Perspectives and Recommendations for Laparoscopic Surgery in the COVID-19 Era

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ABSTRACT

A new human coronavirus called SARS-CoV-2 is currently causing a pandemic of the coronavirus disease 2019 (COVID-19). Healthcare institutions including surgical centers and their workers are in risk of contagion due to high exposure to SARS-CoV-2. The objective of the present manuscript is to review the available literature and elucidate the key points for maintaining safety in laparoscopic surgery during the pandemic. Currently, any patient who requires surgery and in whom the diagnosis of COVID-19 has not been ruled out should be treated as a positive patient and the correspondent safety measures should be taken. Surgical plume is a bioproduct that places healthcare workers who are exposed to it in a potential risk of acquiring different health conditions. There is no clear evidence to affirm that the exposure to surgical plume and pneumoperitoneum can cause COVID-19; nevertheless, as we do not know yet the real risk of transmission and infectivity of particles found in surgical smoke, it is recommended to take measures for a controlled evacuation of pneumoperitoneum and the use of a simple filtration system during laparoscopic surgery. We must understand that as our entire life changed with this pandemic, laparoscopic surgery should also change in particular aspects to give our patients the best treatment under the safest conditions as possible.

Keywords: COVID-19, Laparoscopy, SARS-CoV-2, Surgery.

RESUMEN

Un nuevo coronavirus humano llamado SARS-CoV-2 actualmente se encuentra ocasionando la pandemia de enfermedad de coronavirus 2019 (COVID-19). Las instituciones de salud, incluyendo los centros quirúrgicos y su personal, se encuentran en riesgo debido a la alta exposición al SARS-CoV-2. El objetivo de este manuscrito es revisar la literatura disponible y dilucidar los puntos claves requeridos para mantener la seguridad de la cirugía laparoscópica durante esta pandemia. En la actualidad cualquier paciente que requiera una intervención quirúrgica, en el que no se haya descartado COVID-19, debe ser tratado como positivo y por ende se deben tomar todas las medidas de protección pertinentes. El humo quirúrgico es un bioproducto que puede exponer al personal de salud a un potencial riesgo de adquirir diferentes patologías. No existe evidencia contundente para afirmar que la exposición al humo quirúrgico o al neumoperitoneo pueda causar COVID-19, sin embargo, en la actualidad no conocemos el riesgo real de transmisión e infectividad de las partículas que se encuentran en el humo quirúrgico, es recomendable tomar medidas para conseguir una evacuación controlada del neumoperitoneo junto con el uso de un sistema de filtración simple durante la cirugía laparoscópica. Debemos entender que así como esta pandemia ha cambiado nuestra vida en general, la cirugía laparoscópica también debe cambiar en ciertos aspectos particulares para ofrecer a nuestros pacientes el mejor tratamiento bajo las condiciones más seguras posibles.

Palabras clave: COVID-19, Laparoscopia, SARS-CoV-2, Cirugía.

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INTRODUCTION

A novel human coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in Wuhan, China, at the end of 2019 leading to the current pandemic.¹ It is an RNA virus whose size is 0.12 microns (µm). It can be found in the nasopharynx, the upper and lower respiratory tract, and in the entire gastrointestinal tract, from the mouth to the anus. It is suspected that given the multiple locations that it can be found it has multiple transmission pathways.²⁻⁵ Vertical transmission from mother to child has not been demonstrated. The RNA of SARS-CoV-2 has not been found in samples from the umbilical cord blood, vaginal discharge, or breast milk.⁶⁻⁸

The outbreak has extended rapidly throughout the world and it constitutes an international public health emergency. It also places the medical community and health workers who perform procedures at high risk due to exposure to the virus. Theoretically, the virus is still viable in aerosols for at least 3 hours and remains transmissible.^{9,10} As of June 6, 2020, the infection extended to 199 countries, with 6,663,304 confirmed cases and 392,802 deaths. In Ecuador, 42,106 cases and 3,592 deaths were reported.¹¹

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Previous studies of SARS-CoV-1 have demonstrated that endotracheal tube placement was highly associated with the transmission of infection to healthcare workers who perform the procedure. Additionally, other procedures such as tracheostomy, noninvasive ventilation, and mask bag ventilation performed before the endotracheal tube placement were associated with a high risk of infection.¹²

Considering the risks for the healthcare personnel in the operating room to contract the virus, most of the surgical services for elective procedures have been discontinued. This practice brings into question how and when surgeons should perform surgical procedures that are urgent or time-limited. This review will elucidate key points for safety in laparoscopic surgery in the midst of the SARS-CoV-2 pandemic.

