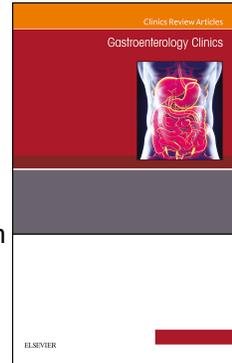


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Surgical Implications of COVID-19

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Abstract

As the COVID-19 pandemic continues to evolve in 2022 with the surge of novel viral variants, it is important for physicians to understand and appreciate the surgical implications of the pandemic. This review provides an overview of the implications of the ongoing COVID-19 pandemic on surgical care and provides recommendations for perioperative management.

All preoperative patients should be screened for 1) history of exposure to individuals with known COVID-19 within the last 14 days, and 2) symptoms suggestive of COVID-19. Surgical risk assessment in COVID-19 patients is challenging; most observational studies suggest a higher risk for patients undergoing surgery with COVID-19 compared to risk-adjusted non-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. The risk of contracting COVID-19 perioperatively is low (<2%) and the use of COVID-19-free surgical pathways reduce the risk of postoperative infection. There are no data comparing operative vs. non-operative management of COVID-19 patients for emergency surgical conditions that can also be treated medically; decision to operate should be made judiciously considering clinical acuity, patient comorbidities, and local resources. 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. Disruptions in the healthcare supplies related to the pandemic continue to impact surgical care such as the critical ongoing blood shortages and the contrast medium shortages. Postoperative follow-up of COVID-19 patients should be tailored to the specific morbidity profile of COVID-19, anticipating higher rates of postoperative thrombotic and pulmonary complications, and potentially a lower rate of bleeding complications.

Introduction

Coronavirus Disease-19 (COVID-19), caused by the Severe Acute 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 healthcare systems and resulted in unprecedented challenges to healthcare providers around the world. For surgical patients, COVID-19 complicates perioperative risk and subsequently the benefits versus risks balance of any invasive operation. Additionally, it quickly became evident that surgery plays a central role in the treatment of severe COVID-19 (e.g., tracheostomy and gastrostomy tube placement) as well as COVID-19 complications (e.g, bowel ischemia).² In addition, healthcare providers involved in the perioperative care of patients are at 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 healthcare 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 (Figure 1). This review provides an overview of the implications of the ongoing COVID-19 pandemic on surgical care 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.^{3,4} 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.⁵ Due 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 (e.g., 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.⁶⁻

⁹ An international multicenter study of 8,784 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 low disease prevalence performing minor surgery.¹⁰ 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 pre-operative 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 (CDC).¹¹

Surgical Risk in Patients with Perioperative COVID-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-19.¹²⁻¹⁴ 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. 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

(POTTER) Calculator and the ACS-NSQIP Surgical Risk Calculator are applicable in the setting of SARS-CoV-2 infection.^{15,16}

An early study evaluating the outcome of patients with perioperative COVID-19 (defined as the presence of SARS-CoV-2 infection within seven days before or within 30 days after an operation) reported a remarkably high 30-day mortality rate of 23.8%.¹⁴ In this international observational study including 1,126 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.¹⁷ Other cohort studies demonstrated substantial variability in mortality from 5.4% to 42.8%.^{18,19} 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.^{12,20} 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.²¹ 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).²² This study compared COVID-19-negative patients treated during the pandemic period (2020) to propensity score matched patients treated prior to 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 healthcare systems. Based on this data suggesting an association between perioperative COVID-19 and a higher risk of postoperative morbidity and mortality, most studies recommended delaying non-

essential surgical interventions, and carefully weighing the benefits versus risks of all operative interventions in patients with current COVID-19 infection.^{12,14,20}

Timing of Surgery After SARS-CoV-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 2020.²³ Among them, 3,127 patients were preoperatively diagnosed with COVID-19. This study demonstrated that patients operated within seven weeks following COVID-19 diagnosis had a significantly increased risk of 30-day postoperative mortality and pulmonary complications compared to COVID-19-negative patients. Additionally, 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: 0-2 weeks= 4.1 (95% CI, 3.3 – 4.8), 3-4 weeks= 3.9 (95% CI, 2.6 – 5.1), and 5-6 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 prior to widespread vaccination and the emergence of novel virus variants (e.g., delta, omicron). The APSF and ASA 2022 joint statement, on the timing of elective surgery after COVID-19 infection,²⁴ 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 (e.g., cough, dyspnea) who did not require hospitalization
- Eight to 10 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.²⁵ This statement also highlights the importance of preoperative vaccination and suggests that the last dose should be administered at least two weeks before the operation.

