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Surgical Implications of Coronavirus Disease-19

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KEYWORDS
- COVID • SARS-CoV-2 • Surgery • Operative • Risk • Anesthesia

KEY POINTS
- All preoperative patients should be screened for (1) history of exposure to someone with known COVID-19 within the last 14 days and (2) symptoms suspicious of COVID-19.
- Perioperative COVID-19 increases the risk of postoperative morbidity and mortality. Surgical risk calculators may underestimate postoperative risk in COVID-19 patients.
- A multicenter international study suggests that elective surgery should be delayed for 7 weeks following COVID-19 diagnosis, at which time perioperative risk becomes comparable to the non-COVID-19 population.
- There are no data comparing operative versus nonoperative management of COVID-19 patients for emergency surgical conditions that can also be managed medically; decision to operate should be made judiciously considering clinical acuity, patient comorbidities, and local resources.
- COVID-19 patients seem to have higher rates of postoperative thrombotic and pulmonary complications, and potentially a lower rate of bleeding complications. Telemedicine appointments could be a viable approach to minimize ambulatory hospital visits.

INTRODUCTION

Coronavirus disease-19 (COVID-19), caused by the severe adult respiratory syndrome coronavirus-2 (SARS-CoV-2), was first reported in late 2019 and quickly developed into a global pandemic in the first few months of 2020.\(^1\) COVID-19 strained health care systems and resulted in unprecedented challenges to health care providers around the world. For surgical patients, COVID-19 complicates perioperative risk and subsequently the benefits versus risks balance of any invasive operation. In addition, it quickly became evident that surgery plays a central role in the treatment of severe COVID-19 (eg, tracheostomy and gastrostomy tube placement) as well as COVID-19 complications (eg, bowel ischemia).\(^2\) In addition, health care providers

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involved in the perioperative care of patients are at a significant risk of contracting the disease, especially those involved in airway management. Finally, COVID-19 poses a major logistical challenge for the surgical service, as the strain on health care systems led to widespread cancellations of elective surgery and difficulties in maintaining even basic surgical services.

As the COVID-19 pandemic continues to evolve with the surge of novel virus variants such as the delta and omicron, it is important for physicians to understand and appreciate the surgical implications of COVID-19 (Box 1). This review provides an overview of the implications of the ongoing COVID-19 pandemic on surgical care.

| Box 1 | Surgical implications of coronavirus disease-19 |
|-------|-----------------------------------------------|
| **Preoperative Screening and Testing** | All preoperative patients should be screened for (1) history of exposure to someone with known COVID-19 within the last 14 days and (2) symptoms suspicious of COVID-19 (eg, fever, cough, dyspnea, and chills). Patients who answer “yes” to at least one of these questions should undergo PCR testing for SARS-CoV-2. |
| **Surgical Risk Assessment** | Patients with perioperative COVID-19 seem to have higher risk of postoperative morbidity and mortality compared with patients without COVID-19. Surgical risk calculators may underestimate postoperative risk in COVID-19 patients. |
| **Timing of Surgery after SARS-CoV-2 Infection** | A multicenter international study suggests that elective surgery should be delayed for 7 weeks following COVID-19 diagnosis, at which time perioperative risk becomes comparable to the non-COVID-19 population |
| **Risk of Contracting SARS-CoV-2 Perioperatively** | The risk of contracting SARS-CoV-2 perioperatively is low (<2%), and the use of COVID-19-free surgical pathways reduce the risk of postoperative infection. |
| **Emergency Surgery** | There are no data comparing operative versus nonoperative management of COVID-19 patients for emergency surgical conditions that can also be managed medically; decision to operate should be made judiciously considering clinical acuity, patient comorbidities, and local resources. |
| **Elective Surgery** | An estimated 28.5 million elective surgical cases were cancelled worldwide during the peak 3-month period of the pandemic, resulting in a significant backlog in surgical care. Hospitals and health care systems should prepare to address the backlog in surgical care despite the ongoing disruptions in the health care supply chain. |
| **Oncological Surgery** | Cancer surgeries are frequently time-sensitive and are considered essential operations. Cooperation between surgical centers could help maintain the regional quality of surgical cancer care, despite capacity issues or other problems at individual hospitals. |
| **Anesthesia Considerations** | The type of anesthesia should be primarily dictated by the individual operation and patient characteristics. The number of personnel in the operating room during intubation and extubation should be minimized and high-level PPE should be used for aerosol-producing procedures on COVID-19 patients. |
| **Postoperative Follow-up** | COVID-19 patients seem to have higher rates of postoperative thrombotic and pulmonary complications, and potentially a lower rate of bleeding complications. Telemedicine appointments could be a viable approach to minimize ambulatory hospital visits. |
and provides recommendations for the perioperative management of all patients during the pandemic.

