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Early Recognition of Coronavirus 2019 Disease (COVID-19) Infection in Surgical Inpatients: The Importance of a Risk-Stratified Approach for Early Testing and Isolation

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Abstract

Background: In the ongoing coronavirus disease 2019 (COVID-19) pandemic, resuming provision of surgical services poses a challenge given that patients may have acute surgical pathologies with concurrent COVID-19 infection. We utilized a risk-stratified approach to allow for early recognition and isolation of potential COVID-19 infection in surgical patients, ensuring continuity of surgical services during a COVID-19 outbreak.
Patients and Methods: Over a four-month period from January to April 2020, surgical patients admitted with concurrent respiratory symptom, infiltrates on chest imaging, or suspicious travel/epidemiologic history were placed in a dedicated ward in which they were tested for severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). If emergency operations were necessary prior to the exclusion of COVID-19, patients were managed as per suspected cases of COVID-19, with appropriate precautions and full personal protective equipment (PPE).
Results: From January through April 2020, a total of 8,437 patients were admitted to our surgical department; 5.9% (498/8437) required peri-operative testing for SARS-CoV-2. Because testing was in-house with turn-around within 24 hours, only a small number of emergency operations (n = 10) were conducted for suspected COVID-19 cases prior to results; none tested positive. The testing yield was lower in surgical inpatients compared with medical inpatients (odds ratio [OR] = 0.20, 95% confidence interval [CI], 0.12–0.32, $p < 0.001$). Three operations were conducted in known COVID-19 cases; all healthcare workers (HCWs) used full PPE. A risk-stratified testing strategy picked up previously unsuspected COVID-19 in six cases; 66.7% (4/6) were asymptomatic at presentation. Although 48 HCWs were exposed to these six cases, delayed diagnosis was averted and no evidence of spread to patients or HCWs was detected.
Conclusion: A risk-stratified approach allowed for early recognition, testing, and isolation of potential COVID-19 infection in surgical patients, ensuring continuity of surgical services.

Keywords: COVID-19; healthcare-associated; hospital; surgical

In the ongoing coronavirus disease 2019 (COVID-19) pandemic caused by the novel coronavirus, severe acute respiratory syndrome coronavirus-2 (SARS CoV-2), patients may present with symptoms and signs of COVID-19 mimicking acute surgical pathologies or have acute surgical pathologies with concurrent COVID-19 infection. Given that atypical manifestations of COVID-19, such as gastrointestinal symptoms or undifferentiated fever [1], potentially overlap with common acute surgical presentations, there may be delayed recognition of COVID-19 infection leading to healthcare-associated outbreaks [2]. However, testing all surgical admissions for COVID-19 infection is logistically

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challenging and would be an inappropriate utilization of a limited resource. Risk-stratification is crucial in ensuring early institution of appropriate infection prevention measures for all potential COVID-19–infected patients requiring operations, to ensure safe delivery of surgical services [3].

In Singapore, a globalized Asian city–state, the first imported case of COVID-19 was reported at the end of January 2020, followed by the first case of local transmission in February 2020 [4]. At our institution, the largest acute tertiary care hospital in Singapore, a bundle of interventions was implemented to ensure safe provision of surgical care, including reduction in non-urgent elective operations, segregation of surgical teams, and use of appropriate personal protective equipment (PPE) [3,5]. Emphasis was placed on early recognition, testing, and isolation of surgical inpatients who could potentially be infected with COVID-19 via a risk-stratified approach, given our institution's previous experience with severe acute respiratory syndrome (SARS), in which delayed recognition in a surgical inpatient resulted in a healthcare-associated outbreak of SARS [6].

Patients and Methods

Institutional setting and study period

Singapore General Hospital (SGH) is the largest public tertiary hospital in Singapore, with 1,785 beds. Approximately 80,000 inpatient operations are performed per annum at our institution. A full range of comprehensive surgical services is available, including neurosurgery, cardiothoracic surgery, plastic surgery, colorectal surgery, endovascular surgery, surgical oncology, minimally invasive surgery, surgical endoscopy, urology, trauma, and transplant services. We present our institution's experience with testing for COVID-19 in surgical inpatients over a four-month period, from January through April 2020, during the ongoing COVID-19 outbreak in Singapore.