PREOPERATIVE ASSESSMENT

The goal of preoperative assessment is to ensure the safety of the patients and the providers. The transmission of SARS-CoV-2 is primarily by droplets and/or contact with infected individuals that may or may not have symptoms.^{13–15} The disease is highly contagious. To date, there is not enough data to truly understand the exact reproductive number (R0). Some studies have estimated a mean R0 between 2.2 and 3.58. This means that each patient will propagate the infection to other 2–4 people.^{16,17} The incubation period of the virus can be as long as 14 days with a mean duration of 5.2 days. An asymptomatic carrier can have an incubation period up to 19 days and the majority of patients experience one or more symptoms at 12.5 days after initial contact with SARS-CoV-2.^{16,18,19}

Patients with SARS-CoV-2 run the spectrum from asymptomatic carriers to a severe form of the disease leading to multisystem organ failure. When infected with SARS-CoV-2, it is referred to as COVID-19. Most patients present with fever, dry cough, myalgia, fatigue, anosmia, hyposmia, dysgeusia, and dyspnea. Less common symptoms include abdominal pain, dizziness, productive cough, pleuritic pain, and 10% of patients can present with nausea and diarrhea.^{3,16–21} At the beginning of the disease, the white blood count may be normal. Common laboratory findings in patients with COVID-19 include leukopenia and lymphopenia. It is also frequent to find elevated levels of ferritin, C-reactive protein (CRP), lactic dehydrogenase (LDH), creatine kinase (CK), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and almost 30% of patients show an elevation of D-dimer.^{19,20,22}

Computed tomography (CT) in patients with COVID-19 has characteristic image patterns related with different clinical types of the disease (mild, moderate, severe, and critical).²² The diagnosis of

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COVID-19 is currently based on quantitative real-time polymerase chain reaction (RT-PCR). The universally recommended sample must be collected by the nasopharyngeal swab, which has a positive predictive value (PPV) that varies from 47 to 96% and a sensitivity of 89%. Bronchoalveolar lavage has a sensitivity of 93%.^{22,23} The sampling technique for a nasopharyngeal swab is difficult to perform accurately and this may increase the false-negative rate. This may account for the observation that the sensitivity of RT-PCR has been suggested in some series to be lower than the sensitivity of the thoracic CT scan.^{24,25}

The antibody detection tests for immunoglobulin M (IgM) and immunoglobulin G (IgG) using immunochromatography are known as rapid tests and their sensitivity can be affected by various factors such as the disease progression time, the viral load of the patient, and the type of kit used, among others. Currently, we do not know with certainty the time required to develop antibodies nor the exact cutoff to consider a patient positive because of the novelty of the disease. Considering all of these factors, it has been estimated that the sensitivity for rapid tests varies from 34 to 80%.²⁶ In a patient with a rapid test negative result but a clinical course that would suggest COVID-19, a RT-PCRq should be performed as well.²⁷

Emergency Surgery

If a patient presents with a potentially life-threatening condition that requires immediate surgical treatment and the situation does not allow time for the RT-PCR result, they should be considered a SARS-CoV-2 carrier. Between 18% and 50.5% of COVID-19 patients are asymptomatic carriers and can potentially transmit the disease. These patients should be treated using all the preventive measures and personal protective equipment the same as confirmed patients (Flowchart 1).^{22,28,31} Safety measures should be taken during the preoperative workup, the surgical procedure, and in the postoperative period. In a suspected or confirmed case, additional caution is needed to guarantee contact and droplets isolation, which include the N95 respirator approved by the National Institute for Occupational Safety and Health (NIOSH), goggles, face shield, gown, double pair of gloves, and protective shoe covers.^{22,29–32}

