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REVIEW ARTICLE

What Is the Appropriate Use of Laparoscopy over Open Procedures in the Current COVID-19 Climate?

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Abstract

Introduction Among surgeons worldwide, a concern with the use of minimally invasive techniques has been raised due to a proposed risk of viral transmission of the coronavirus disease of 2019 (COVID-19) with the creation of pneumoperitoneum. Due to this proposed concern, we sought to collect the available data and evaluate the use of laparoscopy and the risk of COVID-19 transmission.

Methods A literature review of viral transmission in surgery and of the available literature regarding the transmission of the COVID-19 virus was performed. We additionally reviewed surgical society guidelines and recommendations regarding surgery during this pandemic.

Results Few studies have been performed on viral transmission during surgery, but to date there is no study that demonstrates or can suggest the ability for a virus to be transmitted during surgical treatment whether open or laparoscopic. There is no societal consensus on limiting or restricting laparoscopic or robotic surgery; however, there is expert consensus on the modification of standard practices to minimize any risk of transmission.

Conclusions Despite very little evidence to support viral transmission through laparoscopic or open approaches, we recommend making modifications to surgical practice such as the use of smoke evacuation and minimizing energy device use among other measures to minimize operative staff exposure to aerosolized particles.

Keywords COVID-19 · Laparoscopic viral transmission · Smoke evacuation · Robotic surgery · SARS-CoV-2 · Viral transmission

Introduction

With the growing pandemic of the coronavirus disease of 2019 (COVID-19) and lack of available clinical knowledge, many of our traditional ways of practicing medicine and surgery have come into question. This has included the use of minimally invasive techniques such as laparoscopic and robotic surgery that require creating pneumoperitoneum. Leading surgical societies and institutions have helped guide us in terms of surgical practice; however, the appropriate use of laparoscopic and robotic techniques remains in question among many surgeons both nationally and internationally. And although in times like these it may be easier to give into our fears of the unknown and revert to older practices, we should remember, "nothing in life is to be feared, it is only to be understood"—Marie Curie.

Among surgeons around the world, a proposed theoretical risk of viral transmission with the use of laparoscopy has been raised in the setting of COVID-19. This concern has arisen from not only the discovery that COVID-19 virus RNA can be found in the stool of infected patients[1,2] but also the suggestion that the virus can be found in the gastrointestinal mucosa. Thus, despite the lack of evidence to demonstrate or refute the viral transmissibility from the gastrointestinal tract,[2] a threat that the virus can be transmitted from the abdomen exists. And some have theorized that the environment created by pneumoperitoneum for laparoscopy creates a relatively stagnant heated volume of gas in the abdominal cavity which may subsequently allow for a concentrated aerosolization of the virus. Thus, it is hypothesized that sudden bursts of this pneumoperitoneum from trocar valves during exchange of instruments or during the venting of trocars can allow for transmission of

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the virus. Due to this proposed concern as well as the discussion of this topic within our own group of surgeons, we sought to collect the available data and evaluate the use of laparoscopy and the risk of COVID-19 transmission.

Advantages of Laparoscopy with COVID-19

The current climate with the rising threat of COVID-19 makes for complex surgical decision-making. This decision-making must take into account the patients' exposure and well-being, the healthcare providers' exposure and well-being, and, lastly, resource conservation which includes hospital beds, ventilators, personal protective equipment (PPE), and medications. Therefore, the risks and benefits of every decision must be calculated in this limited climate of COVID-19 and so we review the benefits of laparoscopy in this environment.

First, the use of laparoscopy during this pandemic can contribute to decreased length of stay as compared with open surgery as well as minimizing the need for medical treatments, and in turn increasing availability of beds, a limited resource. Laparoscopy is less traumatic compared with a laparotomy, and in the case of a patient infected with COVID-19, a minimally invasive operation as compared with an open procedure might result in improved survival and faster recovery. Laparoscopy allows for a self-contained operative field with less and possibly no spillage of fluids and tissues, thus decreasing any risk to the operative staff. For this reason, in the 1990s during the acquired immunodeficiency syndrome (AIDS) epidemic, laparoscopic surgery was strongly encouraged over open surgery in patients infected with the human immunodeficiency virus (HIV).[3,4] And lastly, laparoscopic surgery and in particular robotic surgery allow for the staff and surgeon to be remote from the patient and from each other. This minimizes the risk of transmission of virus not only from the patient to the staff but also from operative staff infecting each other, as operative staff are in much closer proximity to each other and to the patient during open operations. Thus, as reviewed here, the benefits of laparoscopy that we have promoted and valued for many years can still provide a benefit even during the current pandemic and may even offer other benefits to this specific situation we may not have otherwise appreciated.