Risk stratification for testing of COVID-19 in surgical inpatients and clinical management prior to results

At SGH, an expanded set of criteria was used to screen all admissions for better detection of COVID-19 cases, based on the presence of respiratory symptoms, presence of lung infiltrates on chest imaging, or suspicious travel/epidemiologic history [7]. Recognizing that the diagnosis in surgical patients might be less straightforward given non-specific clinical manifestations [1,6], an infectious diseases (ID) specialist was available for round-the-clock consultation. If patients had respiratory symptoms, lung infiltrates on baseline chest imaging, or suspicious travel/epidemiologic history, they were placed in a dedicated ward (respiratory surveillance ward [RSW]) where respiratory specimens (e.g., oropharyngeal swabs) were obtained for SARS-CoV-2 testing and healthcare workers (HCWs) used full PPE including N95 masks, disposable gowns, gloves, and face shields, until COVID-19 was excluded [8]. If vital imaging studies or emergency operations were necessary prior to the exclusion of COVID-19, patients were managed as per suspected cases of COVID-19, with appropriate precautions and full PPE. At our institution, during all aerosol-generating procedures, including endoscopy procedures, proceduralists utilized full PPE, similar to the practice at other institutions in Singapore [9]. A small operating room (OR) complex separate from the main OR complex was set aside for operations in patients suspected or confirmed to have COVID-19, with usage of full PPE for confirmed or high-risk suspect cases of COVID-19. [10]

Sampling and detection of respiratory viruses in surgical inpatients

Respiratory specimens were tested for SARS-CoV-2 along with other common respiratory viruses. Testing for SARS-CoV-2 RNA was done by qualitative real-time reverse transcription polymerase chain reaction (RT-PCR) testing. Viral RNA was first isolated from respiratory specimens and RT-PCR was performed targeting E gene and ORF1b-nsp14 for SARS-CoV-2 [11,12]. Respiratory specimens were also processed for a common panel of viral respiratory pathogens via respiratory virus (RV) multiplex PCR testing. This was performed using the Seegene Anyplex II RV16 Detection Multiplex PCR kit (Seegene, Seoul, South Korea).

Ethical approval

Because this was a descriptive study based on data collected by the hospital's Department of Infection Prevention and Epidemiology (IPE) as part of outbreak management and surveillance, ethics approval was not required under our hospital's Institutional Review Board (IRB) guidelines. Waiver of informed consent was approved by our hospital's IRB.

Results

From January through April 2020, a total of 8,437 patients were admitted to our surgical department; 5.9% (498/8437) required peri-operative testing for SARS-CoV-2 (Fig. 1). The number of surgical inpatients tested for COVID-19 increased steadily over the study period, from 21 patients in January 2020 to 310 patients in April 2020. The testing yield for respiratory viruses in surgical inpatients was low compared with medical inpatients, who were screened over the same time period utilizing a similar risk-stratified approach (odds ratio [OR] = 0.20, 95% confidence interval [CI], 0.12–0.32, $p < 0.001$). Only 3.4% (17/498) of surgical inpatients tested positive for respiratory viruses (six SARS-CoV-2, two other coronaviruses, five rhinovirus, one metapneumovirus, two influenza, one adenovirus), compared with 15.1% (836/5,545) of medical inpatients with respiratory symptoms testing positive over the same period (499 SARS-CoV-2, 337 other respiratory viruses). Because testing was in-house with turnaround within 24 hours, only a small number of emergency operations (n = 10) were conducted for suspected COVID-19 cases prior to results; none tested positive. Three operations were planned in known COVID-19 cases, including an appendicectomy, a laparotomy for resection of newly diagnosed cecal cancer, and a tracheostomy; all HCWs used full PPE.