**Preoperative Evaluation**

A joint statement by the American Society of Anesthesiologists (ASA) and the Anesthesia Patient Safety Foundation (APSF) recommends screening all patients preoperatively for (1) history of exposure to someone with known COVID-19 within the last 14 days and (2) symptoms suspicious of COVID-19 (fever, cough, dyspnea, chills, muscle pain, headache, sore throat, and/or new loss of taste or smell, nausea, vomiting, or diarrhea) not explained by other causes. Patients who screen positive for one of these criteria should be referred for further evaluation. Careful screening of symptoms can also be important for risk stratification of COVID-19 positive patients, as a multicenter retrospective observational study from the United States showed that the presence of such symptoms increased patient risks, COVID-19 patients who had preoperative respiratory symptoms were at higher risk of pulmonary complications than asymptomatic COVID-19 patients, following emergency general surgery. Owing to the highly variable presentation of COVID-19, screening for symptoms and viral exposure can yield false negative results in a subset of infected patients. During the peak of the pandemic, many institutions implemented universal testing protocols for all patients undergoing surgery or other aerosol-producing procedure (eg, esophagogastroduodenoscopy). If resources allow, universal testing less than 3 days before the operation could help to identify asymptomatic patients, and such testing has been supported by major organizations. An international multicenter study of 8784 patients undergoing elective cancer surgery during the first peak of the pandemic found that routine polymerase chain reaction (PCR) testing from a nasopharyngeal swab sample was associated with lower rates of pulmonary complications in regions with high prevalence of COVID-19 and before major surgery, but not in regions with a low disease prevalence performing minor surgery. The efficacy of universal testing in fully vaccinated patients and in communities with high vaccination rates remains unclear. As such, we recommend that institutional policies for preoperative testing be tailored to the local prevalence of COVID-19 and to available local resources. Testing may be deferred if a patient has tested positive within the last 90 days and meets the criteria for Ending Isolation and Precautions for People with COVID-19, as described by the Centers for Disease Control.

**Surgical Risk in Patients with Perioperative Coronavirus Disease-19**

Surgical patients with COVID-19 represent a distinct population requiring special consideration to assess perioperative risk. A growing body of evidence shows a substantially higher risk of morbidity and mortality in patients undergoing surgery with perioperative COVID-19. SARS-CoV-2 status should be considered in the decision for operative management, carefully weighing the expected operative benefits versus the postoperative risk associated with COVID-19. The precise prediction of surgical risk can be challenging in COVID-19 patients because it is unclear whether the established risk calculators for postoperative mortality and morbidity such as the Predictive Optimal Trees in Emergency Surgery Risk Calculator and the American College of Surgeons (ACS)-National Surgical Quality Improvement Program (NSQIP) Surgical Risk Calculator are applicable in the setting of SARS-CoV-2 infection.

