

Déjà Vu or Jamais Vu? How the Severe Acute Respiratory Syndrome Experience Influenced a Singapore Radiology Department's Response to the Coronavirus Disease (COVID-19) Epidemic

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OBJECTIVE. This article shares the ground operational perspective of how a tertiary hospital radiology department in Singapore is responding to the coronavirus disease (COVID-19) epidemic. This same department was also deeply impacted by the severe acute respiratory syndrome (SARS) outbreak in 2003.

CONCLUSION. Though similar to SARS, the COVID-19 outbreak has several differences. We share how lessons from 2003 are applied and modified in our ongoing operational response to this evolving novel pathogen.

The severe acute respiratory syndrome (SARS) epidemic of 2003 affected more than 8000 people in 26 countries [1]. SARS appeared in Guangdong Province, China, in November 2002, and the first SARS cases emerged in Singapore in February 2003. Over the next 3 months, there were 238 SARS cases in Singapore, resulting in 33 deaths [2]. Health care workers accounted for 40.8% of cases (including three radiographers) and five deaths, indicating transmission in the health care environment. The SARS outbreak left a deep impression when our radiology department was a site of cross infection that affected patients, accompanying persons, and one health care staff member (who subsequently died of SARS). After extensive efforts, Singapore was declared SARS-free on May 31, 2003 [3, 4].

Although radiology is not typically viewed as a frontline clinical service, our experience with SARS revealed a different perspective. Timely radiologic results were needed to identify cases. Portable imaging was extensively used, directly exposing radiology staff to the pathogen. Furthermore, radiology departments are places in which different patients (inpatient, outpatient, febrile, nonfebrile), accompanying persons, visitors, and health care workers from other departments potentially mix. Hence, any breach in infection prevention and control mechanisms in the radiology department has far-reaching consequences.

During the SARS epidemic, our department underwent substantial changes [5, 6].

These changes included segregation of work-flows for inpatients, outpatients, and febrile and nonfebrile cases, over and above usual protocols for patients on isolation precautions for more common pathogens. Resources were diverted to cope with a surge in portable imaging requests (radiography and ultrasound). Enhanced infection prevention and control measures became pervasive. Everyone knew their N95 mask type and became proficient with using personal protective equipment (PPE). Hand sanitizers and disinfectant wipes became commonplace across the department. To this day, radiology SARS veterans will disinfect their workstations before starting work, much to the amusement of their younger colleagues.

When news of the coronavirus disease (COVID-19) emerged from Wuhan, China, in December 2019, there were concerns that this could be the next SARS-like outbreak [7, 8]. Recent novel pathogens such as the Middle East respiratory syndrome (MERS) in 2012 never reached the scale of a progressive global outbreak [9]. By January 2020, the situation rapidly evolved, and it was clear that COVID-19 was different.

The timing of the COVID-19 outbreak, just before Chinese New Year, was a double-edged sword. On the downside, it coincided with extensive travel and gathering of large groups of people, which aided disease transmission. On the upside, it resulted in a 3-day-long public holiday in Singapore that decreased patient load in hospitals. This gave us additional time to prepare before normal workload resumed.

The World Health Organization (WHO) declared COVID-19 a Public Health Emergency of International Concern on January 30, 2020. As of February 16, 2020, WHO reported a total of 51,857 confirmed cases and 1669 deaths in 26 countries, with most of the cases (51,174 confirmed) and almost all deaths from mainland China [10].

As our hospital went into disease-outbreak response mode, our radiology department also implemented measures to prevent and control possible spread in a radiology setting. With lessons learned from 2003 and the presence of many radiology SARS veterans, we are better prepared to respond this time. However, although the pathogen causing COVID-19 has substantial genetic overlap with the SARS coronavirus, it is a different entity. Disease transmission by asymptomatic individuals has been reported, and the incubation period was initially uncertain, complicating its detection [11].

Some of the disease control measures instituted by us in response to the COVID-19 outbreak may seem excessive. However, in the early phase of an outbreak, decisions are often made without complete information. Furthermore, some outbreak containment measures are only effective in the earlier stages before substantial local transmission occurs. We suggest that radiology departments be integrated into the hospital's outbreak response team to permit a coordinated response that synchronizes with changes within the hospital. These measures should also be adjusted as the situation evolves.

