ABSTRACT
Background: The COVID-19 pandemic has had a major impact on cardiac surgery patients. Significant reductions in access to surgical treatment have forced surgeons to prioritize patients and follow strict COVID-19 protocols to protect surgeons, staff, and patients. Adult cardiac surgery and the COVID-19 pandemic: aggressive infection mitigation strategies are necessary in the operating room and surgical recovery. Nosocomial infections among cardiac surgery patients have been reported and are associated with a high mortality rate. As a COVID-19 tertiary care centre and a tertiary cardiac centre, we tried to balance the need to operate on urgent cardiac cases while protecting patients and staff from COVID-19.

Methods: During the first wave of the pandemic, we performed 579 surgeries. We report findings from an outbreak of 4 nosocomial infections.

Results: All patients tested negative within 24 hours of surgery or admission. Three patients were positive after surgery, suggesting an overall nosocomial rate during the first wave of 0.5% (3/579). One patient admitted for evaluation tested positive during mass screening. Two of the 4 patients died after respiratory complications. No health care worker (HCW) or family member with direct contact with these patients tested positive for COVID-19.

Since the World Health Organization (WHO) declared COVID-19 to be a global pandemic in March 2020, there have been more than 100 million confirmed cases with more than 2.5 million fatalities caused by COVID-19 around the world.

Because of increased demand for intensive care unit (ICU) beds and health care resources, most cardiac surgery centres have had to adjust their case volumes during the first wave to liberate resources to care for COVID-19 patients. The Canadian Society of Cardiac Surgeons has been actively involved in providing guidance for the safety of both patients and medical personnel and providing effective methods to prioritize and follow up with preoperative patients to mitigate the risk of protracted waiting times. However, it is clear that a balance is required between the need to treat COVID-19 and the need to treat cardiac patients while ensuring the safety of patients and health care workers (HCW). In small case series, the rate of nosocomial COVID-19 infection among cardiac surgery patients is deemed to be low, but it is reported to have a high mortality rate of up to 43%. We report findings from an outbreak of 4 nosocomial infections among cardiac surgery patients during the first wave in a tertiary care hospital, which is also heavily involved in the treatment of COVID-19 patients.

Methods
The first wave was defined to occur from March 16 to December 10, 2020. This period essentially reflects the
Nosocomial COVID-19 infection is uncommon when adhering to safety protocols. Although uncommon, the mortality rate is high (50%) in our series.

Conclusions: As widespread vaccination of HCWs and high-risk individuals susceptible to COVID-19 is in progress, we suggest that cardiac surgery patients, when feasible, be vaccinated before surgery given this could prevent excess mortality, protect HCWs and reduce resource use.

impact on cardiac surgery cases starting with a significant reduction then a gradual increase to normal volumes to the start of another period of reduced activity. Preoperatively, all patients were carefully screened with a detailed history, physical examination, chest radiograph and a reverse transcriptase polymerase chain reaction swab test within 24 hours of surgery. Patients from other institutions were swabbed for COVID-19 and placed under contact-droplet precautions and remained under precaution for 14 days regardless of a negative COVID-19 result. Patients from home were called to confirm absence of COVID-19 symptoms and history of exposure and remained under contact-droplet precautions until negative test results were achieved. During hospitalisation, patients were isolated if they had COVID-19 symptoms and were tested. Only patients with a negative result had surgery. Strict operating room protocols were enforced and have been previously described. All health care professionals, patients, and visitors wore a mask with application of hand hygiene, appropriate donning and doffing of personal protective equipment for contact-droplet precautions, and aerosol protection when indicated. Nosocomial infections were defined as patients that contracted the disease in the hospital and were symptomatic or tested positive 14 days after admission. Those who tested positive after 5 days from admission and had no presenting symptoms, were considered probable nosocomial infections, as it is also possible that they had a latent period of a community-acquired infection.

Results

During this period, we performed 579 cardiac surgeries, representing 78% of our normal capacity. Three patients tested positive for COVID-19 after surgery, whereas a fourth patient with a left ventricular assist device (LVAD) tested positive as part of mass screening after being transferred to our centre from another hospital for management of gastrointestinal bleeding. All patients tested positive within 3 days of each other. The ward was quarantined, contact droplet precautions were applied to all patients, and mass screening was performed for all HCWs, patients, and family members every 5 days until 14 days of the last exposure. Two HCWs tested positive but were not directly involved in care of the positive patients.

