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The Risk for SARS-Cov-2 Virus Contamination through Surgical Smoking and Aerosolization by Laparoscopic Surgery: A Systematic Review

FaridElmi Sadr[1,*], Zahra Abadi[2], NavidElmi Sadr[3], Maryam Milani Fard[4]

[1]General Surgeon. School of Medicine, Iran University of Medical science, Tehran, Iran.
E-mail: Farid.elmisadr@gmail.com.

[2]Neurologist, School of Medicine, Iran University of Medical science, Tehran, Iran.
E-mail: Drzahrabadi@gmail.com.

[3]Clinical Research Development Unit, Kowsar Educational, Research and Therapeutic Hospital, Semnan University of Medical Sciences, Semnan, Iran. E-mail: navid.elmi.sadr@gmail.com.

[4]ENT and Head & Neck Research Center,The Five senses Institute , & Department of Anatomy .Iran university of medical Sciences,Tehran, Iran (E-mail: Maryammilani837@yahoo.com).

*Corresponding Author FaridElmi Sadr: General Surgeon. School of Medicine, Iran University of Medical science, Tehran, Iran. E-mail: Farid.elmisadr@gmail.com.

ABSTRACT

Laparoscopic surgery is one of the risky procedures due to exposing operating team to aerosols. In fact, aerosol exposure may occur in different steps to perform the operation including intentional or unintentional CO2 releasing mainly during insertion or removal of ports, retrieving specimens or removing pneumoperitoneum at the end of operation. High rates of other pathogens such as hepatitis B virus, human immunodeficiency virus, and human papillomavirus in smokes and aerosols generated by laparoscopic devices have been reported, but there is no strong evidence of an increased risk of transmitting the SARS-CoV-2 virus through laparoscopic surgery. The present study aimed to systematically review the literature with respect to safety of laparoscopic and minimally invasive surgeries during Covid-19 pandemic with respect to the risk of viral contamination through surgical smoking and aerosolization, and then to summarize the delivered recommendations for smoke evacuation and aerosol production control during Covvid-19 outbreak.

Introduction

With the outbreak of the Covid-19 pandemic, not only has the world faced a major problem of preventing and controlling the high likelihood of the transmission of this viral infection, but also the management and planning of healthcares in medical centers were also of great concern (1,2). This issue was significant in several respects. First, the capacity of available facilities for the treatment and care of patients in hospitals, especially intensive care units, was limited in many communities, so that in some developing countries, it was not even possible to complete the treatment of patients in these centers leading continue of healthcares as outpatient or homecare (3). Second, treatment personnel also faced major problems, including the high risk of infection due to frequent exposure to patients and the provision of medical services (4). In this regard, scheduling aerosol generating operations especially those involve imaging procedures (gastrointestinal endoscopy, laparoscopy, bronchoscopy), or protective procedures (intubation,

extubation, chest tube insertion) or energy-based devices (electrocautery) exposes the personnel to this infection (5). Laparoscopic surgery is one of the risky procedures due to exposing operating team to aerosols. In fact, aerosol exposure may occur in different steps to perform the operation including intentional or unintentional CO2 releasing mainly during insertion or removal of ports, retrieving specimens or removing pneumoperitoneum at the end of operation (6). In fact, each steps of laparoscopic surgery may increase the risk for smoke inhalation to surgical and operating room personnel. In this regard, in spite of high safety of laparoscopic surgeries, due to the fear of COVID-19 transmission because of generating SARS-CoV-2 contaminated aerosols, its beneficial during Covid-19 outbreak is uncertain.In contrast, open surgery for suspected patients with Covid-19 also puts staff at high risk of transmitting this infection (7). Therefore, surgeons are generally reluctant to perform elective surgeries and try to delay such surgeries as much as possible (8). Also, emergency surgeries are performed in special circumstances and with a definite emphasis on protocols related to the control of Covid-19 disease and in special and selected centers. Therefore, it is still questionable which procedure is preferred for patients undergoing surgery, especially emergency surgery during Covid-19 outbreak. It seems that in order to perform each of these procedures, special instructions and recommendations should be developed and presented in order to reduce the possibility of transmitting the virus to personnel to a minimum and also to ensure the highest level of safety for patients. The present study aimed to systematically review the literature with respect to safety of laparoscopic and minimally invasive surgeries during Covid-19 pandemic with respect to the risk of viral contamination through surgical smoking and aerosolization, and then to summarize the delivered recommendations for smoke evacuation and aerosol production control during Covvid-19 outbreak.