This article examines what has changed since 2003, what new challenges we face with COVID-19, and how we capitalized on lessons from our experience with SARS. A summary of the main operational considerations for a radiology department during an infectious disease outbreak is given in Table 1.

People

Ensure Rapid Sharing of Accurate and Useful Information

Cognizant that we are only as strong as our weakest link, we rapidly disseminated information to all staff at the start of the outbreak. This was facilitated by meetings and e-mails and also using smartphones with new capabilities not available in 2003. These capabilities included approved group instant messaging applications and workplace social media. Before the first publications about COVID-19 emerged in Western medical literature, our residents found, translated, and disseminated a Chinese-language presentation by medical personnel from a hospital in Wuhan detailing the clinical features and radiologic findings of COVID-19.

One challenge is to ensure that every staff member is included when information is shared. Our hospital radiologic services have more than doubled in size since 2003, and some groups were inadvertently overlooked in the initial rapid dissemination of information (e.g., research assistants, elective students, and part-time staff). There is also a need to quickly address false rumors so that personnel have the correct information to work safely.

Ensure Infection Prevention and Control Knowledge and Practices Are Up to Date

Because of our SARS experience, staff are already primed for various levels of infection prevention and control. Most are fitted for N95 masks, and only a few need refitting. Everyone also undergoes annual infection prevention and control education, so there is familiarity with using PPE (Fig. 1). However, familiarity with theory does not necessarily translate into competence in practice; hence, refresher courses and videos are provided to bring everyone up to speed.

TABLE 1: Main Operational Considerations for a Radiology Department During an Infectious Disease Outbreak

Areas for Review	Useful Questions to Consider
People	
Ensure rapid sharing of accurate and useful information	What means do we have to rapidly send information to all staff? Is anyone inadvertently excluded from the information dissemination chain (research assistants, elective students, vendors, etc.)?
Ensure infection prevention and control knowledge and practices are up to date	Is the contact information of all staff up to date? Are all staff members fitted for N95 masks? Are staff current on donning and doffing of PPE?
Create new hybrid working teams	Do we have easily accessible refresher videos showing how to use PPE? Can staff be divided into separate functional hybrid teams that do not interact? How do residents and fellows fit into these hybrid teams?
Manage emotions during adversity	Are all professional domains accounted for in cohort plans (doctors, radiographers, nurses, frontline counter staff, administrative staff, porters, cleaners, etc.)? What is the ground sentiment? Are we showing care and concern for all staff members? What are fears that staff members have, and how can we address them?

(Table 1 continues on next page)

How SARS Experience Influenced Response to COVID-19

TABLE I: Main Operational Considerations for a Radiology Department During an Infectious Disease Outbreak (continued)

Areas for Review	Useful Questions to Consider
Places and equipment	
PPE	<p>Do all staff have timely access to PPE when needed?</p> <p>Is there a need to centralize or track distribution of PPE?</p>
Dedicated scanners for isolation and high-risk cases	<p>Do we have negative air pressure rooms for all imaging modalities?</p> <p>Do we have dedicated routes to transfer infectious patients in and out of radiology services?</p> <p>What is the enhanced cleaning requirement for scanners after imaging an isolation or high-risk case?</p>
Physical security and access control	<p>How well controlled is access to the radiology facility?</p> <p>Are we screening all patients and staff entering facilities adequately?</p> <p>Are we able to track who has entered and exited the department at different times for contact tracing (if needed)?</p>
Decentralized or alternate work areas	<p>How many alternate working and reporting sites do we have? Are they in operational condition?</p> <p>Should we redeploy radiology workstations and augment off-site reporting?</p>
Portable imaging capability	<p>Is there enough portable imaging equipment (e.g., radiography and ultrasound)?</p> <p>Do we need portable advanced imaging capability (e.g., mobile CT or MRI)?</p> <p>Is staffing sufficient to cope with the surge in portable imaging services?</p>
Processes and policies	
Review of policies and procedures	<p>Have we reviewed all imaging policies and procedures (inpatient, outpatient, emergency, febrile cases, nonfebrile cases, overseas patients, etc.)?</p> <p>Do we have response templates that can be modified for the current outbreak?</p>
Isolation or high-risk cases	<p>Are there off-site or outsourced radiologic facilities that need reevaluation?</p> <p>Do requests for high-risk or isolation cases need extra vetting for appropriateness?</p> <p>Can the case be done as a portable study?</p> <p>Can the study be focused to reduce exposure time for radiology staff?</p> <p>How can the study process be expedited?</p>
Modified interventional radiology processes	<p>Can interventional radiology facilities be segregated physically or temporally for patients with different infection risks?</p> <p>Is there a staff segregation plan to minimize cross transmission and ensure continuity of service in the event of staff quarantine?</p> <p>Is there a vetting process to assess infection risk, appropriateness of the procedure, and urgency of the procedure?</p> <p>Can the procedure be done at the patient's bedside in the isolation ward?</p> <p>Is there a special workflow for patient transfer from the isolation ward to the angiography suite and back?</p>
Rapid provision of radiologic results	<p>Are we providing timely and relevant radiology results for screening, suspected, or confirmed cases?</p> <p>Do we need to redeploy staff to address the shortened turnaround time for such radiology studies?</p> <p>Are staff aware of the radiologic findings of the novel infection?</p>
Daily routine instructions	<p>Are we providing relevant summaries of the new hospital and department procedures to staff?</p> <p>How do we manage information overload?</p> <p>Do members of our staff feel updated and cared for during this outbreak?</p>

