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Experience from a Singapore tertiary hospital with restructuring of a vascular surgery practice in response to national and institutional policies during the COVID-19 pandemic

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ABSTRACT

Singapore was one of the first countries to be affected by COVID-19, with the index patient diagnosed on January 23, 2020. For 2 weeks in February, we had the highest number of COVID-19 cases behind China. In this article, we summarize the key national and institutional policies that were implemented in response to COVID-19. We also describe in detail, with relevant data, how our vascular surgery practice has changed because of these policies and COVID-19. We show that with a segregated team model, the vascular surgery unit can still function while reducing risk of cross-contamination. We explain the various strategies adopted to reduce outpatient and inpatient volume. We provide a detailed breakdown of the type of vascular surgical cases that were performed during the COVID-19 pandemic and compare it with preceding months. We discuss our operating room and personal protective equipment protocols in managing a COVID-19 patient and share how we continue surgical training amid the pandemic. We also discuss the challenges we might face in the future as COVID-19 regresses. (J Vasc Surg 2020;72:1166-72.)

Keywords: Coronavirus disease 2019; COVID-19; Vascular surgery; Surgical practice; Segregation

The statistics speak for themselves. As of April 13, 2020, an astounding 1.9 million people around the world have been diagnosed with coronavirus disease 2019 (COVID-19), resulting in nearly 120,000 deaths.1 Singapore was one of the first countries to have been affected by COVID-19, having diagnosed the first case on January 23, 2020. The index patient was a Chinese national from Wuhan, China, who arrived in Singapore with his family on January 20, 2020.2 Since then, as of April 13, 2020, a total of 2918 cases of COVID-19 have been diagnosed. Of these cases, 1158 (39.7%) patients remain hospitalized, with 29 (1.0%) patients requiring intensive care. Nine patients (0.3%) have, unfortunately, died of complications arising from COVID-19.3

The sustained rise of COVID-19 cases in Singapore can be described by three distinct waves of disease influx and propagation.4 The initial surge in COVID-19 cases in late January and February can be attributed to travelers from China visiting Singapore and causing limited local transmission. This resulted in Singapore’s having the highest number of COVID-19 cases outside mainland China for approximately 2 weeks in mid-February.5 From March onward, the number of COVID-19 cases rose steeply again as Singapore citizens based abroad returned home. Currently, in April, COVID-19 case numbers are surging again because of widespread local transmission.3 Preparation for COVID-19 in our unit began in late January after Singapore announced its index case of COVID-19 infection. In this narrative, we describe the various governmental and hospital policies that were implemented as a response to COVID-19. We also describe and discuss the aftereffect these policies had on vascular surgery services in our unit.

NATIONAL POLICIES

Equipped with lessons learned from the severe acute respiratory syndrome outbreak in 2003, the government was quick to respond to the evolving COVID-19 situation weeks before COVID-19 reached our shores.5,7 In January 2020, the government expeditiously instituted measures such as mandatory temperature screening for all travelers, advised citizens to defer all nonessential travel to China, and implemented compulsory quarantine measures for all returning residents with recent travel history.

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to China. New visitors with recent travel history to China were also barred from entry or transit into Singapore.8,9

On February 7, 2020, as cases of COVID-19 continued to rise and cases of COVID-19 with no prior travel history or traceable link to prior cases were discovered, the Disease Outbreak Response System Condition (DORSCON) alert level was raised from yellow to orange, signifying more severe disease and easier community transmission.9 The DORSCON alert level system is a systematic outbreak response system with a color-coded framework (green, yellow, orange, and red) that reflects the severity of the outbreak (Fig 1).10

On March 11, 2020, the World Health Organization declared COVID-19 a pandemic.11 The travel entry ban into Singapore was extended to include new visitors from Italy, France, Spain, and Germany on March 13, 2020.12 By March 18, 2020, Singapore citizens or residents who returned home had to serve a 14-day stay-at-home requirement.13 Social distancing measures were also enforced. By March 22, 2020, the government extended the travel entry ban to all new visitors from anywhere in the world.14 Draconian measures, such as the closure of entertainment venues and the suspension of all religious gatherings, were instituted from March 26, 2020, onward.15,16 With the surge of COVID-19 cases in early April 2020, more stringent measures, such as the closure of all nonessential businesses and schools, were enforced by the government in an attempt to curb local transmission. Public gatherings were prohibited by law. All Singapore residents were strongly advised to stay at home and to work from home whenever possible unless for specific reasons, such as seeking medical attention or buying groceries.17

INSTITUTIONAL POLICIES

The National University Hospital is an academic tertiary hospital located in the southwest of Singapore with a total of 1239 beds. Before COVID-19, bed occupancy rates were commonly in excess of 90%. Crucial institutional policies had to be implemented to increase resources for the potential influx of COVID-19 patients.