Two patients died of respiratory failure related to COVID-19, whereas another patient recovered from the respiratory infection, albeit he suffered wound dehiscence and mediastinitis after starting steroids for his COVID-19 pneumonia. One patient was essentially asymptomatic. Table 1 provides a summary of patients’ characteristics.

Patient 1

A 65-year-old man with a medical history of chronic renal failure on dialysis, hypertension, diabetes mellitus II, dyslipidemia, and atrial fibrillation presented with an ST-segment elevation myocardial infarction and had coronary artery bypass graft (CABG) × 3. He had postoperative pneumonia and was eventually transferred to the ward on postoperative day (POD) 6. While waiting for convalescence, he spiked a fever on POD 19, tested positive for COVID-19, and was transferred to the COVID-19 unit. After discharge, he was readmitted with worsening dyspnea, hypoxia, and infiltrates requiring intubation. He was treated with dexamethasone and intravenous (IV) antibiotics. His condition continued to deteriorate, and he died of respiratory complications of COVID-19 on POD 30.

Patient 2

An 80-year-old man with hypertension and dyslipidemia presented with a non−ST-segment elevation myocardial infarction and an ascending aortic aneurysm of 5.2 cm and underwent CABG × 4 with hemiarch replacement. He was extubated and transferred to the floor on POD 1. On POD 2, he was readmitted to ICU for noninvasive respiratory support and IV antibiotics for aspiration pneumonia and was discharged again to the floor on POD 4. On POD 12, while waiting for convalescence, he complained of shortness of breath; a chest radiograph showed bilateral lung infiltrates, and he tested positive for COVID-19. He was admitted to the COVID-19 unit for 6 days and started treatment with dexamethasone and IV antibiotics before being transferred to the ICU for severe dyspnea and increased oxygen requirement. He was eventually intubated and had acute renal failure. He died after 10 days in the ICU of respiratory failure.

Patient 3

A 57-year-old man with hypertension, diabetes mellitus II, and previous ischemic stroke presented with acute congestive heart failure. He was found to have multivessel coronary artery disease with severe mitral regurgitation. He underwent
Both an in-patient and an outpatient rehabilitation centre when tested positive and had a subsequent prolonged hospital stay. A 75-year-old man presented with a previous LVAD surgery in 2015. His medical history included hypertension, dyslipidaemia, chronic renal failure, and diabetes mellitus II. He was transferred from another institute after he presented there with gastrointestinal bleeding less than 48 hours earlier. He was admitted to the ICU instead of the ward that infected 4 patients, 3 of which were waiting for discharge 12-19 days after surgery. Unfortunately, 2 patients died after a prolonged ICU stay.

**Patient 4**

A 75-year-old man presented with a previous LVAD surgery in 2015. His medical history included hypertension, dyslipidaemia, chronic renal failure, and diabetes mellitus II. He was transferred from another institute after he presented there with gastrointestinal bleeding less than 48 hours earlier. He was admitted to the ICU instead of the COVID-19 unit on minimal oxygen support and treated with dexamethasone. He was transferred back to the cardiac surgery floor after he recovered from his COVID-19 pneumonia. A sternal wound infection developed that required treatment with IV antibiotics and a pectoral flap. He was discharged after spending 52 days at the hospital.

**Table 1. Summary of patient characteristics and COVID-19 infection timeline**

| Sex          | Patient 1         | Patient 2         | Patient 3         | Patient 4         |
|--------------|-------------------|-------------------|-------------------|-------------------|
| Age, y       | Male 65           | Male 80           | Male 57           | Male 75           |
| Diabetes mellitus | Yes              | Yes               | Yes               | Yes               |
| Hypertension | Yes               | Yes               | Yes               | Yes               |
| Smoker       | No                | No                | Ex-smoker         | Ex-smoker         |
| COPD         | No                | No                | No                | No                |
| Chronic kidney disease | End-stage renal disease on dialysis | Yes | No | Yes |
| LVEF, %      | 40                | 60                | 25                | 30                |
| Operation    | CABG × 3          | CABG × 4 + hemiarch replacement | CABG × 5 + mitral valve repair | LVAD (2015) |
| STS-PROM, %  | 2.96              | 2.33              | 3.02              | 3.02              |
| Tested COVID-19 positive | POD 20 | POD 12 | POD 16 | — |
| ICU readmission stay, d | 15 | 10 | — | 4 |
| Outcome      | Died              | Died              | Discharged        | Discharged        |
| Hospital stay, d | 39 | 34 | 52 | 8 |

CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; ICU intensive care unit; LVAD, left ventricular assist device; LVEF, left ventricular ejection fraction; POD, postoperative day; STS-PROM, Society of Thoracic Surgeons Predicted Risk of Mortality.