An early study evaluating the outcome of patients with perioperative COVID-19 (defined as the presence of SARS-CoV-2 infection within 7 days before or within 30 days after an operation) reported a remarkably high 30-day mortality rate of 23.8%. In this international observational study including 1126 patients, 51.2% developed pulmonary complications in the postoperative period. A similar trend was
observed in another prospective multicenter study assessing the impact of COVID-19 on outcomes in 70 US hospitals across 27 states: rates of 30-day mortality and postoperative pulmonary complications were 11.0% and 39.5%, respectively. Other cohort studies demonstrated substantial variability in mortality from 5.4% to 42.8%. This heterogeneity in mortality should be carefully interpreted as several studies were subject to selection bias in comparing outcomes between patients with COVID-19 versus without COVID-19. Patients in the COVID-19 arm were potentially sicker at baseline because many centers had a higher threshold to operate on patients with COVID-19. To address this potential selection bias, an observational study compared the surgical outcomes of COVID-19-positive patients to a propensity score-matched controls who underwent surgery during the same period and were COVID-19-negative. Although this study did not find a statistically significant difference in 30-day mortality between the matched cohorts, patients with COVID-19 had higher 90-day mortality, a higher rate of complications (primarily pulmonary), and a higher rate of failure to rescue (mortality in patients who develop complications). This study compared COVID-19-negative patients treated during the pandemic period (2020) to propensity score-matched patients treated before the pandemic (2019). Interestingly, patients undergoing surgery during the pandemic had a higher rate of failure to rescue events, suggesting that the perioperative risk associated with COVID-19 may not be solely related to the biological effects of SARS-CoV-2 infection, but also to the strain on health care systems. Based on these data suggesting an association between perioperative COVID-19 and a higher risk of postoperative morbidity and mortality, most studies recommended delaying nonessential surgical interventions and carefully weighing the benefits versus risks of all operative interventions in patients with current COVID-19 infection.

Timing of Surgery After Severe Adult Respiratory Syndrome Coronavirus-2 Infection

The first large study examining the optimal timing of surgery following COVID-19 infection was an international, prospective, cohort study that enrolled more than 140,000 patients in October 2020. Among them, 3127 patients were preoperatively diagnosed with COVID-19. This study demonstrated that patients operated within 7 weeks following COVID-19 diagnosis had a significantly increased risk of 30-day postoperative mortality and pulmonary complications compared with COVID-19-negative patients. In addition, there was a gradual and consistent relationship between the precise timing of surgery within 7 weeks of diagnosis and the risk of mortality, with the following odds ratios for specific time periods within 7 weeks: 0 to 2 weeks = 4.1 (95% CI, 3.3–4.8), 3 to 4 weeks = 3.9 (95% CI, 2.6–5.1), and 5 to 6 weeks = 3.6 (95% CI, 2.0–5.2). In contrast, there was no significant difference in mortality between patients who were operated at ≥7 weeks following COVID-19 diagnosis (and were asymptomatic at the time of surgery) and COVID-19-negative patients. However, patients with ongoing COVID-19-related symptoms at the time of surgery (even after 7 weeks following diagnosis) had significantly higher 30-day mortality. It should be noted that most studies evaluating outcomes of COVID-19 patients undergoing surgery were conducted before widespread vaccination and the emergence of novel virus variants (eg, delta, omicron). The APSF and ASA 2022 joint statement, on the timing of elective surgery after COVID-19 infection, suggests the following waiting times between the COVID-19 diagnosis and surgery:

- Four weeks for an asymptomatic patient or a patient recovering from only mild, non-respiratory symptoms
Six weeks for a symptomatic patient (eg, cough, dyspnea) who did not require hospitalization
Eight to ten weeks for a symptomatic patient who is diabetic, immunocompromised, or hospitalized
Twelve weeks for a patient who was admitted to an intensive care unit due to COVID-19 infection

Surgical and anesthesia societies from the United Kingdom similarly provided an updated multidisciplinary statement pertaining to the timing of elective surgery, which also recommended postponing elective surgery for 7 weeks following COVID-19 diagnosis, unless the benefits of immediate surgery clearly outweigh the risks of operation. This statement also highlights the importance of preoperative vaccination and suggests that the last dose should be administered at least 2 weeks before the operation.

Risk of Contracting Severe Adult Respiratory Syndrome Coronavirus-2 Perioperatively

The risk of contracting COVID-19 perioperatively seems to be low. An international multicenter study, including 9171 patients from 447 hospitals and 55 countries, conducted during the first peak of the pandemic (Spring 2020) found that the rate of postoperative COVID-19 infection was as low as 3.2%. The rates of postoperative COVID-19 infection, pulmonary complications, and mortality were lower in patients treated at hospitals implementing a COVID-19–free surgical pathway, defined as complete segregation of operating rooms, intensive care units, and inpatient ward areas used in the treatment of elective surgical patients versus patients with COVID-19. In a single-center study from the United States during the initial peak of the pandemic (March 15–May 15, 2020), the rate of postoperative SARS-CoV-2 infection was reported at 1.8%. Preoperative and intraoperative variables associated with postoperative SARS-CoV-2 infection were history of diabetes mellitus, cardiovascular disease, use of angiotensin receptor blockers, and surgery for liver transplantation.