The details of the six surgical patients diagnosed with COVID-19 to date are provided in Figure 2. Case 1 was a 55-year-old female presenting with sudden-onset anosmia and contact history with a known cluster of COVID-19 infections; she was referred by a primary care physician to the otolaryngology outpatient clinic for evaluation of sudden-onset anosmia. Because anosmia was one of the high-alert screening criteria for suspected COVID-19 at our institution

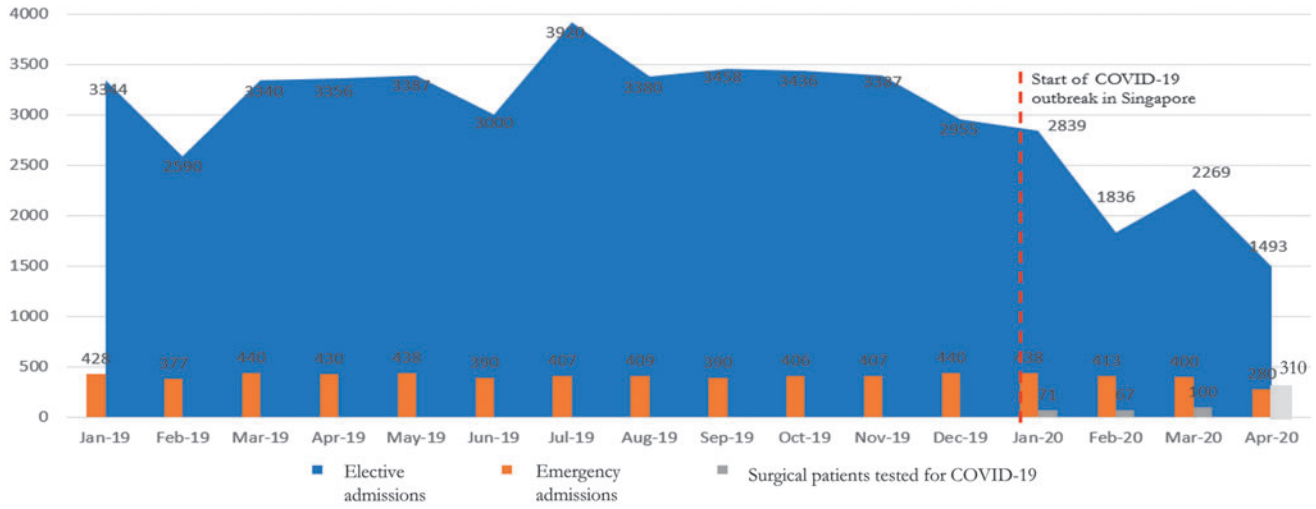

FIG. 1. Volume of surgical admissions and clinical details of surgical patients positive for SARS-CoV-2 at an acute tertiary hospital during a coronavirus disease 2019 (COVID-19) outbreak.

[13], she was reviewed in the otolaryngology clinic by doctors using full PPE and subsequently transferred briefly to the emergency department (ED) for swabs before being admitted to the isolation ward; respiratory swabs returned positive.

Case 2 was a 30-year-old male who presented with right iliac fossa pain; a provisional diagnosis of appendicitis was made. However, he reported mild cough prior to presentation, although respiratory symptoms were mild. Although the patient had no close contact with COVID-19 cases, he was staying in a dormitory, which at that point was recognized as a possible risk association in Singapore because COVID-19 cases had been found among dormitory residents. Because of

FIG. 2. Details of surgical patients who tested positive for severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) (n = 6), including demographic and clinical details, and epidemiology investigations (period of overlap between index case and exposed inpatients (h), prior to isolation; number of exposed staff and patients). COVID-19 = coronavirus disease 2019; HCW = healthcare worker; ED = emergency department; PPE = personal protective equipment.

respiratory symptoms and epidemiologic risk factors, the patient was seen in the designated ''fever area'' of the ED and staff used appropriate PPE [7]. The patient was subsequently transferred to a designated RSW, where urgent computed tomography (CT) scan of the abdomen was performed prior to the return of results from COVID-19 testing; the scan showed ileocolitis. Throughout the patient's stay in the RSW, the inpatient surgical team, as well as the radiographer performing the CT scan, had all worn appropriate PPE prior to the diagnosis of COVID-19. Upon diagnosis, the patient was isolated immediately and the ileocolitis was managed conservatively.

Case 3 was a 52-year-old female admitted electively for living-donor renal transplant. Upon admission, although the patient denied respiratory symptoms, chest imaging revealed pneumonia and SARS-CoV-2 testing was ordered after discussion with ID physicians; the elective operation was postponed.

Case 4 was a 31-year-old male who presented with left flank pain and a low-grade fever but no respiratory symptoms; a provisional diagnosis of renal colic was made and on imaging, a calcific focus noted in the region of the left renal shadow, consistent with the diagnosis. Although the patient had no respiratory symptoms, again, as the patient had previously worked on a construction site with known cases of COVID-19, he was reviewed in the designated fever area of the ED and was admitted to an RSW under the urology service, where the diagnosis of COVID-19 was made. The renal colic was managed conservatively.