From late January onward, the listing of nonurgent elective operations was prohibited, except for “time-sensitive cases,” such as oncologic cases or limb salvage procedures. Departments were also urged to plan for a segregated team model for both clinical and nonclinical staff to avoid possible cross-contamination. As the DORSCON alert level progressed to orange on February 7, 2020, more extensive institutional measures were enforced (Fig 1). These measures included ground implementation of the segregated team model, prohibition of staff and patient movement between health care institutions, scaling back of outpatient services, postponement of all elective cases that were already listed before COVID-19, suspension of annual leave application for health care workers, and mandatory temperature screening. Clinical clerkship programs for medical students were also suspended and transitioned to virtual lessons. Compulsory personal protection equipment training was also conducted for all health care workers.

The clear and concise flow of information to ground staff was paramount to ensure compliance with implemented policies. This was achieved by daily e-mails and text messages from the hospital’s leadership. These messages also served to boost the morale of health care workers and to augment organizational loyalty. As the number of COVID-19 cases continued to rise, arrangements were made for administrative staff to work from home from April 2020 onward.

SEGREGATED TEAM MODEL

After the DORSCON alert level system was raised to orange on February 7, 2020, our vascular surgery unit immediately adopted a segregated team model as part of its business continuity plan. Our unit is composed primarily of four attending surgeons and four senior residents or fellows. Each attending surgeon was paired to a senior resident or fellow to form a pair. The roster was planned in a cyclic fashion such that each pair would move through four sequential 7-day phases (inpatient, outpatient, backup, and rest). The inpatient team covered ward patients and performed surgery, whereas the outpatient team ran the outpatient clinics. If additional staff was required, the team in the backup phase could be mobilized to help.

The segregated team model would prevent cross-contamination and ensure that the entire vascular surgery unit would not be infected or quarantined in the event of COVID-19 exposure. It also allowed each team to have a 7- to 14-day washout period from the last patient contact before embarking on patient contact again. The washout period allowed sufficient time for symptom manifestation if a team member had contracted COVID-19 before returning to patient care. A 7- to 14-day washout period was more than adequate after taking into consideration the mean incubation time of COVID-19.18

Besides segregation within the unit, interdepartmental segregation was practiced. All face-to-face multidisciplinary team meetings were suspended and replaced by virtual meetings. As our unit provided consultative services to a rehabilitation-focused subsidiary hospital, these consultations were also conducted in a virtual fashion.

OUTPATIENT CLINICS

Vascular surgery outpatient clinics were immediately scaled down when the DORSCON alert level was escalated to orange on February 7, 2020 (Fig 1). We reduced the number of scheduled outpatient clinic sessions from 10 half-day to 5 half-day sessions per week. Although we kept our outpatient clinic open from 9 AM
to 6 PM to accommodate any possible patient who might require an urgent ad hoc review. Scheduled patients were reviewed only in the morning session from 9 AM to 12 noon. We aggressively reduced the number of patients who required scheduled on-site visits by conducting teleconsultations and reviewing electronic medical records. Per the segregated team model, an attending surgeon paired to a senior resident or fellow would run the outpatient services for 7 days before another pair took over. The other segregated pairs that were on nonclinical duties would remotely review new clinic referrals and conduct telephone interviews with patients who were scheduled for upcoming clinic visits. Nonurgent new clinic referrals, such as varicose veins without ulceration, asymptomatic peripheral artery disease, or pre-emptive dialysis access creation, were postponed.

Patients who were on active follow-up were screened carefully through a combination of electronic medical records and teleconsultations. Teleconsultations allowed us to assess the patients for any red flag symptoms or symptom progression. The decision to defer the patient’s follow-up appointment would be made on the basis of the patient’s underlying surgical condition and symptoms. Patients who still required active follow-up, such as patients in the acute postoperative period or patients who require aneurysm surveillance, advanced wound care, and assessment for dysfunctional dialysis access, would still be reviewed per usual in the outpatient clinics.