Note—The term “department” may have differing definitions between hospitals. For Singapore General Hospital, the radiology services are provided by a division of radiological sciences (total staff strength of about 750) comprising three different departments (diagnostic radiology, vascular and interventional radiology, and nuclear medicine and molecular imaging) supported by a radiography unit and nursing expertise. The division is led by a division chair and supported by three respective department heads and a division administrative team. PPE = personal protective equipment.



Fig. 1—Photograph shows personal protective equipment (PPE) reminder notices placed on radiology angiography room doors to remind staff to don correct PPE before entering rooms. Obscuring of facial features has been applied for privacy reasons for publication.

Create New Hybrid Working Teams

During the SARS outbreak, a shift system was used to prevent cross infection between teams working at different times or locations. This allowed radiology services to continue uninterrupted in the event any group had to be quarantined. The extent of any quarantine then depended on how closely group members interacted and whether they were wearing PPE.

Our current subspecialty radiology team setup facilitates radiologist cohorts. Because of our growth in size since 2003, the plan was updated to include new sites comprising a mix of subspecialty radiologic expertise. Resident rotations between teams have been temporarily halted until the risk of transmission within health care settings becomes clearer. The use of electronic medical records, radiology information systems (RIS), and PACS allows remote provision of services. The updated cohort plan is also applied to all other staff members including radiographers, nurses, and other health care support staff. We are also activating back-up teleradiology plans to allow radiologists who may be quarantined to report from home.

Manage Emotions During Adversity

In addition to addressing radiology work, radiology leadership must address the emotional response of staff. SARS veterans are mostly calm and measured, though some have posttraumatic stress. For newer or younger staff members, responses range from indifference to concern to near panic. We deliberately

share our SARS stories with newer staff. For those who worry about PPE effectiveness, it is reassuring to hear a SARS veteran say, “I know PPE works because I treated SARS cases while wearing PPE, and that is why I am still alive today.” Special attention is paid to staff with specific concerns (e.g., those with young children or who are pregnant). The radiology leadership mantra is not only “wear PPE and clean your hands” but also “look out for each other.” Beyond informal ground-level staff support initiatives, official staff welfare groups in our department and hospital are ramping up efforts to actively manage increased staff stress levels during this time.

Places and Equipment

Personal Protective Equipment

At the start of the outbreak, basic PPE like surgical masks was made available in multiple department locations. As the outbreak progressed, the global supply chain for selected PPE was progressively strained. Mask distribution is now centralized at fewer points to ensure PPE stock can be sustained for an extended period.

Dedicated Scanners for Isolation and High-Risk Cases

Learning from the SARS experience, our radiology infrastructure was modified to cater to infection prevention and control. We now have negative air pressure rooms for radiography, ultrasound, CT, and MRI to cater to high-risk or isolation cases. Patients from different groups (e.g., inpatient, outpatient, emergency, febrile, and nonfebrile) are segregated by place or time with minimal crossover. Protocols detail which elevators and routes to take to radiology services during an outbreak.

