Review Article

The status of laparoscopic surgery in the COVID-19 crisis: a narrative review of current recommendations

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Abstract: SARS-CoV2 (COVID-19) is an unprecedented pandemic which has required thoughtful resource management for all specialties, including general surgery. There is uncertainty regarding risks of virus aerosolization and laparoscopic surgery. This narrative review discusses these concerns of virus exposure and transmission for health care workers in the operating room by summarizing currently available recommendations and describing our institution's experience. Our virology review was performed by compiling published data on various viruses' presence in blood, peritoneal fluid and surgical smoke. Our recommendations review was performed by researching official organizational guidelines and medical archives (medRxiv) pre-prints. SARS-CoV-2 is mainly transmitted via respiratory droplets. Previous studies have demonstrated the ability of other viruses to form aerosol particles in peritoneal fluid and surgical smoke. Aerosol-generating medical procedures (AGMPs) are considered important risks for nosocomial transmission of viruses, but there is no consensus to include all surgical procedures as so. Most local and international organizations highlight the concerns surrounding laparoscopy, but are not strictly discouraging this modality. They recommend proceeding with caution to minimize surgical smoke exposure by ensuring the use of filtration systems, tight air-seals and fewer incisions. We can extrapolate from other viruses that SARS-CoV-2 may present a potential infectious risk in the operating room. Until evidence arises otherwise, we recommend considering all surgical procedures to be aerosolizing. Laparoscopy continues to be a safe and appropriate modality. Full airborne personal protective equipment (PPE) should be utilized in all emergent cases, and droplet PPE only in urgent elective cases for asymptomatic, screen- and test-negative patients.

Keywords: COVID-19; SARS-CoV-2; pandemic; laparoscopy; recommendations

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Introduction

In the midst of a generational pandemic, one is confronted by decision-making in the absence of high-quality evidence. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic is one such unprecedented global threat, with over 1,400,000 infections and 80,000 deaths by early April 2020 (1). All across the world, elective operations are being cancelled, and the focus has been shifted to life-saving surgical interventions. For many General Surgery programs, this has meant cancelling all elective operations, saving resources for cancer and emergent surgeries. With ever-increasing procedures done through minimally invasive or laparoscopic techniques, there is growing uncertainty regarding this approach in the midst of the coronavirus disease (COVID-19) pandemic. This uncertainty arises from the potential danger to healthcare workers (HCW) of virus exposure through laparoscopic surgery and resource concerns around increased operating times and utilization of operating rooms, ventilators and personal protective equipment (PPE).

In this paper, we discuss concerns around exposure of HCWs to COVID-19, drawing analogies to other better understood viruses. Our narrative review of current guidelines from local, national and international organizations around laparoscopy and COVID-19 aims to summarize the current guidance. We also discuss potential advantages and disadvantages towards adopting laparoscopic techniques in the midst of the COVID-19 pandemic. We present the following paper in accordance with the Narrative Review reporting checklist (available at http://dx.doi.org/10.21037/ales-20-86).

Methods

Our virology review was performed by compiling previously published data on various viruses' presence in blood, peritoneal fluid and surgical smoke. We searched published journal articles in the English language on PubMed using combinations of the following terms: "MERS", "SARS", "SARS-CoV-1", "SARS-CoV-2", "coronavirus" or "virus", and "surgical smoke", "blood", "peritoneal fluid" or "fluid". We included all relevant studies in our review and summary table. Our recommendations review was performed by researching official surgical organizations' guidelines and medical archives (medRxiv) pre-prints.

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This manuscript did not require Research Ethics Board approval as it does not involve patient or animal data.

Laparoscopy's risks in the setting of viral infections

A considerable amount of evidence based on experience is accumulating regarding the modes of transmission of COVID-19. Similar to previous coronaviruses (SARS-CoV-1 and MERS-CoV), SARS-CoV-2 is thought to be transmitted from person to person mainly via respiratory droplets and contact (2), but has been isolated in upper respiratory tracts as well as stool and blood (3,4). Airborne transmission through formation of aerosols was an important cause of transmission with previous coronaviruses (5,6) and it appears that in certain circumstances, aerosolized COVID-19 can remain viable for up to three hours (7). Aerosol-generating medical procedures (AGMPs) are procedures that have the potential to create new aerosols in addition to those created by infected individuals (8). Although AGMPs are increasingly perceived as risks for nosocomial transmission of viruses (9), few studies have investigated whether surgical procedures can be AGMPs (6).