As a result of active measures such as postponement of nonurgent referrals and the adoption of teleconsultations, attendance to the vascular surgery outpatient clinics fell from an average of 965 attendances per month in 2019 to 406 attendances in February 2020 and 361 in March 2020 (Fig 2). Many patients on follow-up with vascular surgery would have a high risk of death if they contracted COVID-19 because of multiple severe comorbidities, such as end-stage renal disease and ischemic heart disease. Keeping these patients at home and away from the hospital may reduce their risk of COVID-19 infection. The reduction in attendances also facilitated staff redirection to busier clinical areas affected by COVID-19.

**INPATIENT SERVICES**

Like outpatient clinic attendances, the number of patients admitted to our inpatient services has been reduced significantly from an average of 110 new admissions per month in 2019 to 79 and 65 admissions in February and March 2020, respectively (Fig 2). Patients who might have been admitted for inpatient management of a condition in the pre-COVID-19 period, such as an infected venous ulcer or diabetic foot ulcer, were now treated in and discharged from the emergency department and given an appointment for early review in the outpatient clinics. The International Working Group on the Diabetic Foot published recommendations for the management of diabetic foot disease and peripheral artery disease that can help inpatient triage.

Several measures have also been instituted to facilitate the discharge of patients who are currently admitted. Expedited pathways were set up to accelerate the administrative processes required to discharge stable patients to subacute facilities for continued wound care and rehabilitation. Virtual meetings were held regularly between medical social workers, therapists, and the
medical team to discuss and to formulate discharge plans for patients with complex social issues. The reduction in our bed occupancy rate meant that more bed space could be used to treat incoming COVID-19 patients.

As part of our inpatient services, we provide an emergency vascular surgical consultation service to medical teams that are managing COVID-19 patients. Thus far, we have not encountered any COVID-19-positive patient with clinical manifestations of a hypercoagulable state. It is possible that clinical manifestations of COVID-19 may differ between ethnicities. Various Asian ethnicities have been shown to have a significantly lower risk of venous thromboembolism compared with whites because of genetic polymorphisms. These genetic polymorphisms have been shown to affect levels of activated protein C, factor V Leiden, and fibrinogen. The intriguing disparity in the incidence of thromboembolic complications in COVID-19 patients between different regions of the world certainly warrants further investigation.

**OPERATIVE VOLUME AND CASE MIX**

Since February 2020, elective cases that were originally scheduled were postponed if possible. Listing of new elective cases was also prohibited by our institution. However, a large proportion of our vascular surgery practice involves caring for and treating patients with lower extremity critical limb ischemia and hemodialysis accesses. Interventions for these patients tend to be semiurgent or urgent and cannot be deferred. We classified interventions performed for patients who presented with lower extremity critical limb ischemia or patients with dysfunctional or failing dialysis accesses as emergency surgery because of their time-sensitive nature. As such, our operative volume in 2020 has mostly remained constant compared with 2019 because of a high emergency workload (Fig 3).

However, because of the various institutional policies implemented for COVID-19, the amount of elective vascular surgery cases, such as pre-emptive dialysis access creation and venous surgery, has fallen. The amount of aorta-related cases has also decreased as we now tend to postpone patients with abdominal aortic aneurysms who are asymptomatic. Interestingly, the number of major amputations has risen considerably compared with 2019. This is primarily due to a lower threshold of offering either primary major amputation for patients with a low chance of successful limb salvage, such as those who present with severe infection or extensive tissue loss, or early major amputation for patients who have not improved despite maximal revascularization. As such, these patients can be discharged earlier to a subacute facility or directly home to free vital bed space in the hospital.

We have also created and implemented an in-house scoring system to triage patients who require arteriovenous dialysis access creation. This scoring system consists

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**Fig 2.** Vascular surgery outpatient clinic attendances and inpatient admissions from November 2019 to March 2020. DORSCON, Disease Outbreak Response System Condition.
of variables such as prior catheter-related bloodstream infection, extended tunneled catheter time of 6 months or more, access concerns such as limited catheter options, and history of catheter malfunction. Currently, we still selectively perform arteriovenous dialysis access creation only for patients who have two or more of these variables. When COVID-19 subsides, this scoring system can also be used as a tool to prioritize patients who require dialysis access creation earlier.

Our triage strategy of vascular surgery cases is mostly in line with recommendations made by the American College of Surgeons.24 The postponement of elective surgical cases will allow resources such as personal protective equipment, resuscitative drugs, intensive care unit, high-dependency bed space, and nursing and medical staff to be channeled toward the fight against COVID-19.