Case 5 was a 32-year-old male who presented with an axillary abscess and had no concomitant respiratory symptoms, however, because he was staying in a dormitory with known cases of COVID-19, he was admitted to an RSW for swabs, which returned positive.

Case 6 was a 27-year-old male who presented with right iliac fossa pain; he had no respiratory symptoms and a presumptive diagnosis of appendicitis was made. However, because he was staying in a dormitory with known cases of COVID-19, he was admitted to an RSW for swabs, which returned positive. A CT scan of the abdomen (done with the radiographer wearing full PPE) revealed a right ureteric calculus, which was managed conservatively.

Among the six cases of COVID-19, 83.3% (5/6) had a significant epidemiology history, 16.7% (1/6) had findings on chest imaging, and 33.3% (2/6) had respiratory symptoms (Table 1). Among the 498 surgical inpatients screened for COVID-19, 32.9% (164/498) had respiratory symptoms, 36.8 (183/498) had significant epidemiology (high-risk contact history), and 50.8% (253/498) had infiltrates on chest imaging. High-risk contact history was the most sensitive as a screening criterion, with a sensitivity of 83.3% (95% CI, 35.9%–99.6%) and a specificity of 63.8% (95% CI, 59.4%–68.1%), because the majority of surgical inpatients with COVID-19 (66.6%, 4/6) were actually asymptomatic. In all six cases, a risk-stratified testing strategy averted delayed diagnosis. As a result of increased vigilance, no HCWs required quarantine, the surgical wards were not locked down, and no onward healthcare-associated transmission was detected on close follow-up for 21 days.

Discussion

As hospitals attempt to resume provision of services interrupted by the COVID-19 pandemic, surgical services,

Table 1. Sensitivity and Specificity of Various Screening Criteria for COVID-19 Disease among Surgical Inpatients

Clinical symptoms (respiratory symptoms, olfactory and taste disorders)	*Confirmed COVID-19 case*	*Negative*	*Total*	*Infiltrates on chest imaging*	*Confirmed COVID-19 case*	*Negative*	*Total*	*High-risk contact history*	*Confirmed COVID-19 case*	*Negative*	*Total*
Concurrent respiratory symptoms upon presentation	2	162	164	Infiltrates on baseline chest imaging	1	252	253	Contact with known COVID-19 cases, clusters, high-risk occupation, or recent travel in last 14 d	5	178	183
No concurrent respiratory symptoms upon presentation	4	330	334	No infiltrates on baseline chest imaging	5	240	245	No contact with known COVID-19 cases, clusters, high-risk occupation, or recent travel in last 14 d	1	314	315

Sensitivity of concurrent respiratory symptoms alone as a screening criterion for COVID-19 disease: 33.3% (95% CI, 4.3%–77.7%), specificity 67.1% (95% CI, 62.7%–71.2%), positive predictive value 1.2% (95% CI, .4%–3.7%), negative predictive value 98.8% (95% CI, 7.9%–99.3%).

Sensitivity of infiltrates on chest imaging alone as a screening criterion for COVID-19 disease: 16.7% (95% CI, 0.4%–64.1%), specificity 48.8% (95% CI, 44.3%–53.3%), positive predictive value 0.4% (95% CI, 0.1%–2.3%), negative predictive value 98.0% (95% CI, 97.1%–98.6%).

Sensitivity of high-risk contact history alone as a screening criterion for COVID-19 disease: 83.3% (95% CI, 35.9%–99.6%), specificity 63.8% (95% CI, 59.4%–68.1%), positive predictive value 2.7% (95% CI, 1.9%–3.9%), negative predictive value 99.7% (95% CI, 98.1%–99.9%).

