during this period of high manpower demand. Secondly, working in a high-risk environment and being constantly gowned in PPE for 14 days consecutively can be physically and mentally exhausting for staff. As the outbreak prolongs, this arrangement may not be sustainable or ideal for team morale and efficiency.

As such, we decided to adopt a more sustainable “1+1” variation, given that most symptoms show up within the first 6.4 days (95% CI: 5.6 – 7.7 days) of infection [16]. In addition, staff are rotated to ‘low-risk’ areas instead of home quarantine after their shift in the ‘high-risk’ zones to minimize impact on manpower. An example of this would be for an interventional radiologist to go on a 1-week shift of reporting diagnostic imaging studies with no patient contact, following a 1-week shift of performing interventional procedures with patient contact. Implementation of temporal strategies is cumbersome from the rota planning perspective, but would be critically important if staff transmission truly occurs.

Physical Segregation
On a national level, physical segregation involves prohibiting staff from working in different hospitals except in critical subspecialties with limited expertise (e.g. neurointervention). Staff are now restricted to working in a single defined hospital to reduce the risk of inter-hospital virus transmission. The same principle applies to radiology resident rotations between hospitals. Adjustments to the residents’ training have been made to allow them to continue at their respective hospitals. These strategies are not expected to cause major issues due to the vast improvements in technology since SARS outbreak in 2003. For example, radiologists can now report scans remotely from other locations with the use of electronic medical records, radiology information systems (RIS), and picture archiving and communication system (PACS).

Within the radiology department, further physical segregation can be performed. Unlike radiographers and nurses who have to be on-site, radiologists can potentially report from home via teleradiology. However, this may not be feasible for many centres to perform on a large scale due to inherent differences in technical and economic support. In Singapore, healthcare institutions face a unique situation of “internet separation”. The option of teleradiology is non-feasible locally as the Singapore Government has terminated direct access to the internet from the hospital’s internal systems due to previous cyber-attacks [17]. Hence, our department has implemented physical segregation by dividing reporting areas into “dirty” (i.e. high risk) and “clean” (i.e. low risk) areas. Reporting rooms which are close to areas with high patient flow and contact (e.g. ultrasound, fluoroscopy, inpatient CT scanners) are classified as “dirty”, with the remaining rooms classified as “clean”. Radiologists reporting in the “dirty” rooms would be isolated within the rooms during working hours, with no interaction with colleagues in the “clean” rooms. This is achievable in part due to Singapore’s experience with SARS, where we have learnt to segregate outpatient and inpatient areas by building separate out- and in-patient wings in the same hospital to minimise cross contamination. Hence, the department is distributed over several satellite reporting areas, rather than a single ‘central’ reporting area. By adopting these
strategies, the extent of team/group quarantine could be further minimized in the event of staff infection. It is also easier to take necessary actions including disinfection of workplace and equipment that had contact with the identified staff.

Potential challenges could arise in radiology departments with unique architecture layout where inhibition of human traffic may impair workflow patterns. To overcome these issues, departments can consider the use of technology in the form of hospital endorsed online meeting platforms to disseminate information. One example would be to alert radiology staff on the location and timing of radiology scans for confirmed or suspected cases of COVID-19 in the department.

**Combination Strategies**

Implementation of both temporal and physical segregation policies may seem excessive. However, departments can adopt variations of the temporal and/or physical segregation strategies to best suit their needs. Ultimately, the segregation strategy implemented aims to achieve a balance between (1) meeting clinical demands, (2) maintaining team spirit/morale, (3) reducing extent of disease spread should it occur while (4) not compromising the safety of patients and staff.

**STRATEGY #4 – Limitation of staff interactions**

**Staff-to-Staff Interactions**

While physical segregation of radiology staff serves to limit intra-department staff interactions, additional steps can be implemented to limit inter-departmental staff interactions. These inter-departmental interactions may be unscheduled interactions, such as doctors coming to the department for urgent scans request and/or discussion, or scheduled interactions such as multidisciplinary meetings. These inter-departmental interactions increase the risk of disease transmission and hence should be limited.

Our department has now restricted access of doctors from other departments, apart from urgent reasons such as accompanying unstable patients for imaging studies or procedures. Face-to-face
scan requests or discussions are now replaced by phone discussion or text messages through a secured network. Scheduled interactions, such as multi-disciplinary meetings, are performed through third party video-conferencing applications (e.g. Zoom) to facilitate complex patient care discussions, while maintaining physical segregation.

On a social level, lunch meetings or after office hours social gatherings between colleagues are discouraged during this period, as is attendance at professional conferences and seminars. This is to minimise congregation of healthcare workers from different institutions or different countries.

Staff-to-Student/Resident/Fellow Interactions

Our radiology department is heavily involved in undergraduate and post-graduate radiology education for domestic and international students and radiologists. With the COVID-19 outbreak, medical students have been barred from hospitals to minimize staff-to-student and student-to-patient interactions.

To continue delivery of radiology education, large group lectures have been converted to online modules with either a pre-recorded voice-over or a real-time online teaching session, whereby students can dial-in to participate in a live Q&A session. To supplement online lectures, materials have also been uploaded for students to review. In addition, our overseas medical student elective program has been put on hold due to the current worldwide outbreak.

The training of residents and overseas fellows have been similarly affected. All large group teachings/lectures and small group sessions are also conducted online. Trainees might face difficulties in their education during this period of uncertainty. Hence, the department should emphasize open channel communication, should residents or fellows require any assistance.

CONCLUSION
The COVID-19 outbreak has created chaos and disrupted many routines globally. Radiology being one of the important assessment tools is similarly affected. While some issues may be unique to individual departments, the majority of challenges faced by Radiology departments globally are similar. By sharing our experience, it is our hope that worldwide institutions may benefit from the practical experiences and strategies implemented in our department.

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**FIGURE LEGENDS**

Figure 1: Schematic of the fever facility set up with a digital radiography portable x-ray system.

Figure 2: Separation of clean and dirty areas for CT scan. Scan protocol to be performed by 2 radiographers. The “dirty” radiographer dons on full PPE at the Donning Area before entering CT Room. After positioning and preparation of the patient for the scan, the “dirty” radiographer then exits the scan room to a dedicated waiting area without removing the PPE (Waiting Area) while the “clean” radiographer remains stationed in the CT Control Room to complete the CT study. Upon scan completion, the “dirty” radiographer re-enters the scan room and assists in moving the patient off the scanner. The “dirty” radiographer would then remove the outer gloves and begins cleaning the equipment including the power injector. The “dirty” radiographer then removes the PPE in a dedicated changing area (Doffing area) and performs hand hygiene prior to exiting the scan room.
TAKE HOME POINTS

- Radiology departments should ensure adequate portable imaging capabilities, manpower demands and personal protective equipment (PPE) stock in this time of outbreak.
- Strict infection control practices, heightened levels of hygiene and rigorous cleaning are essential in reducing spread of COVID-19.
- Physical and temporal staff segregations with deliberate limitation of staff-to-staff interactions play a role in reducing disease spread while maintaining hospital services.