

**Protecting Surgical Teams During the COVID-19 Outbreak:
A Narrative Review and Clinical Considerations**

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SARS-CoV-2, the virus responsible for coronavirus disease 2019 (COVID-19), has caused a global pandemic that may infect millions in the United States alone. Given the baseline rate of emergency operations in the US,¹ thousands of COVID-19 positive patients are likely to require surgical interventions during this outbreak.

Surgeons' obligation, as always, will be to provide timely, high-quality surgical care that achieves the best outcomes for patients. But if surgical teams are not adequately protected from virus transmission during the COVID-19 outbreak, our health systems' capacity to provide necessary care will collapse as more clinicians are forced into quarantine. Moreover, protecting those who care for the acutely ill and injured is the ethical decision to prevent anxiety and attrition.

In this review, we draw from published literature and clinical experience to highlight key considerations for surgical teams operating on patients with suspected or known COVID-19.

KEY CONSIDERATIONS FOR SURGEONS

Surgical teams are at uniquely high risk for SARS-CoV-2 exposure. Viral particles have been found in nasal swabs, pharyngeal swabs, sputum, bronchial swabs, gastrointestinal tissue, blood, and stool.^{2,3} Surfaces in isolation rooms and even clinician shoe covers have tested positive as well.^{4,5} Moreover, the virus can spread via aerosols and fomites, and survive as aerosol for at least 3 hours and on surfaces for days.⁶ Studies of other viruses have found viral load in essentially all tissues and fluids tested and even surgical smoke from the use of electrocautery.^{7,8} Given these inherent risks, we outline key considerations for protecting surgical teams below.

I. Structure Frequent Communication Before Key Events

Without detailed planning and protocols, transporting a patient with COVID-19 puts clinicians and patients at high risk of viral transmission. Frequent, structured communication in the form of huddles plays an integral role in mitigating this risk. A recent article described the value of bringing together stakeholders to plan safe patient transport and the process of getting the patient onto the operating room table.⁹ Huddles should include surgeons, the anesthesia team, intensive care unit (ICU) attendings and nurses, respiratory therapists, operating room (OR) nursing staff, environmental services, security, and members of infection control. To standardize this process, hospitals have developed transport protocols for the operative team^{10,11} and are performing transport simulations to prepare for high numbers of potential patients. Open

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communication between the surgical team and peri-operative staff allows the group to transfer high-risk patients from wards to the OR and back with reduced risk to the team.

II. Assume the Entire OR Will Be Contaminated

SARS-CoV-2 can survive for days on multiple operating room surfaces, including plastic and stainless steel.⁶ Under ordinary conditions, operating rooms use positive pressure airflow, but this runs the risk of contaminating adjacent ORs and hallways; thus, operating rooms with negative pressure capabilities are recommended.¹² When negative pressure rooms are unavailable, it is important to allow sufficient time between cases for complete room air exchange--usually on the order of 30 minutes. This time interval is based on the number of air changes per hour as described by the CDC.¹³

Items such as hospital charts, pagers, and cell phones must be left outside the OR with contingencies to respond to time sensitive pages. Additionally, anything that was in contact with the patient, such as the ward bed, should also be considered contaminated. If possible, a dedicated runner should be posted outside of the OR to obtain supplies such as suture, surgical staplers, and energy devices as needed.⁹ This eliminates the need for excessive movement into and out of the room by the circulating nurse, and also minimizes consumption of personal protective equipment with every entry and exit of the room. All single-use equipment (even unopened) in the room is thrown away at the end of the case, and thus only what is currently needed and absolutely required for the case should be brought in.

III. Choose Protective Equipment Effective Against Aerosolized Particles

Standard surgical personal protective equipment (PPE) includes a face shield, mask, waterproof gown, double gloves, and shoe covers. There is some disagreement, however, about the type of respiratory protection--N95 respirator, powered air purifying respirator (PAPR), or standard surgical mask--that should be used for surgical procedures on patients with COVID-19. Currently, we are not aware of data to suggest that either the N95 or PAPR are better to protect against COVID-19. PAPRs are generally used when HCWs cannot achieve a proper fit with an N95; guidelines and mask specifications suggest equivalence for aerosolized agents.¹⁴ A surgical mask is capable of blocking gross inhalation of droplets, while a well-fitted N95 respirator is additionally capable of filtering aerosols. This is of particular interest to surgeons as aerosols have been identified from multiple surgical procedures, including those that use electrocautery and high-speed tools,^{15,16} and smoke from electrocautery has been shown to harbor intact bacterial and virus particles.^{7,8, 17-19} As such, surgery can be considered a form of "aerosol generating procedure" (AGP),²⁰ especially with the use of electrocautery and/or laparoscopy.