Laparoscopic surgery is an essential part of general surgery, but can pose a risk of aerosolization and expose health care workers to potential harm during the operation via two main processes: creation of surgical smoke and use of pneumoperitoneum. While studies have demonstrated the presence of viable bacterial and viral aerosols in the large amount of smoke produced with the use of electrocautery or laser (10), there have been no tangible demonstrations of transmission. Viruses such as human immunodeficiency virus (HIV), human papillomavirus (HPV), and hepatitis B (HBV) have been identified in surgical smoke (*Table 1*) (11-13,16,17,19), with one study reporting a surgeon developing laryngeal papillomatosis after treating a patient (18). The presence of virus particles such as hepatitis B and C viruses (HBV and HCV), HIV, herpes simplex virus (HSV) and SARS-CoV-1 has also been observed in different collections of peritoneal fluid (*Table 1*) (14,15,20-23). Recent case reports published varying results in regards to SARS-CoV-2, describing both its presence and absence in peritoneal fluid (24-27).

In the context of COVID-19, these concepts are of immediate concern. Acknowledging that other types of viruses have been found in surgical smoke and peritoneal fluid specimens, and that SARS-CoV-2 has also been

Table 1 Presence of viruses in surgical smoke and peritoneal fluid

Viruses	Surgical smoke (aerosols)	Peritoneal fluid
Human immunodeficiency virus (HIV) (11-15)	Present	Present
Human papillomavirus (HPV) (16-18)	Present	n/a
Hepatitis B virus (HBV) (19,20)	Present	Present
Hepatitis C virus (HCV) (21)	n/a	Present
Herpes simplex virus (HSV) (22)	n/a	Present
Severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1) (23)	n/a	Present
Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (24-27)	n/a	Present/absent

isolated from peritoneal fluid samples, it is fair to question its ability to have the same properties as previous viruses. As such, release of air through trocar valves and non-air-tight exchange of surgical instruments could be seen as AGMPs. This has led to concern that surgical procedures as a whole, whether open or laparoscopic, could potentially be hazards for airborne transmission to health care workers in the operating room.

As the COVID-19 pandemic has evolved, evidence has emerged that asymptomatic infections and infections in the presymptomatic phase can be associated with high viral loads and up to 12.6% of transmissions are thought to be from asymptomatic or presymptomatic patients (28). This has led to discussions regarding appropriate screening of patients being assessed for surgery. Current nasopharyngeal swab testing for COVID-19 yields an approximately 30% false negative rate (29). Routine use of CT scans of the chest has been recommended by some, including the Intercollegiate General Surgery Guidance (30), however false negative results remain possible (31,32). Further, the majority of acutely unwell patients presenting to general surgery Acute Care Surgery services will meet symptomatic criteria with fever, abdominal pain and some element of nausea, vomiting and diarrhea. Thus, recommendations for surgery in acutely unwell patients without suspected COVID-19 must acknowledge this reality and treat all emergency patients, including those who are asymptomatic, as potentially COVID-19 positive. For urgent elective surgeries, patients who are asymptomatic, have no exposure history and test negative for SARS-CoV-2 have a very low false negative risk.

Considerations in laparoscopy

There are well-recognized advantages to laparoscopic techniques for many pathologies. In general, laparoscopic techniques are often associated with improved post-operative pain and decreased post-operative length of stay when compared with open approaches. As well, there are some procedures, such as cholecystectomy and appendectomy, where many surgeons may be more comfortable with a laparoscopic approach compared to open procedures. When considering the use of non-operative treatment approaches for some conditions, such as appendicitis and cholecystitis, it is also important to consider the advantages of surgery including the longer duration of hospitalization often required with antibiotics-only management, the risk of antibiotic treatment failure requiring the patient to return to receive further care, and the long-term risks of recurrence.

Despite the well-known benefits of laparoscopic surgical techniques, during the COVID-19 pandemic it is important for surgeons to consider the disadvantages to laparoscopy. Considering all surgeries to be potentially AGMPs and all acutely unwell patients needing emergency surgery to be COVID-19 positive suggests that surgical personnel may be at risk of contracting COVID-19 during procedures. As well, the process of intubating and extubating patients, as required with laparoscopy, places our anesthesia colleagues at particular risk for contracting the virus. Many regions globally are also encountering shortages of PPE as the COVID-19 pandemic progresses. Given the risk of aerosolization, routine use of airborne PPE in emergent laparoscopic surgical cases is prudent to protect surgical teams, but may strain systems already experiencing supply shortages and avoidance of all surgical procedures may be required. In fact, many systems have looked at other options to clean and reuse surgical masks, N95 respirators and powered air-purifying respirators (PAPRs) in order to optimize supplies and ensure their availability in high-

risk situations (33). In addition, safe operating room protocols (negative pressure rooms, lockdown periods for air exchange after intubation and between procedures, and minimalization of staff presence) are important adjuncts to ensure HCW safety and reduce COVID-19 infection risks (34,35).