Risk of Transmission of Abdominal Aerosolized COVID-19

Coronavirus Transmission

Our understanding of the process of viral transmission in surgery is limited and our understanding of COVID-19 is even further limited. The virus responsible for COVID-19 (SARS-CoV-2) belongs to the subgroup of coronaviruses that include the severe acute respiratory syndrome coronavirus (SARS-CoV) and the Middle East respiratory syndrome coronavirus (MERS-CoV). Although very similar to these viruses, COVID-19 appears to be highly contagious due to its longer latency period. The only current known modality of transmission of the COVID-19 virus is through respiratory droplet transmission.[5,6] The size of these viral particles themselves ranges from 0.07 to 0.09 μm, which however are transmitted through droplet particles.[7] The mechanism for successful transmission is thought to be twofold: (1) *direct human to human* when the infected person coughs or exhales droplets that reach the other persons nose, mouth, or eyes to enter their respiratory tract or (2) *contaminated surfaces* when larger droplets produced from the infected person are spread onto surrounding surfaces and another person touches these contaminated surfaces and then touches their eyes, nose, or mouth. A third proposed mechanism has been suggested, although sufficient evidence is lacking, that an *aerosolizing procedure on an infected person* creates smaller droplets from the respiratory tract that are thought to be able to reach up to 1-m distance reaching another person's nose, mouth, or eyes. Thus, for procedures that generate aerosols from the respiratory tract, such as laryngoscopy, bronchoscopy, and upper endoscopy, enhanced precautions are recommended such as the use of filtering facepiece respirators and airborne infection isolation rooms. However, since the only proven mode of transmission of COVID-19 is through respiratory droplets, the risk of transmission from the abdomen is unclear.

Aerosolization of Particles During Surgery

The growing awareness of surgical smoke produced during surgery has allowed us to learn about not only the chemical toxins in surgical smoke but also the aerosolization of particles during operations. However, much of the concern and literature is centered on the risk secondary to electrosurgical smoke. In laparoscopy specifically, all the studies of aerosolization are related to electrosurgical smoke produced in a closed environment and the consequent aerosolized debris into suspended particles from energy devices. Thus, in the absence of electrosurgical devices, we do not know the ability of CO_2 alone to aerosolize particles in the abdomen. This raises the question regarding the theoretical risk of aerosolization of virus with the use of electrosurgical devices and whether eliminating or minimizing the use of these devices minimizes the presumed

Table 1 Energy devices and surgical plume[8]

Device	Plume
Electrocautery	< 0.1 microns
Laser ablation	0.3 microns
Ultrasonic scalpel	0.35–6.5 microns

risk. Table 1 demonstrates the expected debris from the various categories of energy devices used in the abdomen. So, although the ability to aerosolize COVID-19 in the abdomen is unknown, minimizing electrosurgical use and the avoidance of certain devices, such as ultrasonic scalpel, may reduce aerosolization of particles in general[8] and thus reduce the potential risk of viral emission.

Viral Emission in Laparoscopy

Viral emission in laparoscopy is not well studied, and in fact has only been investigated in one study. Kwak and colleagues collected data from eleven patients with hepatitis B virus (HBV) that underwent laparoscopy. They demonstrated that HBV was isolated in surgical smoke when using a high-efficiency collector to obtain surgical smoke in the form of hydrosol. They then analyzed this smoke using PCR and demonstrated that in 10 of 11 cases, there was detectable HBV in the collected smoke.[9] However, no further studies were performed to determine if these particles were capable of transmitting disease or if they even have viral infectivity. The route of transmission for HBV clearly differs from droplet transmission but to date there is no study that demonstrates or can suggest the ability of viral transmission by laparoscopy.

Viral Transmission in Surgery

If we are to further investigate viral transmission in open surgery, the large amount of literature examines viral transmission of HPV through surgical smoke during surgical treatment. Several groups found that although HPV can be detected in the surgical plumes,[10,11] there was no evidence that this aerosolized HPV DNA could develop into an active infection or be transmitted to the surgeon.[12] In fact, one group collected the surgical smoke during the treatment of laryngeal papillomas and cultured the specimens with several cell lines and demonstrated there was in fact no sign of viral infection.[13] Furthermore, with the use of smoke evacuation systems and PPE, there was no evidence of the dispersion of viral DNA on the skin of the surgeon.[11] These studies demonstrate that historically there has not been any proven ability for a virus to be transmitted during surgical treatment whether open or laparoscopic.