The Centers for Disease Control in both the US²⁰ and in China,²¹ as well as the Association of Spanish Surgeons,²² specifically recommend use of N95 respirators (preferably without valves)

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for surgeries with AGPs on COVID-19 patients. Australia's Department of Health encourages N95 use for "high-level contact" with infected patients.²³ A recent guideline in the Chinese Journal of Surgery presented recommendations for emergency surgery in COVID-19 patients that specifically include the use of N95 masks for anesthesia and surgical teams.²⁴

However, the World Health Organization (WHO) recently published PPE guidance for healthcare workers that did not specify that surgical procedures required N95 respirators.²⁵ Some groups may erroneously interpret the absence of laparoscopy or electrocautery on the list to imply that most surgical procedures are not aerosol-generating. The meta-analysis cited by the WHO guidance specifically noted that there were nearly no surgical cases included in its analysis because it focused on tracheal aerosols--and only open thoracotomy was extracted as a data element.²⁶ In a time when there is limited information about transmission of COVID-19, aggressive protection⁴ with complete PPE for AGPs (which includes N95 masks) is in line with guidance from multiple national organizations as well as the limited data available from previous research.

IV. Adapt Surgical Technique to Reduce Exposure Risks

It is unclear if laparoscopy increases surgeon risk of exposure to aerosolized viral particles. Carbon dioxide insufflation, energy devices, and high-speed surgical equipment generate significant aerosols. Though aerosols may be contained in the abdomen during laparoscopy, when expelled under pressure—such as with release of pneumoperitoneum—they may spread widely.^{27,28} Care should be taken to minimize the possibility of inadvertent release and filter the CO₂ using existing technology.^{24,29}

However, this risk may not be unique to laparoscopy. Viral and bacterial aerosols have been identified in surgical plumes in both laparoscopic and open procedures.^{8,15,17,18} However, the use of a smoke evacuation device is in line with pre-existing OR guidelines³⁰ and may reduce aerosol exposure in both open and laparoscopic procedures. In the absence of convincing data, when both open and laparoscopic approaches are clinically appropriate, the safest approach may be the one that is most familiar to the surgeon and reduces operative time.

V. Use a "Buddy System" for Donning and Doffing

Clinicians may actually be more likely to infect themselves when removing their PPE than when caring for a contagious patient.³¹ To avoid self-contamination, everyone in the OR must be able to put on (don) and remove (doff) PPE correctly. Proper gowning and doffing procedures should be reviewed with surgeons, residents, and OR staff before each case to ensure proper technique.^{32,33} In addition, based on previous viral outbreaks, a "buddy system" has been recommended, in which providers assist with and oversee the doffing of a colleague.³⁴ In our experience, the combined use of video-based instruction and a colleague's oversight

significantly improves anxiety among staff and may lead to less self-contamination during PPE removal.

Concluding Thoughts

Though careful planning and appropriate PPE are essential, the most effective way to prevent viral exposure is to avoid performing non-essential surgical procedures. As recommended by the American College of Surgeons,³⁵ this limits the opportunities for patients and clinicians to become exposed, conserves personal protective equipment, and preserves health system capacity. Non-operative approaches (e.g. for appendicitis, diverticulitis, and cholecystitis) may be a safe alternative to surgery for some patients. Many patients, however, will require emergency operative intervention.

Our evaluation of the literature has provided more questions than answers with regard to PPE choices and surgical technique. Recent clinical trials have focused on outpatient clinicians,³⁶ but no study has effectively evaluated how best to protect operating surgeons. As we better understand the epidemiology of transmission of these agents and methods of prevention, there is a need to study and re-evaluate the information above.

Thus, the issues highlighted in this review should not be taken as official guidelines, mandates, or standard operating procedures. The global community is learning more about COVID-19 every day. Surgeons should seek guidance from their appropriate national, local, and hospital guidelines and regulations—many of which are likely to change over time as new information becomes available to the global community.

By presenting our best understanding of the literature, we are hoping to promote the safety of surgical teams and, as a result, the patients who are relying on them for life-saving surgical care.

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