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SAFETY AND FEASIBILITY OF LAPAROSCOPIC SURGERIES DURING COVID-19 PANDEMIC- A SYSTEMATIC REVIEW

Mohd Yunus Shah[1], Sagarika Bhole[2], Avinash Rode[3], Kapil Panchbhai[4], Zansher Nazar[5], Shubhi Parwani[6], Aashima Prakashe[7], Shridhar Munde[8], Abhay Sawalkar[9], Unmay Agarwal[10], Jaskaran Singh[11]

[1]Associate Professor, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[2]Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[3]Professor, Department of General Surgery, Datta Meghe Medical College, Nagpur, India.
[4]Assistant Professor, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[5]Assisstant Professor, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[6]Senior Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[7]Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[8]Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[9]Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[10]Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
[11]Resident, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.

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Corresponding Author: Dr. Mohd Yunus Shah, Associate Professor, Department of General Surgery, NKP Salve Institute of Medical Sciences and Research Centre Nagpur, India.
Email: shahyunus94@yahoo.com

Abstract

Background: During the Covid19 pandemic, the potential spread of the SARS-CoV-2 virus during surgeries, especially in laparoscopic surgeries, is a key concern. Surgical smoke released during laparoscopic surgeries may cause viral transmission. Therefore, the risk and benefits of viral transmission during laparoscopic surgery needs to be carefully evaluated. For the safety of healthcare professionals are adapted from the previous pandemics/epidemics, the preventive measures especially applicable to laparoscopic surgeries include care during CO_2 insufflation/desufflation, minimal use of energy sources, personal protection measures are recommended. **Objective:** The aim of this article is to review the contemporary literature pertaining to the risk of conducting laparoscopic surgeries during the Covid-19 pandemic. In addition, we summarize the relevant safety protocols for the patients, surgical team, anesthetists, and the operation room staff. **Materials and Methods:** A systematic literature search was performed using the key words: Covid-19

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laparoscopy, Surgical smoke, Covid safety in operation rooms, Laparoscopic surgeries and Covid safety, prevention, Aerosol transmission, Laparoscopic surgery, Covid-19' Search articles were considered from the aims of the articles, nature, safety protocols, and risk mentioned in the literature. **Results and Conclusions:** Although the initial guidelines advocated by various organizations stated that Laparoscopy generally should not be used as it is considered to carry some risks of aerosol-type formation and infection and considerable caution is advised. Though some reports have suggested the use of Laparoscopy in selected cases where clinical benefit to the patient substantially exceeds the risk of potential viral transmission to the surgical team. Based on this review of the current scientific knowledge, no scientific evidence was found to support the use of open surgery over laparoscopy to reduce viral transmission of COVID-19 if the advocated Covid-19 guidelines are followed strictly; however, there is still much to discover about the viral transmission.

Introduction

Laparoscopic surgery (LS) is the standard approach for treatment of many surgical conditions with promising results and early postoperative recovery of patients. However, there are concerns related

to the safety of LS in the ongoing COVID-19 pandemic due to the potential risk of viral transmission via surgical smoke/laparoscopic pneumoperitoneum. [1-4] The During LS, use of energy sources such as monopolar/bipolar diathermy or ultrasonic scalpels results in generation of surgical smoke/plume due to burning and vaporization of the body tissues. This smoke contains traces of harmful gases such as hydrogen cyanide, benzene molecules, carbon monoxide, and methyl propane; in addition, it may also contain viruses, bacteria, cell residues, and blood. [1,5] The presence of Hepatitis B virus, human immunodeficiency (HIV) virus, and Human papilloma virus(HPV) has been reported in the surgical smoke. [6-8]

Viral RNA of novel coronavirus 2019 (Covid- 19) has been found in the respiratory, gastrointestinal, and genitourinary tracts, as well as in saliva, sputum, blood. [9.10]

The concerns related to the risk of Covid-19 transmission during LS largely pertain to pneumoperitoneum and the energy sources used in LS. Use of these modalities increases the risk of COVID-19 transmission to the surgeons and staff if the patient is carrying viral load in the operation room. Release of carbon-dioxide during laparoscopic procedures and exposure to aerosolmay potentially lead to virus spread among the surgeons and staff. [11]

During LS, surgical smoke produced during cauterization and dissection of tissues along with aerosol gets concentrated in the peritoneal cavity and may be released along with CO_2 during the placement or removal of ports, change of instruments, suction irrigation, and specimen retrieval, and along with CO_2 released at the completion of the procedure.

Studies have shown that per procedural inhalation of smoke by surgeons and staff during this pandemic can be a potential route of viral transmission. [12] Therefore, surgeons must be cautious about the potential risks of aerosol transmission in surgical practice as outbreaks of viruses such as COVID-19 or other emerging infectious agents are likely to continue in future.