Trauma and Emergency Surgery

The COVID-19 pandemic has had a profound impact on acute care surgery including emergency general surgery and trauma surgery as well as on surgical critical care. During the first wave of the pandemic, and with the overwhelming number of critically ill COVID-19 patients and the need for critical care experts, most acute and critical care surgeons assumed the role of medical intensivists, caring for severely ill COVID-19 patients. Acute care surgeons also played a critical role in the management of devastating COVID-19 complications, such as COVID-19-related bowel ischemia (ie, COVID bowel). One of the earliest studies evaluating the outcomes of patients undergoing emergency operations was conducted at two hospitals in New York City. The findings revealed a substantially elevated risk of perioperative morbidity and mortality in this patient population which was later confirmed by several other large multicenter studies. These studies recommended judicious consideration of nonoperative management for certain “emergent” surgical conditions or possibly delaying operative intervention. These data should be interpreted carefully as these studies did not evaluate outcomes after nonoperative management in COVID-19 patients. The results of the World Society of Emergency Surgery COVID-19 survey conducted in June 2020 on surgical specialists in emergency surgery revealed alarming results. Respondents reported fewer emergency surgical patients, and an increased number of patients with more severe abdominal sepsis which might be associated
with delayed presentation, potentially due to strains on health care systems and fear of contracting SARS-CoV-2 among patients.

Trauma teams similarly experienced reallocation of resources toward the treatment of COVID-19. \cite{31} Following the implementation of stay-at-home orders, several studies, across different geographic locations, reported decreased overall trauma volume. \cite{32–34} In the United States, several studies reported alterations in injury patterns: a markedly increased proportion of penetrating trauma potentially associated with increased gun violence or possibly a relative increase in the ratio due to decreased blunt trauma. \cite{35,36} Despite lower patient volume, the pandemic presented significant challenges to trauma care. The contemporary management of the massively bleeding patient, largely based on early and balanced blood product transfusions while minimizing crystalloid infusions, \cite{37} and most trauma centers had to adopt stringent transfusion practices because of critical blood shortage related to the pandemic. \cite{38,39} Rehabilitation and physical therapy post-injury, which are associated with improved outcomes following injury, were limited to minimize hospital length of stay and ambulatory hospital visits. \cite{40} A retrospective study evaluating the overall impact of COVID-19 on the outcomes of patients admitted to trauma centers across Pennsylvania between March and July 2020 reported an elevated risk of morbidity and mortality associated with COVID-19. \cite{41}

**Elective Surgery**

Elective surgery was severely disrupted during the COVID-19 pandemic. During the initial peak, elective surgery came to a near-complete halt as hospitals were overwhelmed by the influx of severely ill patients and available resources were directed to the care of COVID-19 patients. Although such care was prioritized, a significant proportion of elective operations were canceled for benign and even malignant indications, creating a backlog of surgical cases that remains a burden after more than 2 years since the first peak. A global expert study estimated that during the peak 3-month period of the pandemic, nearly 28.5 million elective surgical cases were canceled worldwide (190 countries), with an overall cancellation rate of 72.3% (81.7% for benign conditions, 37.7% for malignant conditions). \cite{42} The same study estimated that if countries increased surgical volume by 20% following the pandemic, it would take approximately 45 weeks to remedy the backlog created by the pandemic. \cite{42} COVID-19 has also resulted in severe shortages in the supply of several surgical resources hindering the surgical volume of hospitals. In 2022, the American Red Cross, the major supplier of blood products in the United States, declared the most severe blood shortage crisis in more than the prior decade, suggesting that on certain days, hospitals may receive less than 25% of the blood products requested. \cite{39} A significant shortage in contrast media used in computerized tomography imaging disrupted surgical care significantly since May 2022. \cite{43} In response to the significant disruption of elective surgery, The ACS, ASA, Association of Perioperative Registered Nurses (APRN), and American Hospital Association (AHA) issued a joint statement suggesting a roadmap for resuming elective surgery after the COVID-19 pandemic. \cite{44} This roadmap suggested that:

1. The prevalence of COVID-19 cases should be low for at least 14 days before resuming elective operations, and the facility should have the necessary resources (e.g., ICU and floor beds, personal protective equipment [PPE], and ventilators) to care for elective surgical patients without the need for crisis-level operations.
2. The hospital should have adequate resources for SARS-CoV-2 laboratory testing and should implement a systematic protocol to test surgical patients and personnel for COVID-19.
3. The hospital should have adequate PPE and other surgical supplies before resuming elective cases.