Laparoscopic Technique, How Best to Protect Ourselves Even Against a Theoretic Risk

Although our review of the literature thus far would suggest a very low risk of transmission of COVID-19 and the risk with laparoscopy may not be different from open, we are practicing in a situation that is not well studied with a highly contagious virus, and thus, we should still minimize the risk with the proper protective techniques. Several surgical societies have made recommendation regarding the use of laparoscopy; however, these societies also recognize that the risk of aerosolization of the virus is unclear. The American College of Surgeons have stated "there are insufficient data to recommend for/against an open versus laparoscopy approach." The Royal College of Surgeons recommends that surgeons "consider laparoscopy only in select individual cases," and also recognizes the risk is not clearly demonstrated. The Society of American Gastrointestinal and Endoscopic Surgeon (SAGES) in the recent development of this pandemic advocates for the use of filters for the released CO_2 during laparoscopy and robotic surgery. Therefore, in this section, we review current practices in laparoscopy and any modifications that can be made to minimize any potential risk for transmission of the virus to operative staff. In particular, we will focus on smoke evacuation and insufflator systems used for performing laparoscopy or robotic surgery with the principle of developing a closed-circuit system to prevent room contamination with any aerosolized particles.

Smoke Evacuation

The conventional laparoscopic CO_2 pressure insufflator that many hospitals are equipped with works by toggling between CO_2 insufflation for approximately 3 s and resting for 1 s to measure the pressure before it re-insufflates the abdomen to maintain the set pressure. Generally, in this situation, traditional trocars are used with one-way valves within the proximal portion of the port. It should be noted with these trocars there is a risk of a small amount of gas to leak when exchanging instruments. As the case progresses with the use of electrosurgical devices in the absence of an independent smoke evacuator, it is not uncommon for a trocar stopcock to be intermittently vented to release surgical smoke into the room to maintain a clear operating field. Additionally, at the conclusion of the case, the pneumoperitoneum will be desufflated by opening trocar stopcocks allowing release of that gas/surgical smoke into the room. This traditional practice of laparoscopy has not been demonstrated to cause harm to the providers or staff in the operating room. However, with the unknown risk of transmission of COVID-19, we would recommend avoiding these traditional practices and creating a closed circuit for insufflation with the use of some sort of smoke evacuator device to avoid any release of pneumoperitoneum into the room. Additionally, desufflation at the end of the operation should be done through a smoke evacuator device or direct suction. When this is done, care should be taken to evacuate the abdomen under direct vision for as long as possible and placing the tip of the trocar on suction away from bowel, either resting above the liver or turned up toward the abdominal wall. Any specimen to be removed should also be done at this time of the operation with the abdomen desufflated.

Several different insufflation systems exist, and some vendors have also upgraded systems to include smoke evacuation. And independent smoke evacuator systems also exist that are supplemental to conventional insufflator systems (Table 2). The most common system that has been suggested for use during this COVID-19 pandemic is ConMed AirSeal®. One of the first sophisticated insufflator systems, this device uses an intelligent flow system control unit.[14] The benefits of this system include the valveless access port with small circumferential CO_2 nozzles within the trocar as opposed to a one-way valve, which minimizes any loss of pneumoperitoneum during instrument exchange. The trilumen flow tube set allows for three tubes for simultaneous: (1) CO_2 inflow, (2) CO_2 outflow, and (3) pressure monitoring and filters particles down to 0.01 μm. However, when using the AirSeal® mode, the insufflated CO_2 is recirculated rather than continually adding fresh, cooler CO_2. This feature is beneficial for the technical aspects of laparoscopy and robotics to decrease fogging of the camera and minimize use of CO_2. However, recirculation of the same CO_2 may add to the theoretic risk of concentrating the aerosolized virus further. Thus, when using this system, we recommend evaluating the use of the access port and AirSeal® mode and considering the use of the smoke evacuation mode to allow for more liberal circulation of pneumoperitoneum. Alternatively, an independent smoke evacuation system can be used.

The PneumoClear is another integrated insufflator with smoke evacuation system similar to that of the AirSeal® with a dual-lumen tubing set except it uses traditional trocars. The PneumoClear also has an added feature of desufflating the abdomen at the end of the case. Other independent smoke evacuation systems are also widely used (Table 2) and provide high-efficiency filters as well. These systems can be added to the use of conventional insufflator systems with traditional trocars and the use of wall suction or waste management systems.