So the points of concern are – Is there any risk of Covid-19 transmission among the surgical teamand other operating room staff during LS in the Covid-19 pandemic?

Various International surgical societies have issued guidelines and recommendations for laparoscopy use during Covid-19 and have also discouraged laparoscopic surgeries in elective settings. [13-17]

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Materials and Methods

The PubMed, Direct Science, Medline, and Scopus databases were systematically searched for relevant articles. The search terms used separately or in combination were Covid-19 laparoscopy, Surgical smoke, Covid safety in operation rooms, Laparoscopic surgeries and Covid safety, prevention, Aerosol transmission, Laparoscopic surgery, Covid-19'. After excluding the duplicate data, two researchers independently screened the retrieved studies for eligibility and exclusion.

Inclusion criteria

We retrieved citations published in English language that discussed the use of laparoscopy during the COVID-19 pandemic by using the search criteria (Fig. 1). Original research full text articles, case reports, systematic and narrative review articles, evaluations, analysis, and recommendationsby professional societies were eligible for inclusion.

Exclusion criteria

The Articles which were not related to laparoscopic surgery and Covid-19 were excluded. Citations for which the full-text articles were not available, editorials, or letter to editors were also excluded. The non-English articles and other specialties data like ENT and Endocrine surgery were excluded as shown in Fig. 1- Flow diagram of the literature search and results.

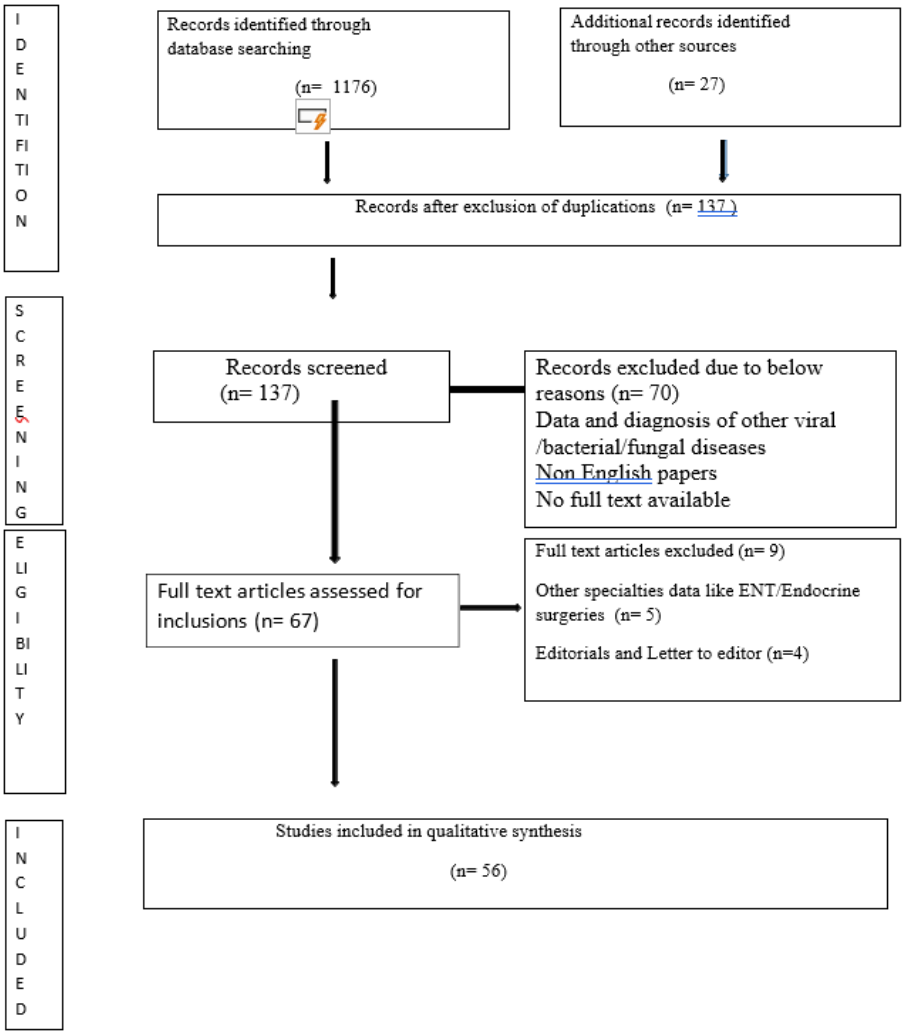

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Figure 1: Flow diagram of the literature search and results

Results

The initial literature search showed a total of 1176 studies were found.