ENSURING SAFE SURGERY

Our institution does not have a universal COVID-19 testing protocol for preoperative patients. Instead, patients who are planned for surgery are meticulously screened for symptoms of acute respiratory infections, abnormalities on chest imaging, and prior direct contact with a COVID-19-positive individual. If a patient has or is suspected of having COVID-19 infection but requires immediate lifesaving or limb-saving surgery, such as repair of a ruptured abdominal aortic aneurysm, the surgery would be performed in a designated COVID-19 operating room. This operating room has a negative pressure environment with a dedicated ingress and egress route that segregates it from the rest of the operating room complex. Within the operating room, it is compulsory for health care workers to don full personal protective equipment consisting of eye protection with either an N95 respirator mask or a powered air-purifying respirator. A protocol for managing COVID-19 patients in the operating room has been published by our institution.25 However, if surgery for a patient thought to have COVID-19 can be delayed, COVID-19 testing by a nasopharyngeal swab and reverse transcriptase-polymerase chain reaction will be performed. If two consecutive nasopharyngeal swabs are negative, the patient can be deisolated and operated on in the normal operating room. Standard personal protective equipment, such as a normal surgical mask, will suffice in performing surgery for COVID-19-negative patients. At the point of manuscript writing, we have operated on patients who were thought to have COVID-19 but not on patients who are COVID-19 positive.

VASCULAR SURGERY TRAINING AMID COVID-19

Surgical training for fellows and residents has been affected in multiple ways by the COVID-19 pandemic. The cancellation of elective surgery, team segregation, and redeployment of junior staff to other clinical areas have led to a significant decrease in hands-on surgical training. In response to this inevitable paradigm shift in surgical training, we implemented several measures to ensure continued training for our trainees. We curated surgical or procedural videos from the various online sources for our trainees to view. For example, we found...
that the “Houston Methodist DeBakey CV Education” channel on YouTube contained multiple highly educational surgical videos and didactic lectures that were immensely useful to our trainees. We also encouraged our trainees to listen to the “Audible Bleeding” podcast and to participate in the interactive online symposiums organized by Vascupedia. We found that myriad tools for vascular surgery education had already existed before COVID-19, and we aim to continue using these tools to facilitate and to augment surgical training in the foreseeable future.

Educational activities that were previously conducted in a face-to-face manner, such as journal clubs and case discussions, have now been transitioned to a virtual platform. Virtual platforms such as Zoom (San Jose, Calif) and Microsoft Teams (Redmond, Wash) allowed interactive discussion and sharing of presentation slides. Attending surgeons who were not performing clinical duties led these sessions. COVID-19 is also a time for opportunistic learning. Surgical trainees are also actively encouraged to improve their knowledge in critical care or resuscitation if they are redeployed to clinical areas such as the emergency department or intensive care unit.

PREPARING FOR THE FUTURE

We need to start preparing for the future. Technologies that have flourished during COVID-19, such as telemedicine and remote monitoring technologies, should be harnessed for our future practice.26,27 We will face a large backlog of cases once COVID-19 dwindles. Sensible triaging still applies, such that more essential cases are operated on first. As we gradually increase our outpatient and inpatient services to pre-COVID-19 levels, we must continue to screen for patients with potential COVID-19 and be vigilant in maintaining a high level of hygiene. Once COVID-19 subsides, we plan to transition from the current four-phase segregated model back to the pre-COVID-19 state by reducing the number of phases and simultaneously increasing the number of medical staff in each phase gradually. This cautious approach is adopted in anticipation of a second COVID-19 wave.

CONCLUSIONS

COVID-19 has affected our vascular surgery unit in multiple ways. Most of these changes are invariably due to national and institutional policies made to preserve hospital resources. These policies are essential and crucial, especially in a resource-constrained country like Singapore. However, we are not alone as multiple vascular surgery units around the world are experiencing the same changes.28 As the number of COVID-19 cases in Singapore continues to rise because of local transmission within several foreign labor communities, we must continue to prepare for a sudden influx of patients. As vascular surgeons, we will have to remain dynamic and tailor our vascular surgery services accordingly on the basis of available resources. In the extreme situation, challenging decisions like declining surgery for an elderly patient with a ruptured abdominal aortic aneurysm to preserve intensive care unit capacity might have to be made.

AUTHOR CONTRIBUTIONS

Conception and design: JJN, RM, PH, RD, JW, AC Analysis and interpretation: Not applicable Data collection: TG, JYN Writing the article: JJN, TG, JYN Critical revision of the article: JJN, RM, PH, RD, JW, AC Final approval of the article: JJN, TG, JYN, RM, PH, RD, JW, AC Statistical analysis: Not applicable Obtained funding: Not applicable Overall responsibility: JJN

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