Flowchart 1: Assessment flow diagram for emergency surgery in symptomatic or asymptomatic patient

Elective Surgery

Every patient who needs an elective surgery should have a negative result from a RT-PCR test performed 48 hours prior to surgery and a complete preoperative evaluation. If the result of RT-PCR is positive, it is recommended to delay surgery, treat COVID-19 according to its severity, and repeat the RT-PCR 10–14 days after the first positive result. Surgery is considered safe when the RT-PCR result has turned negative. In cases in which the surgery cannot be delayed, the patient should be handled the same as emergency procedures (Flowchart 2).^{33,34}

SURGICAL PERSPECTIVE IN PATIENTS WITH COVID-19

Stahel stratified elective surgical procedures according to their urgency. This urgency should be analyzed on a case-by-case basis. This strategy will enable the surgeons to identify the optimal timing to perform each intervention during the pandemic (Table 1).³⁵

In a retrospective study in Wuhan, which included 34 asymptomatic carriers who underwent elective surgery, none of them presented with COVID-19 symptoms at the time of surgery. They developed symptoms around the 5th day of admission. All the patients developed pneumonia, 44% required the intensive care unit (ICU) and 20% died. Surgeries with a mean operative time of 200 minutes had a higher complication rate compared with those whose mean operative time was 70 minutes.³⁶ Care must be taken to avoid viral exposure related to aerolization during surgery for those who are asymptomatic if tests are not available, which can result from assisted ventilation.¹

SURGICAL PLEUME AS A RISK FACTOR FOR HEALTHCARE WORKERS

Surgical plume is a bi-product resulting from the use of electrosurgical devices and can lead to a theoretical biological risk in health care. It can have up to 150 products, which include toxic gases, nitriles, live and death cell material, bacteria, and active virus.^{37–40} Ball described that the incidence of respiratory disease such as asthma and sinusitis can be twice as common in full-time surgical healthcare workers compared to the general population. This finding was attributed to surgical plume inhalation.⁴¹

Flowchart 2: Assessment flow diagram for elective surgery patients

The concentration of particles in surgical plume after 10 minutes of using electrosurgical devices is higher in laparoscopic vs open surgery.⁴² Electrocautery use during 15 minutes generates plume equivalent to the smoke generated by six nonfiltered cigarettes.^{39,43} The size of particles found in surgical plume varies from 0.05 μm to more than 25 μm and they can travel up to 1 meter from their source.^{44,45} Particles ranging from 2.5 μm to 10 μm can enter the respiratory tract and can be found as far distal as the alveoli.⁴⁴ Ultrasmall particles (0.1–0.8 μm) had been found in surgical plume from laparoscopic ports after using laparoscopic monopolar cautery.^{46–50} In laparoscopic surgery, the generation of 0.3 μm particles was higher after 10 minutes of electrocautery use.⁴²

The ultrasonic scalpel produces aerosols without a heating process. This contributes to a higher possibility of carrying viable and infectious particles compared to aerosols from high temperature (electrocautery). Particles generated by ultrasonic scalpel may contain tissue, blood, and its bioproducts. Although currently there is no evidence in the scientific literature, the risk is considered potentially higher in particles generated by the ultrasonic scalpel. More research is needed to determine the potential risk regarding aerosols generated by the ultrasonic scalpel and their ability to spread pathogens and cell components.⁴⁵

VIRAL PRODUCTS IN SURGICAL PLEUME AND TRANSMISSION RISK

Human hepatitis virus has been found in surgical plume generated during laparoscopic surgery but its infective capacity as an aerosol has not been determined yet. Nevertheless, it is recommended to establish control methods for the surgical plume generated by electrosurgical devices.⁵¹