Physical Security and Access Control

Access control to our department has been tightened. All entrances are now only accessible with a staff card. New screening stations have been set up at entrances to screen patients, accompanying persons, and other visitors (e.g., research assistants, vendors, or technicians) (Fig. 2). Screening is done on the basis of hospital advisories and includes assessment for fever, travel and contact history, and symptoms. Department access is tracked, and screening before entry and visit records are kept to facilitate contact tracing. Nonessential clinical meetings are postponed to reduce staff traveling through our department. Wherever possible, virtual or telephone consultations are used instead.

Decentralized or Alternate Working Areas

Our department has decentralized reporting rooms at six locations across the campus.

Before the outbreak, each radiology reporting room was occupied by one subspecialty team. In the current epidemic, we now configure mixed subspecialty teams to work from each reporting room. These mixed teams are separated physically to minimize cross infection.

Portable Imaging Capability

Because portable imaging capability was in high demand during the SARS outbreak, our department procured several additional portable imaging units in its aftermath. Despite that, the need for dedicated portable imaging units for the isolation wards, emergency department, staff clinic, and selected outpatient sites rapidly drained our existing portable radiography resources. We preemptively rented extra portable radiography units so that they could be rapidly deployed into operations. During the SARS epidemic, in addition to portable radiography and ultrasound, one other Singapore hospital reconfigured a hospital ward for portable CT [12]. At the time of writing, our hospital is in the process of setting up a large separate fever screening area with portable radiography capability.

Processes and Policies

Review of Policies and Procedures

As the outbreak progressed, we quickly reviewed processes and policies across our service and different professional domains. Prior SARS policies were useful templates for updated processes in the COVID-19 outbreak. These included policies for enhanced screening of cases and visitors, managing isolation or high-risk cases, expansion of portable

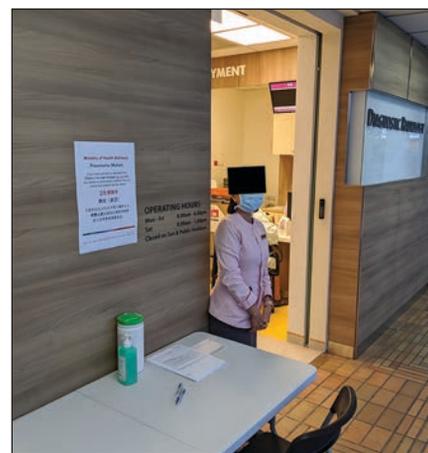


Fig. 2—Photograph shows screening station setup at radiology department entrance in early phase of outbreak, including staff member wearing mask. These smaller department-level screening stations were subsequently replaced by larger screening facilities at entrances to each building. Obscuring of facial features has been applied for privacy reasons for publication.

imaging capability, using powered air-purifying respirators, resuscitation protocols, temperature monitoring, and contact tracing.

One new area needing review was the use of off-site imaging facilities. These off-site facilities include scanners in other public hospitals, medical centers, and privately owned facilities. We ensured that all these external sites use effective screening procedures.

Isolation or High-Risk Cases

Imaging isolation or high-risk cases exposes more health care personnel to the risk of cross infection; therefore, the value of requested imaging for such patients is discussed between the referring physician and radiologist. This helps ascertain that the study is indicated and can answer the clinical question. Wherever possible, portable imaging is performed to reduce transport of infectious patients. When portable imaging is performed, efforts are made to minimize staff exposure time. Studies are tailored to answer a specific clinical question, rather than as general screening. Portable ultrasound teams are composed of a sonographer and a radiologist so that the procedure can be expedited and focused on the clinical issue.

Modified Interventional Radiology Processes

After the SARS outbreak in 2003, our interventional radiology (IR) facilities were segregated to cater to inpatient and outpatient procedures in separate physical locations. In the current epidemic, all procedure requests are vetted for indication, urgency, and infection risk so that nonurgent procedures can be postponed and cases with high infection risk identified. It is important to reduce nonurgent workload because heightened infection control measures lengthen procedure time and require increased staffing.

To minimize movement of high-risk infectious patients, portable ultrasound-guided procedures are performed at the bedside when possible. If patient transfer is unavoidable, we use preplanned routes straight into a procedure suite designated for infectious patients with thorough cleaning of equipment and the procedure room after use. Our IR clinics and electronic medical records allow procedure triage and appropriate case scheduling.

For IR practices covering multiple hospitals, segregation of IR staff members for different sites minimizes risk of cross transmission. The separation of staff into independent teams also prevents disabling of the entire team should quarantine be required.