After applying the eligibility criteria and exclusion criteria and exclusion of duplicate data a total of 56 full text articles were analyzed. Those articles reporting the Laparoscopic surgeries and Covid-19 viral transmission were taken into consideration. Based on this review of the current scientific knowledge, no scientific evidence was found to support the use of open surgery over laparoscopy to reduce viral transmission of COVID-19. Mostly the studies have reported that the risk of contamination of healthcare workers is highest during the insertion of trocars, extraction of the excised tissues and removal of trocars at the end of the operation. Recommendation in the use of laparoscopy included preferring the 'closed' technique for obtaining pneumoperitoneum. Prefer intracorporeal bowel anastomosis and extract excised tissue after complete emptying of the pneumoperitoneum. Although some studies have suggested that Laparoscopy generally should not be used as it is considered to carry some risks of aerosol-type formation and infection and considerable caution is advised.It should only be considered in selected individual cases where clinical benefit to the patient substantially exceeds the risk of potential viral transmission to surgical and theatre teams in that particular situation.Where non-operative management is possible and reasonable, should be implemented. No literature suggests that laparoscopy should be replaced by laparotomy or open surgery to avoid the transmission risk of SARS-CoV-2 during the Covid- 19 epidemic.

Viral transmission during Laparoscopic Surgery

Airborne transmission is an important mode of transmission of the previous coronaviruses. [18, 19] Compared with SARS-CoV-1, SARS-CoV-2 can remain infective in aerosolized form for up to 3 hours in certain conditions. [20] The procedures that result in aerosol production such as laparoscopy may theoretically result in virus transmission. There are no reports of contamination of health care workers by SARS-CoV-2 during laparoscopy. Aerosolization of SARS-CoV-2 in laparoscopic surgeries has not been documented. [21-23] Aerosol produced by laparoscopic or robotic surgery, particularly when using low-temperature ultrasonic devices, may not effectively deactivate the cellular components of a virus. [12] Moreover, studies conducted during previous outbreaks such as. Influenza and other coronaviruses (severe acute respiratory syndrome [SARS] and Middle East respiratory syndrome [MERS-CoV]) did not provide any evidence of viral transmission through pneumoperitoneum or surgical smoke. [24]

In some studies, DNA of blood-borne viruses such as HIV and HBV was detected after the use of energy sources such as diathermy or laser/harmonic; however, there is no robust evidence that the use of energy sources increases the risk of viral transmission via surgical smoke or pneumoperitoneum. [25, 26] Nonetheless, some studies have documented the presence of various viruses in the surgical plume/smoke such as HPV, HIV, polio virus, and HBV. [27-30]

Studies suggest a theoretical risk of viral transmission during laparoscopy surgery in the Covid-19 era. However, no studies have provided evidence of the risk of virus transmission during surgery,similar to that available for SARS and MERS. [9]

Risk of Covid-19 transmission in Open surgery and Laparoscopy-

The Surgical smoke is an aerosol produced during intraoperative use of any energy device.

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It is formed due to vaporization of tissues, and it typically contains 95% water and 5% mixture of suspended particulate matter with some droplets in gases which can contain blood fragments, cellular debris, bacteria or viruses. [31, 32]

However, there is limited data of viral transmission by laparoscopy or open surgery. [33] In open procedure/laparotomy, there is no barrier between the surgical smoke and the surgeon in the operating room causing direct inhalation and risk of viral transmission. The aerosol generated is distributed equally all over the operating room depending upon the pressure gradient, gravity, and suction or other air movements. Thus, depending upon the type of energy source, the entire surgical team and the support staff are exposed to the risk of viral transmission. [34]

Due to the lack of sufficient evidence, there is no consensus over the presence of higher viral load of SARS-CoV-2 in the pneumoperitoneum during LS. [35, 36]The size of particles produced in the surgical smoke depends upon the type of energy source utilized. Use of monopolar/bipolar diathermy leads to the production of particles of size 0.07 µm. [37]

The size of the aerosolized particles depends on the type of energy source used in the procedure.

Table 1: Types of energy sources and the dimensions of aerosols generated.