No Smoke Evacuation System Available

When a smoke evacuation system is not available, several groups have described using direct suction to laparoscopic trocars to allow for evacuation of the smoke. These systems can be integrated with the use of filters removed from endotracheal tubes or other devices; however, this method cannot guarantee the high filtration efficiency of the manufactured smoke evacuation devices. Thus, we suggest in these cases that advanced PPE be used with N95 respirators.

Table 2 Smoke evacuation and filter systems available for laparoscopy

Device	Filter (microns)	Efficiency (%)
N95 respirator	0.3	95
ConMed PlumePort ActiV	0.1	99.99
Stryker PureView Active Plume	0.1	99.99
Stryker Pneumoclear Insufflator	0.051	99.99
ConMed AirSeal® System	0.01	99.99

Lowering Standard Pneumoperitoneum Pressure

In discussing the theoretic risk of aersolizing the virus in the abdomen, reducing the volume of pneumopertineum required for the operation may reduce this risk. This can be achieved by operating at lower pneumoperitoneum pressures. This is not a new concept, and in fact several groups have demonstrated that traditional laparoscopic procedures can be performed with lower insufflation pressures than the standard 12–15 mmHg.[15–17] Using a set pressure of 12 mmHg rather than the traditional 15 mmHg during laparoscopic cholecystectomy can actually result in lower postoperative pain and quality of life without impacting operative.[18] We propose that the use of lower pneumoperitoneum pressures, when permissable, has low to no risk and has potentional advantage of reducing the volume of aersolized particles.

Modifications for Robotic Surgery

All of the suggested modifications discussed this far regarding laparoscopy should also be observed for robotic procedures as these procedures use the same insufflators and smoke evacuation systems. Additional precautions to take with robotic surgery to avoid leakage from trocars include always using the trocar reducers in 12-mm trocars when inserting 8-mm or 5-mm instruments through the 12-mm trocars. And because the robotic ports and reducers are 8 mm, there is still potential leakage of pneumoperitoneum with 5-mm instruments. Thus, the use of laparoscopic 5-mm instruments through even the 8-mm trocars should perhaps be minimized if possible.

Specific Recommendations Based on Patients' COVID-19 Status

When patients are found to have confirmed COVID-19 or are a person under investigation (PUI), surgery should be deferred if possible as per multiple societal guidelines. When an operation is semi-urgent or urgent, it has been suggested that patients infected with the COVID-19 virus may have worse outcomes and a discussion with the patient is essential prior to proceeding with an operation. As discussed, the risk of transmission from the abdomen is unknown and laparoscopy may still be of benefit to these patients but should be performed with the above precautions. In confirmed infection, additional precautions can be taken including the use of enhanced PPE during the procedure with filtering facepiece respirators such as N95 respirators and use of airborne infection isolation

rooms for the procedure. Practicing surgery in this current climate with asymptomatic COVID-19 carriers and the limited ability for testing, the assumption in terms of precautions for the operative staff should be that every patient carries a risk of transmission. Thus, we recommend that all precautions should be taken whenever possible to minimize the possible risk of transmission regardless of known COVID-19 status.

Conclusion

Based on our review of the current scientific knowledge, we *did not find scientific evidence* to support the use of open surgery *over* laparoscopy or robotic surgery to reduce viral transmission of COVID-19; however, there is still much to learn about the disease and transmission. We understand there may be a theoretical risk of transmission from the abdomen of an infected individual and thus have the following recommendations during laparoscopic or robotic surgery to mitigate any such possible risks of transmission of COVID-19. These recommendations may be of low or debatable benefit; however, they are low risk and should be considered in all cases.

Recommendations

- We recommend *minimizing* the use of energy devices during procedures when possible. When energy is needed, we recommend *avoiding the ultrasonic scalpel* and lower energy settings to minimize surgical smoke (**evidence quality high; expert opinion convergent; strong recommendation**).
- We recommend *using a closed circuit* with smoke evacuation device with high-efficiency particle air (HEPA) filter or best available equivalent substitute (**evidence quality moderate; expert opinion convergent; strong recommendation**).
- We recommend the *use of enhanced PPE in the operating room*, given the theoretic risk of transmission regardless of open, laparoscopic, or robotic procedures (**evidence quality low; expert opinion divergent; weak recommendation)**.
- We recommend the use of low pneumoperitoneum pressures when possible, since many emergency and non-emergency cases can be performed with an insufflation pressure of 12 mmHg or lower (**evidence quality moderate; expert opinion convergent; strong recommendation**).
- We recommend at the conclusion of the operation to *desufflate the abdomen using a smoke evacuation device* or suction substitute (**evidence quality low; expert opinion convergent; strong recommendation**).

Authors' Contribution All authors contributed as stated by the definition of authorship.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

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