Given the low rate of nosocomial infection, patients should have some reassurance that they are relatively safe from COVID-19, and life-saving procedures should take precedence over fear of contracting COVID-19. However, we were fortunate in that our outbreak was limited. The situation could have been much worse with a potential of infecting more than 30 patients on the ward and more than 100 HCWs. Given the high mortality rate and high resource use in COVID-19 patients, this could have been a catastrophe for patients and the hospital. Because we are unsure how the outbreak started in the first place, the best approach would be to maximize prevention. Strict adherence to COVID-19 policies and procedures had a beneficial effect in limiting the number of nosocomial infections and outbreaks. Furthermore, we had no other incidents of outbreaks or any further nosocomial infections to date. Unfortunately, because nearly all HCWs, patients, and families tested negative for COVID-19, the source of the outbreak is not known. This finding underlines the necessity to continue to adhere to COVID-19 guidelines and to remain vigilant. Testing must be done postoperatively to rule out COVID-19 when the clinical situation is appropriate.

## Discussion

COVID-19 nosocomial infection has been a feared complication for patients admitted to the hospital, especially those subjected to cardiac surgery, given that surgery may induce both an inflammatory and immunocompromised state. Our experience during the first wave of the pandemic found that the risk of transmission is low even in a tertiary hospital at the centre of the pandemic. Our case volume slowly improved after nearly 4 weeks of shut down starting March 16 and were fully functional until the start of the second wave. During this time, we were able to perform 579 surgeries, which represents 78% of our normal volume. An outbreak occurred on the ward that infected 4 patients, 3 of which were waiting for discharge 12-19 days after surgery. Unfortunately, 2 patients died after a prolonged ICU stay.

No doubt that the application and adherence of strict COVID-19 policies and procedures had a beneficial effect in limiting the number of nosocomial infections and outbreaks. Furthermore, we had no other incidents of outbreaks or any further nosocomial infections to date. Unfortunately, because nearly all HCWs, patients, and families tested negative for COVID-19, the source of the outbreak is not known. This finding underlines the necessity to continue to adhere to COVID-19 guidelines and to remain vigilant. Testing must be done postoperatively to rule out COVID-19 when the clinical situation is appropriate.

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Moreover, LVAD patients present a special subset of cardiac surgery patients for whom their hospital readmission rates are higher than other cardiac surgical patients, and they
require frequent outpatient follow-up. Follow-up makes these patients more vulnerable to infection; therefore, these patients should be treated diligently with applications of personal protection equipment when being seen in the clinic or hospital setting. Furthermore, they should be encouraged to get vaccinated to help reduce this risk and allow for safer care in the ward or the clinic.

Rapid discharge from the hospital would also seem to be appropriate, as 3 of these patients were waiting in the hospital as a consequence of reduced convalescence beds, even though there have been reports of outbreaks in long-term care facilities at the beginning of the pandemic. These outbreaks were attributed to poor adherence to contact precautions and lack of widespread testing. Increased awareness, better preparations, and strictly admitting patients that test negative for COVID-19 in these centres make them a viable option for patients that can’t be discharged home, particularly when they are hospitalized in a referral centre dealing with COVID-19 patients. With the availability of vaccinations, they can be immunized after surgery before being transferred.

**Conclusions**

The results of our case series can be limited because of the small number of confirmed nosocomial infections, single centre result, and the treatment options of these patients.

Currently, we still don’t have enough evidence of what the best treatment option for postoperative patients with nosocomial COVID-19 infections might be; to our knowledge they should be treated like any other COVID-19 patients according to the severity of the disease. The latest National Institutes of Health guideline recommends dexamethasone for severe illness requiring mechanical ventilation (strong recommendation) or dexamethasone plus tocilizumab (moderate recommendation) within 24 hours of ICU admission. Treatment with antiviral medications such as remdesivir is not recommend as a monotherapy and had moderate rating of recommendation in combination with dexamethasone in severe illness not requiring intubation or extracorporeal membrane oxygenation.

Lastly, our cohort consisted of nonvaccinated patients, and all HCWs were not vaccinated at that time. Vaccination before surgery could be an important component in limiting deadly outbreaks and infection. Many cardiac surgery patients can wait 2 weeks to allow for vaccination. As the roll out starts, cardiac patients should be prioritized for vaccination, not only for their safety but also for the safety of the hospital and staff.

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**Disclosures**

The authors have no disclosures to report.

**References**

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