COVID-19 = coronavirus disease 2019.

including elective operations, will need to be restarted slowly [14]. However, this poses challenges in care delivery and infection control. Whereas guidelines suggest that surgery should be conducted with appropriate precautions if COVID-19 is suspected, this highlights the importance of recognizing COVID-19 infection in patients planned for surgery [3,15]. Healthcare-associated outbreaks of COVID-19 with devastating consequences have occurred in specialized surgical units because of delayed recognition of concomitant infection [16] and mortality among COVID-19 patients requiring surgery remains high [17]. Whereas various guidelines emphasize a separation of positive or potentially positive COVID-19 patients and non-COVID-19 patients to minimize healthcare-associated transmission on surgical units [3,15,18], guidance on how to screen and triage surgical inpatients for suspected COVID-19 remains limited, and there is little information on how these recommendations may be followed practicably [19].

This challenge is exacerbated by the risk posed by potential asymptomatic and pre-symptomatic transmission of SARS-CoV-2 [20], in which patients with COVID-19 may be minimally symptomatic. Indeed, of the six cases of COVID-19 among surgical patients managed in our institution, the majority did not have respiratory symptoms. To address this, universal screening for SARS-CoV-2 through RT-PCR testing upon admission has been advocated in some quarters [19,21], while consideration of chest CT to pick up ground-glass opacities typical of COVID-19 in asymptomatic patients has also been suggested, particularly if an abdominal CT scan is already planned for the evaluation of acute abdomen [22]. Indeed, in one of our cases, the suspicion of COVID-19 was made based on chest imaging findings, although the patient denied respiratory symptoms. However, testing all surgical admissions for COVID-19, whether by RT-PCR testing of respiratory specimens or surveillance via CT scans, is logistically challenging. Furthermore, testing yield for respiratory viruses among surgical inpatients is low, as demonstrated by our findings, raising questions with regards to the cost-effectiveness of such an approach.

Risk-stratification based on travel and epidemiology history is crucial in balancing the need to conserve scarce testing resources, while at the same time ensuring that appropriate infection prevention measures are instituted in surgical inpatients who may potentially be infected with COVID-19. Furthermore, even in institutions that adopted universal screening peri-operatively, cases of COVID-19 infection were still detected post-operatively [23], likely because patients may still be in the incubation period at the point of admission. Stratification based on epidemiologic risk is still necessary even if universal testing is used at the point of entry, in order to identify at-risk patients who should be isolated for repeated testing, even if initial tests are negative [24].

Our study has the following limitations. Because only a limited number of surgical inpatients fulfilled criteria for screening based on our risk-stratified approach, it is possible that minimally symptomatic patients without epidemiologic risk factors may still have been missed. However, all surgical patients with concomitant respiratory symptoms at the point of admission were tested for COVID-19, and if surgical inpatients developed respiratory symptoms or other features in keeping with a viral prodrome (e.g., persistent fever, with normal procalcitonin or lymphopenia), they could be transferred into the RSW for COVID-19 testing after discussion with an ID physician.[25] As a further safeguard, all asymptomatic surgical patients planned for discharge to community facilities for rehabilitation were also screened for COVID-19 prior to transfer as part of national-level policies; none tested positive. Despite intensive staff surveillance measures that included twice-daily temperature recording, syndromic surveillance of acute respiratory illness (ARI) symptoms among HCWs reporting sick, and COVID-19 testing for all HCWs with ARI symptoms, only two HCWs from the surgical department tested positive for COVID-19 over the time period (one OR nurse, one administrative staff) [26]. Epidemiology investigations revealed that both HCWs acquired COVID-19 from community transmission rather than intra-hospital spread, demonstrating the effectiveness of infection control precautions in mitigating patient-to-staff transmission of COVID-19 in our institution [26].

Conclusion

A risk-stratified approach allowed for early recognition, testing, and isolation of potential COVID-19 infection in surgical patients, ensuring continuity of surgical services. Although testing all surgical patients peri-operatively is resource-intensive and has low testing yield, a risk-stratified approach to screening based on the presence of respiratory symptoms and high-risk epidemiology can avoid delayed detection, given that a concurrent surgical problem can confound the diagnosis of COVID-19.

Authors' Contributions

Study conception and design: Venkatachalam, Wee. *Acquisition of data:* Sim, Conceicao, Aung, Wong, Teh, Tan. *Analysis and interpretation of data:* Wee, Sim, Conceicao, Aung, Venkatachalam. *Drafting of manuscript:* Sim, Wee, Venkatachalam, Wong, Teh. *Critical revision of manuscript:* Wijaya, Tan, Ling.

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Author Disclosure Statement

The authors declare that they have no conflict of interests.

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