Some studies had identified active human papilloma virus (HPV) and human immunodeficiency virus (HIV) in surgical plume.^{52–54} However, the infectious capacity of these viruses for healthcare workers in the operating room is still not clear.⁵⁵ A revision published by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) did not find evidence to suggest viral infectivity of electrosurgical instruments including electrocautery and ultrasonic scalpel.^{39,44} In addition, the risk for healthcare workers related to exposition to infective and neoplastic cells found in surgical plume has not been established.^{56,57}

Laparoscopic surgery has clinical outcome advantages in patients including those with viral infections such as HIV; it has a lower recovery time, smaller incisions, less respiratory compromise, lower risk of wound dehiscence, lower incisional hernia rate, and lower surgical site infection rate. It also poses less risk of blood and fluid exposition to surgeons.⁵⁸ In general, laparoscopic surgery has the advantage of maintaining the integrity of the abdominal wall, which generates a controlled setting to allow a safe evacuation of pneumoperitoneum and aerosols generated by electrosurgical devices.^{59–62} The use of laparoscopy involves less surgical trauma for the patients compared to open surgery. In the case of a COVID-19-positive patient, the minimally invasive approach will likely lead to better survival rates and a faster recovery than the open approach.^{62,63}

Until now, the risk of transmission of SARS-CoV-2 or similar viruses such as SARS, MERS-CoV, or influenza, during laparoscopic surgery with the use of electrosurgical devices or robotic surgery, remains unclear. However, considering that SARS-CoV-2 a highly contagious virus is recommended and all precautions should be

Table 1: Surgical case types classification by indication and urgency

Indication	Time for surgery	Examples
Emergent	Vital emergencies. Time for surgery <1 hour	<ul style="list-style-type: none"> Life-threatening emergencies Acute exsanguination/hemorrhagic shock Trauma level 1 activations Acute vascular injury or occlusion Aortic dissection Emergency C-section Acute compartment syndrome Necrotizing fasciitis Peritonitis Bowel obstruction/perforation
Urgent	Time for surgery <24 hours	<ul style="list-style-type: none"> Appendicitis/cholecystitis Septic arthritis Open fractures Bleeding pelvic fractures Femur shaft fractures and hip fractures Acute nerve injuries/spinal cord injuries Surgical infections
Urgent-elective	Low risk to life of the patient in the short-term. Time for surgery <2 weeks	<ul style="list-style-type: none"> Cardiothoracic/cardiovascular procedures Cerebral aneurysm repair Vascular access devices Skin grafts/flaps/wound closures Scheduled C-section Closed fractures Spinal fractures and acetabular fractures
Elective (essential)	Time for surgery 1–3 months	<ul style="list-style-type: none"> Cancer surgery and biopsies Subacute cardiac valve procedures Hernia repair Hysterectomy Reconstructive surgery
Elective (discretionary)	Time for surgery >3 months	<ul style="list-style-type: none"> Cosmetic surgery Bariatric surgery Joint replacement Sports surgery Vasectomy/tubal ligation Infertility procedures

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taken to reduce the potential transmission by aerolization in the operating room.^{39,62–64} Every patient with suspected COVID-19 who requires surgery should be treated as COVID-19-positive until proven otherwise.^{32,63} The potential risk of contamination for the surgeon in laparoscopic surgery arises during smoke evacuation by trocars, surgical specimen extraction, or when unnoticed escape of smoke exists toward trocars or incisions.⁶⁵

It is expected that as days go by, the surgical procedures in patients with COVID-19 will substantially increase. Therefore, the implementation of effective mechanisms for surgical plume evacuation and the prevention of aerosol dissemination are required. The use of a simple and low-cost filtration system like electrostatic filters, which have the capability of efficiently filtering bacterial and viral loads, is recommended.^{66–69}

The use of appropriate filters for surgical plume evacuation has been recommended by the Centers for Disease Control and Prevention (CDC) even before the pandemic.^{39,70} Filters for surgical smoke evacuation can reduce its inhalation by healthcare workers by about 66%.⁴² These evacuation systems were designed as ultralow particulate air (ULPA) filters that can include activated carbon in their composition to neutralize toxic gases and odor.^{39,71–73}

Negative pressure ventilation in the operating room provides an effective way to eliminate contaminant agents for healthcare workers. The use of a hybrid system with unidirectional upward airflow ventilation (UDV) equipped with a high-efficiency particulate air (HEPA) H14 filter in the ceiling of the operating theater with a large airflow volume and well-defined airflow pattern evacuates the surgical smoke nearby the critical area faster and more efficiently than downward displacement airflow systems.