Energy Source	Dimensions of Aerosols (µm)
Electrocautery	0.007–0.420
Ultrasonic scalpel	0.35–6.5
Laser	0.1–0.8

The effects of surgical smoke on the human respiratory system are largely determined by particle size. Particles less than 5 microns are deposited on the oropharyngeal mucosae and do not enter the respiratory tract. Aerosols with a diameter of 5 to 2 m are deposited in the respiratory tract but do not reach the alveoli. Only particles with a diameter of 3 to 0.8 mm may pass through the pulmonary parenchyma. The reported diameter of SARS-CoV-2 is 60–90 nm. [22, 25]

Studies have shown that use of energy sources during dissection in LS is associated with generation of increased concentration of particles sized 0.3-0.5 µm compared to laparotomy. They assessed the amount and concentration of particulates in surgical smoke in 30 patients who underwent laparoscopy or laparotomy. While they found no significant differences in 0.3 or 0.5 µm particles when compared to open surgery, the cumulative count in laparoscopy was higher than in laparotomy after 10 minutes of surgery. This study highlighted the need for more suitable surgical smoke evacuation equipment and regulations. [38] It is a regular practice amongst surgeons to remove the laparoscope from the port to clear the vision which gets blurred during the procedure, which in turn increases the risk of aerosol dispersion in the operation room leading to the risk of viral transmission. In a randomized controlled trial, the degree of surgical smoke generated with use of ultrasound device for dissection during laparoscopic hysterectomy was significantly less ($p < 0.001$) compared to that with monopolar diathermy. [39] Review of literature revealed that SARS-CoV-2 has not been discovered in surgical smoke in any of the studies conducted till date. Furthermore, while viral RNA is detectable in the blood, blood-borne transmission of COVID- 19 has not been documented. [40]

Though SARS-CoV-2 has been found in the blood, lungs, and peritoneal fluid of COVID-positive patients, there is no strong evidence that the disease can be transmitted through surgical plume oraerosolized gas. [41]

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As such, there is no difference between laparoscopy and laparotomy when it comes to the generation of surgical smoke. The differences largely pertain to the aerosol composition and aerosol diffusion, which depend on the type of energy source device used in the surgery.
The risk of aerosol viral transmission during LS can be reduced by taking certain precautionary measures like minimization of gas leak during the trocar handling, minimization of CO_2 leak during specimen retrieval and exchange of instruments.

Surgical smoke evacuation measures during laparoscopic surgery
The various available methods for smoke evacuation in the operation room include the modified ventilation system, surgical site smoke extraction such as suction or local modifications, and personal filtration masks. In modified operating rooms with unidirectional flow, the concentration of the particulate matter in the surgical smoke is comparatively less. [42] Evacuation systems
depends upon various factors such as the flow rate and the angle of the evacuator and the distance between the evacuator tip. [43] The Smoke evacuators suck in the surgical fumes near the source of emission minimizing the exposure of the surgical team to the risk of viral transmission.
Ultralow particulate air (ULPA) filters are ideal for removal of particulate matter generated during electrosurgical and laser procedures depending upon the size of the particles and can retain 99.9
% of particles at 0.1 μm. [44]

Safety measures in laparoscopic surgery during Covid-19 pandemic -
The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), the European Association for Endoscopic Surgeons (EAES), and the Indian Association of Surgical Oncology (IASO) have issued guidelines for the safety of the patients as well as the surgical staff during minimally-invasive surgeries. The important guidelines are summarized below:
Non-emergency surgeries should be postponed during the acute phase of the Covid-19 pandemic.
Covid-19 testing should be performed preoperatively.
All patients should be adequately counseled about the risk of Covid-19 exposure and transmission. Operating room should be separately dedicated with optimum staff members for procedures duringCovid-19.
All health care providers should use N 95 masks, if available, and PPE kits during laparoscopic surgeries.
Ultra Low Particulate Air Filtration (ULPA) smoke evacuator should be used during laparoscopicsurgeries.
Diathermy should be kept at the lowest possible settings without compromising the safety to minimize the risk of aerosol generation.
For pneumoperitoneum creation, Veress needle or Visiport techniques should be utilized instead of open Hassan's technique to avoid CO2 leak. Pneumoperitoneum should be kept at optimum lowlevel without compromising patient safety.
Trocar safety measures such as use of snuggly fit trocars, avoiding repeated change of instruments, avoiding sudden burst of CO2 release, and safe evacuation of pneumoperitoneum from the port attached to the smoke evacuator should be strictly followed.