Review of recommendations

The available recommendations generally approach the issues surrounding laparoscopy and COVID-19 in two ways: discussion of the appropriateness of laparoscopy as a surgical approach and methods to mitigate the risks associated with laparoscopy. The Intercollegiate General Surgery Guidance from the United Kingdom and Ireland is the only document strongly urging against laparoscopy due to concerns around aerosolization (30). They strongly advocate for the open surgical approach whenever feasible, and for avoidance of laparoscopy. Recommendations from Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)/European Association for Endoscopic Surgery (EAES), Canadian Association of General Surgeons (CAGS), *British Journal of Surgery* (*BJS*), American College of Surgeons (ACS), Spanish Society of Surgeons (AEC) and numerous local organizations highlight the concerns around laparoscopy, and advocate for surgeons to proceed with caution (36-45). They consider risks which include prolonged operative times, creation and concentration of surgical smoke, aerosolization of viral particles and the concerns around desufflation.

To decrease the potential risks associated with laparoscopy, all recommendations highlight the need for filtration systems and utilization of appropriate PPE. Minimization of surgical smoke is highlighted by most guidelines. SAGES/EAES, CAGS and AEC speak to the trocar issue by highlighting the importance of tight air-seals, smaller incisions and as few trocars as necessary (36,38,41). Smoke evacuation has also been described to be safely achievable through a self-constructed device, which would be a cost-beneficial alternative for resource-strained systems (46). *Table 2* summarizes the recommendations and possible risks highlighted by the individual documents.

The SAGES/EAES recommendations are the only national guidelines recognizing the potential benefits and advantages of laparoscopy to the patient in urgent and emergent surgery. However, they also do not provide direct guidance regarding whether airborne or droplet PPE should be used in laparoscopy (36). ACS, Intercollegiate and AEC recommendations include clear guidance to use airborne PPE (30,39,41).

A Canadian institution's experience

During this pandemic, the BC Ministry of Health has issued infection protocols for surgical procedures with the goals of ensuring HCW and patient safety, as well as optimizing resource management, which include exposure history, clinical symptoms and laboratory testing for SARS-CoV-2. Airborne precautions including N95 masks have been recommended for all surgical procedures until further guidance is available. This recommendation considers that the operating rooms incur higher risks of transmission given intubation risks, proximity to the patients and potential aerosolization of the virus. In this optic, our tertiary care centers in Vancouver have established operational guidelines for HCWs to provide safe surgical care in and out of the operating room (*Figure 1*). HCWs performing potentially AGMPs, including all surgical procedures, on suspected or positive COVID-19 patients have to use airborne PPE (N95 respirator, head and eye protection, gloves, gown). Non-operative management has been highly recommended if feasible. For emergent and urgent surgeries, all patients undergo pre-operative SARS-CoV-2 testing and a chest computed tomography (CT) should be added to any pending abdominopelvic CT imaging. For all emergent surgical procedures, airborne PPE is used in the operating room. For urgent elective surgeries, a pre-surgical screen has been implemented whereby patients undergo SARS-CoV-2 testing and if possible, a chest CT. For these patients, airborne PPE is used for unknown or positive COVID-19 patients, while droplet PPE can be used at the team's discretion in asymptomatic and COVID-19 test-negative patients.

Conclusions

As the COVID-19 pandemic has worsened, many issues have arisen for which little evidence exists. For surgeons, the optimal treatment of acute and chronic pathologies in settings with COVID-19 epidemics remains unclear. Society and regional guidance documents are being created, but are often based on little scientific evidence, forcing surgeons to weigh individual patient factors against health system concerns. As the pandemic has progressed, the recommendations from many organizations have changed and likely will continue to do so, based on the velocity