Further, the position of the extraction grilles should be well-defined and localized in order to achieve the best evacuation effect without interfering with obstacles within the critical area. The purpose of the evacuation system is to provide surgical staff with adequate ventilation for contaminant removal, and therefore, decreased levels of personnel exposure to surgical smoke.⁷⁴

We are facing a situation in which we are exposed to a highly contagious virus and new information about the virus is constantly evolving given the short period of time of the pandemic. For this reason, we should do our best effort to minimize the risk of infection with the appropriate use of protective techniques.

There is not clear evidence that laparoscopic surgery poses a high risk for the healthcare workers in the operating room. However, as we do not know what the real risk of transmission and infectivity is by being exposed to surgical smoke or pneumoperitoneum evacuation, we recommend avoiding venting surgical plume and pneumoperitoneum directly to the operating room environment. It is essential to use gas evacuation devices and in cases where they are not available, develop a low-cost filtration and suction strategy (Fig. 1).

Recommendations^{32,33,59,60,62,63,75–83}

General

- Every patient should be considered COVID-19 positive.
- Indications for emergency surgery and urgent oncological procedures during COVID-19 pandemic should be similar as surgical indications used before the pandemic.
- The operating room should have a negative pressure system.
- The COVID-19 status of the patient should be added to the safety surgery checklist available in the institution.

Fig. 1: Adaptation of a filter to the suction system. Red arrow shows clipped adapter to prevent system leakage

- In patients with confirmed or suspected COVID-19 diagnosis, the use of a disposable surgical equipment is recommended to avoid the contamination risk during cleaning and sterilization processes.
- At the institution, an exclusive operative room should be assigned for the procedures in patients with confirmed or suspected COVID-19 diagnosis.
- Keep the doors of the operating room closed during surgery.
- Patients with suspected or confirmed COVID-19 diagnosis require closer surveillance during the postoperative period considering that they are at higher risk of developing a condition requiring ICU management and they also have a higher mortality rate compared with surgical patients without COVID-19.

Healthcare Workers

- Management guidelines regarding COVID-19 patients undergoing surgery should be individualized according to the reality of the country and the specific healthcare institution.
- The route for transport of COVID-19 patients between the areas of the hospital should be standardized, known by healthcare workers and respected in every case.
- Healthcare workers should receive training in donning and doffing the personal protective equipment.
- Surgical team should wear the personal protective equipment according to CDC guidelines.
- The number of healthcare workers (including surgeons, anesthesiologists, nurses, and technicians) should be limited to the minimum required to safely perform the procedure.

During Laparoscopic Surgery

- The number and diameter of trocars should be the minimum required to safely perform the procedure.
- The intra-abdominal pressure during laparoscopic surgery should be between 8 and 12 mm Hg
- Minimize the use of electrosurgical devices, especially ultrasonic scalpel. In case of using monopolar, the energy should be used at the lower intensity to achieve desired effects.
- Surgical plume and pneumoperitoneum should be evacuated in a controlled manner and it is recommended to use an appropriate filter to guarantee safety of healthcare workers.

- Port incisions should be as small as possible to avoid pneumoperitoneum leaks.
- Surgical specimen should be extracted only after the evacuation of pneumoperitoneum
- Drains should be used only if it is strictly needed.
- Fascial closure should start only after active evacuation of pneumoperitoneum.
- Hand-assisted surgery should be avoided.
- Transanal total mesorectal excision (TaTME), transanal minimally invasive surgery (TAMIS), and total mesorectal excision (TME) should be delayed because of the high amount of aerosols generated by these procedures.

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