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Discussion

The Covid 19 pandemic has had a profound impact on the health systems including the disciplines that are not directly involved in the management of Covid 19 patients. The pandemic has challenged the various health systems and the health care providers of the risk of viral transmissionduring LS through surgical smoke generated during the procedure. [45]

Different surgical organizations have initially discouraged the use of minimally invasive surgery during the Covid-19 pandemic. [13-17] In a study by Kwak *et al.*, the majority of surgical smoke samples demonstrated the presence of HPV virus. [25]

Some studies have demonstrated the presence of the SARS-Cov-2 virus in the peritoneal fluids, feces, and intestinal wall of Covid-19 positive patients undergoing various laparoscopic procedures. [45-47] The release of aerosol through the trocar valves may potentially expose the operating room staff to SARS-Cov-2. [48] In Laparoscopic colorectal surgery some authors have mentioned that the risk of transmission of SARS-CoV-2 during laparoscopic colorectal surgery remains unknown as there is no evidence of higher viral concentration in the pneumoperitoneum or surgical smoke plume. They suggested special precautions to be taken during transanal minimally invasive procedures. [46]

According to Francis *et al.* found no concrete evidence of the risk of aerosol transmission of SARS- Cov-2 during laparoscopic surgery, but they recommended all precautions for minimizing the transmission risk. [49] Majority of the reported data pertaining to viral transmission was in the context of viruses other than the SARS-CoV-2 virus; therefore, theoretically, the risk of Covid-19 virus transmission during laparoscopic surgeries cannot be completely ruled out. [50]

The analysis of the available data suggests that there is no concrete evidence to support the cessation of laparoscopic surgeries during the Covid-19 pandemic due to the risk of aerosol transmission of virus amongst the surgical team. Also, there is no solid evidence that surgical smoke produced by the use of diathermy (monopolar/bipolar) or ultrasonic dissection contains SARS-CoV-2 for transmission in the operating room. Li CI *et al.* reported that aerosol transmission of the Covid 19 virus during dissection of tissues is doubtful as there is release of very high temperature which may affect the virulence. [38] Generation of surgical smoke occurs both during open surgery and LS. In LS, there is controlled release of surgical smoke in the operating room if proper precautions are taken. Zheng *et al.* have reported certain precautionary measures such as pneumoperitoneum creation under strict safety protocols, avoidance of leakage of body fluids due to pneumoperitoneum pressure, maintaining the CO_2 pressure at the lowest possible level, minimization of surgical smoke and aerosol with generous use of suction devices, and minimal use of diathermy at the lowest possible settings. [12]

Analysis of published data suggests no significant difference in the risk of viral transmission through surgical smoke generation and aerosolization between open or minimally invasive surgery. [33] Choice of open surgery in place of LS in order to reduce the risk of Covid-19 transmission would accrue other disadvantages such as such as longer hospital stay and greater postoperative pain, longer recovery period, and delayed discharge from the hospital and resumption to work. Some reports [51] have suggested conservative treatment in Covid-19 positive patient as far as possible till the complete recovery. In case of emergency, open surgery should be performed. Minimally invasive surgery should be done only in Covid-19 negative patients or with proper precautionary measures in patients with unknown Covid 19 status.

Mallick *et al.* stated that non operative management should be applied in view of the risk of SARS- CoV-2 virus transmission to operation room team. LS can be done in Covid-negative

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patients andit should be performed in the shortest time by the experienced surgeon. [52]
Morris *et al.* [53] reported that the generation of surgical smoke and aerosolization can be minimized in LS by using low CO_2 pressure and minimizing the use of energy source. Surgical plume should be controlled with the use of smoke evacuator or filtration system such as ULPA filter (filters particles of size 0.1 micron) or high efficiency air filters (HEPA) which screens particles of size 0.3 micron in diameter. They had suggested to avoid the release of pneumoperitoneum in air, rather it should be desufflated through filtration system or with suction tube connected to a suction machine. The viral transmission of COVID-19, performing surgery in any way does not differ in terms of open surgery or laparoscopy. However, it should be remembered that minimally invasive approaches shorten the recovery and hospitalization period of the patients. [54]
The surgical team should follow all precautionary measures to protect themselves and the operation room team throughout the procedure. After completion of the procedure or during removal of the specimen, complete desufflation of the pneumoperitoneum should be done throughthe filtration system.

Conclusion

The COVID-19 pandemic has necessitated updating of the patient management strategies for the safety of health care providers as well as patients. In the COVID era, surgeons are often confronted with ethical issues such as the choice of procedure, whether open surgery or laparoscopic surgery. A typical concern is whether to give priority to their own safety or to give benefits of minimally- invasive surgery to the patients.
There is no concrete scientific data regarding the risk of transmission of SARS-CoV-2 by laparoscopic surgery. In the absence of any contraindications, laparoscopic surgery should be done taking all precautionary measures so as to offer benefits of minimally-invasive surgery to the patients. Conservative management should be preferred for all surgical conditions wherein the conservative approach does not compromise patient safety.
Adequate precautionary measures should be implemented during laparoscopic surgeries during this pandemic to protect the surgical team and the operation room personnel from aerosol contamination. We also need to learn from this pandemic and update our safety protocols which should be continued as a routine in the future.

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