Table 2 Recommendations regarding laparoscopic surgery

Authors	Recommendations and guidelines				Rationale		
	Use of laparoscopy	Use of PPE	Surgical techniques	Safe use of laparoscopy techniques	Benefits of laparoscopy	Surgical smoke	Aerosolization of virus
Organizations and societies							
SAGES/EAES (29)	With caution	Appropriate PPE	Small incisions, min. pressures, minimize energy device use	Filtered CO_2 release, smoke evacuation, careful desufflation	Reduced LOS and complications, ultrafiltration of aerosolized particles	Yes	Assumed
BAPES (30)	With caution			Filtered CO_2 release		Yes	Assumed
CAGS MIS Committee (31)	With caution		Seal of ports, lower pressures	Filtered CO_2 release, careful desufflation		Yes	Assumed
ACS (32,33)	With caution	Airborne	Refer to SAGES	Refer to SAGES		Yes	Assumed
Intercollegiate (UK and Ireland) (26)	Generally should not use	Airborne		Filtered CO_2 release, careful desufflation		Yes	Yes
AEC (34)	With caution	Airborne	Reduce number of trocars	Smoke evacuation, careful desufflation	Limiting exposure to aerosols	Assumed	Assumed
Local groups							
Zhejiang Uni. (China) (35)	As per usual	Airborne					
Zheng *et al.*, *Annals of Surgery* (China and Italy) (36)	With caution		Short low-energy electrocautery dissection	Careful desufflation		Yes	Assumed
Spinelli *et al., BJS* (Italy) (37)	With caution			Smoke evacuation, filtered CO_2 release or closed circuit PIPAC, careful desufflation	Reduction of intraoperative smoke		Assumed
Carolinas Health Care (USA) (38)	With caution	Airborne					

EAES, European Association for Endoscopic Surgery; AEC, Spanish Society of Surgeons; ACS, American College of Surgeons; *BJS, British Journal of Surgery*; BAPES, British Association of Paediatric Endoscopic Surgeons; CAGS, Canadian Association of General Surgeons; LOS, length of stay; PPE, personal protective equipment; SAGES, Society of American Gastrointestinal and Endoscopic Surgeons; UK, United Kingdom.

and magnitude of spread. As the COVID-19 pandemic evolves and hopefully begins to resolve, a gradual return of operating time will continue to require thoughtful triaging of cases, appropriate screening of urgent surgical cases and individual assessment of operative approaches.

Based on our current review, we can extrapolate from other viruses, including SARS-CoV-1, that SARS-CoV-2 may be present in peritoneal fluid and blood. This presents a potential infectious risk, should these fluids be aerosolized. Until strong evidence arises suggesting otherwise, we would recommend considering all surgical procedures, including laparoscopy, to be aerosolizing. In areas with expanding COVID-19 community and nosocomial spread, the significant risk of false negative COVID-19 testing leads us to suggest surgeons should treat all patients requiring emergency surgery as presumed COVID-19 positive. As such, full airborne PPE (N95 respirator, eye protection, disposable gown and disposable cap) should be utilized for all

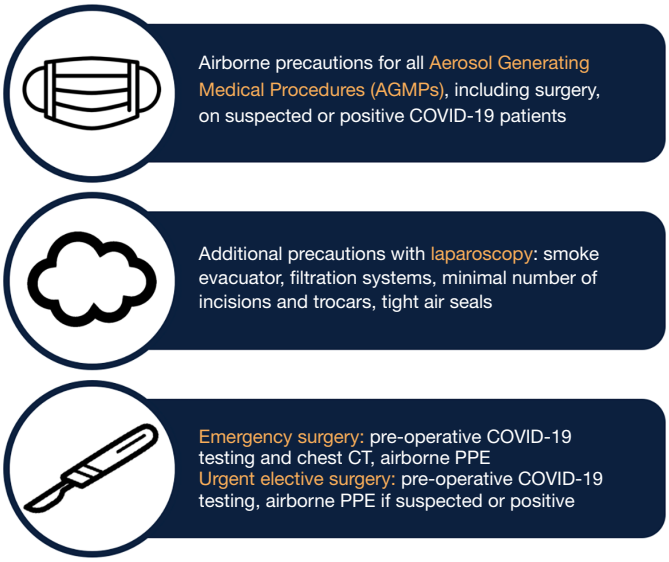

Figure 1 Institutional strategy for surgical care during the COVID-19 crisis. At Vancouver General Hospital and St. Paul's Hospital (Vancouver, BC, Canada), institutional guidelines were made available to help provide safe surgical care to patients during the COVID-19 pandemic. These include recommendations regarding personal protective equipment (PPE) use and precautions with laparoscopy.

emergent surgical procedures, open or laparoscopic. Patients undergoing urgent elective surgery, who are otherwise asymptomatic and screen or test COVID-19 negative, would still require routine droplet PPE. Although rigorous caution should be taken, the use of laparoscopy where deemed necessary still remains a valuable and justified option.

Despite repeated concerns regarding potential aerosolization in laparoscopic surgery, no evidence exists to compare this with open approaches. Laparoscopic surgery should not be treated as more or less aerosolizing than open surgery. Several techniques to minimize aerosol spread have been proposed, including tightening port sites, minimizing pneumoperitoneum, minimizing the use of energy devices, and using filtration systems and controlled desufflation. Despite the COVID-19 crisis, in settings with sufficient resources, laparoscopy continues to represent an appropriate surgical modality which may offer benefit to the individual patient and healthcare system.

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Footnote

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