Risk of Contracting SARS-CoV-2 Perioperatively

The risk of contracting COVID-19 perioperatively appears to be low. An international multicenter study, including 9,171 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%.²⁶ 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 vs patients with COVID-19.²⁶ In a single-center study from the US 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%.²⁷ Pre- and intra- operative 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.²⁷

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 (i.e., COVID bowel).^{28,29} One of the earliest studies evaluating the outcomes of patients undergoing emergency operations was conducted at two hospitals in New York City.¹³ 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.^{21,30,31} 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 non-operative management in COVID-19 patients. The results of the World Society of Emergency Surgery (WSES) COVID-19 survey conducted in June 2020 on surgical specialists in emergency surgery revealed alarming results.³² 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 healthcare systems and fear of contracting SARS-CoV-2 among patients.

Trauma teams similarly experienced reallocation of resources towards the treatment of COVID-19.³³ Following the implementation of stay-at-home orders, several studies, across different geographic locations, reported decreased overall trauma volume.³⁴⁻³⁶ In the US, 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.^{37,38} 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,³⁹ and most trauma centers had to adopt stringent transfusion practices because of critical blood shortage related to the pandemic.^{40,41} 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.⁴² 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-19.⁴³

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. While such care was prioritized, a significant proportion of elective operations were cancelled for benign and even malignant indications, creating a backlog of surgical cases that remains a burden after more than two 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 cancelled worldwide (190 countries), with an overall cancellation rate of 72.3 % (81.7% for benign conditions, 37.7% for malignant conditions).⁴⁴ 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.⁴⁴ 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 U.S., 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.⁴¹ A significant shortage in contrast media used in computerized tomography imaging disrupted surgical care significantly since May 2022.⁴⁵ In response to the significant disruption of elective surgery, The American College of Surgeons (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.⁴⁶ This roadmap suggested that:

1. The prevalence of COVID-19 cases should be low for at least 14 days prior to resuming elective operations and the facility should have the necessary resources (e.g., ICU & floor beds, personal protective equipment, 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 personal protective equipment (PPE) and other surgical supplies prior to 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 2-3 months. These cases are considered “essential” operations and typically not classified as elective.⁴⁷ Efforts should be made to maintain cancer surgery despite the challenges posed by the pandemic. Cooperation between healthcare 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.⁴⁸

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, 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 to 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 et al 2022, unpublished data). Clinicians should adjust their postoperative protocol and weigh the benefit vs. harm of potential interventions (e.g. 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 U.S. concluded that postoperative visits via telemedicine did not increase the risk of readmission compared to in-person visits after oncologic surgery.⁴⁹ Healthcare 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.⁵⁰ The vast majority of research resources were directed towards elucidating the pathogenesis and improving treatment of COVID-19. The impact of the pandemic appears

to be more significant on female researchers. A retrospective analysis of submissions to JAMA (Journal of the American Medical Association) Surgery found that a significantly lower percentage of manuscripts with female corresponding authors were submitted in April-May of 2020 vs. 2019.⁵¹ 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.

Conclusions

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 healthcare personnel, and advanced the field of surgery through academic research.

Figure legend

Figure 1. Surgical Implications of COVID-19

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Surgical Implications of COVID-19

Preoperative Screening & 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 (e.g., fever, cough, dyspnea, 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 appear to have higher risk of postoperative morbidity and mortality compared to 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 vs. non-operative 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 healthcare systems should prepare to address the backlog in surgical care despite the ongoing disruptions in the healthcare 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 & 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 appear 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.