4. A case prioritization committee should be established with the participation of surgery, anesthesia, and nursing to prioritize elective surgeries to best address the needs of the hospital’s patient population.

5. The hospital should develop policies to address the impact of COVID-19 and case cancellations on the five phases of surgical care: preoperative, immediate preoperative, intraoperative, postoperative, and post-discharge care planning.

6. The hospital should collect local data on its COVID-19 and surgical practices and compare these data with regional and national data.

7. The hospital should implement safety and social distancing protocols to mitigate the risk of COVID-19 for patients, personnel, and visitors.

**Oncological Surgery**

Cancer surgeries are frequently time-sensitive and cannot be safely postponed for 2 to 3 months. These cases are considered “essential” operations and typically not classified as elective. Efforts should be made to maintain cancer surgery despite the challenges posed by the pandemic. Cooperation between health care facilities could help maintain the regional quality of surgical cancer care, despite capacity issues or other problems at individual hospitals. The joint statement by the ACS, ASA, APRN, and AHA for maintaining essential surgery during the pandemic provides a valuable guide for the delivery of essential surgical care.

**Anesthesia Considerations**

The choice of anesthesia should be primarily dictated by the individual operation and patient characteristics. The use of regional anesthesia (neuraxial anesthesia or nerve blocks) can eliminate the need for endotracheal intubation and decrease aerosol production. If intubation is not required, the patient should wear a surgical mask during the procedure unless contraindicated. Endotracheal intubation and extubation produce high amounts of aerosols and are high-risk procedures for transmission. High-level PPE (respirator, eye/face protection, gown, and gloves) is required for personnel performing these airway procedures. The number of personnel in the operating room during intubation should be minimized. Low volume and low pressure breaths should be delivered during bag-mask ventilation to potentially decrease exposure to aerosol contamination. In patients with difficult airways and no contraindications, rapid sequence intubation is an acceptable strategy to minimize time to intubation and aerosol production.

**Postoperative Follow-up**

Physicians should anticipate and prepare for challenges in postoperative follow-up during the COVID-19 pandemic. Patients with perioperative SARS-CoV-2 infection have a higher risk of postoperative morbidity and mortality, compared with non-COVID patients undergoing the same operations. Specifically, they have higher rates of postoperative thrombotic and pulmonary complications, and potentially a lower rate of bleeding complications (Argandykov and colleagues 2022, unpublished data). Clinicians should adjust their postoperative protocol and weigh the benefit versus harm of potential interventions (eg, thromboprophylaxis) in light of these data.

Some institutions have implemented telemedicine perioperative appointments to minimize the number of office or ambulatory hospital visits. A single-center retrospective study from the United States concluded that postoperative visits via telem medicine did not increase the risk of readmission compared with in-person visits after oncologic
surgery. Health care providers should use telemedicine judiciously as needed, considering patient factors, local COVID-19 prevalence, and institutional resources.

**Surgical Research**

The clinical burden imposed by the COVID-19 pandemic severely restricted the ability of surgeon-scientists to conduct research studies. The vast majority of research resources were directed toward elucidating the pathogenesis and improving treatment of COVID-19. The impact of the pandemic seems to be more significant on female researchers. A retrospective analysis of submissions to Journal of the American Medical Association Surgery found that a significantly lower percentage of manuscripts with female corresponding authors were submitted in April to May of 2020 versus 2019. After the COVID-19 pandemic, it will be important to address the recession in research areas not related to COVID-19 and the apparent gender disparity in academic publications.

**SUMMARY**

The ongoing COVID-19 pandemic presents multiple clinical, logistical, and academic challenges for surgery. Surgical providers should adapt to the rapidly evolving pandemic to provide the best possible care to patients, ensure the safety of health care personnel, and advanced surgery through academic research.

**DISCLOSURE**

The authors have nothing to disclose.

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