Rapid Provision of Radiologic Results

During the SARS epidemic, chest radiographs were crucial in early diagnosis be-

cause there was no confirmatory test available initially. For COVID-19, the genetic profile was rapidly shared, allowing a confirmatory test to be created. However, chest imaging is still valuable in identifying suspected or confirmed COVID-19 cases. To facilitate rapid reporting of chest radiographs, radiographers flag such cases into new dedicated RIS work lists. This also allows tracking of workload so that staff can be redeployed to areas with surge in demand. The possibility of using chest CT to stratify risk in patients with minimal or no changes on chest radiography is also being considered.

Daily Routine Instructions

Daily routine instructions (issued by the hospital outbreak control task force) are disseminated to staff through all available communication channels. This was critical at the start of the COVID-19 outbreak because the situation evolved rapidly, with new workflows implemented each time. New hospital policies to ensure sustainability of health care services (e.g., freezing of leave, postponement of meetings) also had to be disseminated and explained. To mitigate information overload, summaries are made to highlight changes relevant to radiology services. Senior leadership also regularly record video messages to encourage staff through this demanding period.

Looking Ahead

As the COVID-19 outbreak unfolds, our disease-outbreak response posture will have to be adjusted. If cases continue to be predominantly imported with minimal local transmission, the current strategy of screening, early detection, isolation, and contact tracing will likely continue to be effective. However, if there is sustained community transmission from individuals without symptoms, our ability to detect cases and contain the spread will be limited. If COVID-19 becomes widespread globally with mainly mild disease and low mortality, it may become another respiratory tract pathogen that we have to live with while adopting sustainable universal precautions and waiting for a vaccine. The jury is still out as to how this novel pathogen will behave.

Conclusion

The role of radiology services during an infectious disease outbreak often focuses on identification of the infection through imaging. Beyond this, radiology departments must also be nimble in implementing operational changes to ensure continued radiol-

ogy services, protect patients and staff, and maintain staff morale during a sustained outbreak. People are the most valuable resource during a crisis, and it takes the concerted effort of every staff member to meet the challenges of an outbreak. We hope our experience will help other radiology departments to respond to the COVID-19 outbreak and any future novel infectious pathogen.

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References

1. World Health Organization website. SARS (severe acute respiratory syndrome). who.int/ith/diseases/sars/en. Accessed February 3, 2020
2. Chew V. Severe acute respiratory syndrome SARS outbreak 2003. eresources.nlb.gov.sg/infopedia/articles/SIP_1529_2009-06-03.html. Accessed February 3, 2020
3. Goh KT, Cutter J, Heng BH, et al. Epidemiology and control of SARS in Singapore. *Ann Acad Med Singapore* 2006; 35:301–316
4. Singh K, Hsu LY, Villacian JS, Habib A, Fisher D, Tambyah PA. Severe acute respiratory syndrome: lessons from Singapore. *Emerg Infect Dis* 2003; 9:1294–1298
5. Lau TN, Teo N, Tay KH, et al. Is your interventional radiology service ready for SARS? The Singapore experience. *Cardiovasc Intervent Radiol* 2003; 26:421–427
6. Gogna A, Tay KH, Tan BS. Severe acute respiratory syndrome: 11 years later—a radiology perspective. *AJR* 2014; 203:746–748
7. Lu H, Stratton CW, Tang YW. Outbreak of pneumonia of unknown etiology in Wuhan, China: the mystery and the miracle. *J Med Virol* 2020; 92:401–402
8. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020; 395:497–506
9. Mackay IM, Arden KE. MERS coronavirus: diagnostics, epidemiology and transmission. *Virol J* 2015; 12:222
10. World Health Organization website. Coronavirus disease 2019 (COVID-19) situation report—27. www.who.int/docs/default-source/coronaviruse/situation-reports/20200216-sitrep-27-covid-19.pdf?sfvrsn=78c0eb78_2. Accessed February 17, 2020
11. Rothe C, Schunk M, Sothmann P, et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. *N Engl J Med* 2020 Jan 30 [Epub ahead of print]
12. Parmar HA, Lim TCC, Goh JS, Tan JT, Sitoh YY, Hui F. Providing optimal radiology service in the severe acute respiratory syndrome outbreak: use of mobile CT. *AJR* 2004; 182:57–60