Materials and Methods

The main issues focused in our systematic review were 1) the risk for contamination with coronavirus generating Covid-19 in laparoscopic surgery via surgical smoke and aerosol production, 2) safety of the procedure regarding Covid-19 transmission though procedural smoking and aerosolization, and 3) global recommendation for minimizing the risk for such contamination in operating room. The current systematic review followed the principles of the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" guideline. First, all manuscripts related to Covid-19 were deeply searched by the two reviewers using the related keywords including "Covid-19", "laparoscopy", "minimally invasive surgery", "smoke", "aerosol" and "recommendation" in the international manuscript databases such as Web of Knowledge, SCOPUS, Web of knowledge (ISI), PubMed, Google Scholar, and Cochrane database. Any disagreement across our reviewers was rechecked by the third reviewer as the final arbitrator. The details of eligibility and the reasons for excluding the papers were shown schematically (Figure 1). The primary criterion for selecting articles was their relationship with comparing the risk and safety of laparoscopy and open surgery in transmitting Covid-19 infection and also the presence of one of the keywords in the title of the article. In the inclusion

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criteria for selecting the articles were 1) English language papers, 2) The articles with complete structure and contents, 3) Access to the full text of the article. Thus, the manuscripts with only abstract availability or with incomplete information were not included into our review, 4) all types of articles including the letters or editorials, original articles, and even reviews. The retrieved articles were placed in Endnote software and then duplicate and shared articles were removed in the foreword databases. Finally, the obtained information was categorized and analyzed by descriptive statistics and content analysis. Of the 126 articles available, a total of 36 full-text articles were retrieved and placed at Endnote. After considering the inclusion and exclusion criteria and eliminating duplicate and common articles in the foreword databases (8 articles), 28 articles were obtained and finally assessed. At this stage, all obtained articles were studied separately and the type of article and the main axis of the article were reviewed and extracted (Table 1).

Table 1.The purposes and conclusion of the studies reviewed

Author, country	**Type of paper**	**Main topic**	**Main points**	**Preventive recommendations**
Alabi, Nigeria [9]	Article Review	Gynecological laparoscopy	Increasing COVID 19 transmission to healthcare workers during laparoscopy due to the formation of COVID 19 contaminated aerosols	Assessing risk factor, postponing elective surgeries, employing experienced endo surgeons, using protectors, postoperative following-up and telemedicine
Boghdady, UK [10]	Systematic Review	Safety of laparoscopy	Concerning the viral transmission via aerosol generation under the use of different devices during laparoscopy	Postponing elective surgeries, choosing conservative approaches, using filters for the released CO2 during laparoscopy
Chadi, Kanada [11]	Article Review	Safety of laparoscopy	The viral transmission via aerosol generation	negative-pressure ventilation, minimizing time and exposure during intubation, using surgical masks, as well as smoke evacuation systems

Chene, France [12]	Article Review	Safety of laparoscopy	Viral contamination during Laparoscopy, introducing multi-modal requirements for a safe laparoscopy	high filtration masks during any laparoscopy, simple evacuation with a tube without filter in a washing solution, reducing pressure of the pneumoperitoneum
Choudhary, India [13]	Article Review	Plume Management after Pneumoperitoneum	No reports of the presence of SARS-CoV-2 in the surgical plume generated during laparoscopic surgery	Using smoke evacuation devices, low pneumoperitoneal pressure, minimizing setting of energy device
da Costa, Brazil [14]	Article Review	Using insufflators for safe CO2 removal	Using smoke evacuators with a combination of suction and mechanical filtering. There are electrostatic precipitators that charge surgical smoke	Using smoke evacuators and electrostatic precipitators
Author, country	Type of paper	Main topic	Main points	Preventive recommendations
de Leeuw, Nederland [15]	Systematic Review	Safety of laparoscopy	surgery should be performed on patients with COVID-19 only when necessary, and health care providers should use logic and common sense to protect themselves	converting operating rooms to negative pressure environments with airflow changes

Emile, Sudan [16]	Article Review	Safety of laparoscopy	Minimally invasive surgery use in the treatment of acute abdominal emergency. Avoiding the presumed risk of aerosolization of the virus particles	Using devices to filter the released gas for aerosolized particles, Wearing full PPE, negative pressure room, safe evacuation of pneumoperitoneum via a filtration system, Using appropriate trocar-size, minimize energy devices
Francis, USA [17]	Article Review	Recommendation to increase laparoscopy safety	Laparoscopy can lead to aerosolization of blood borne viruses, but without evidence on Covid-19, but recommendation are essential	Postponing elective surgeries, Testing all patients before surgery, minimizing number of staff members during the procedure, using a closed smoke evacuation/filtration system with Ultra Low Particulate Air Filtration (ULPA) capability, Minimize the use of energy sources
Gupta, India [18]	Article Review	Recommendation to increase laparoscopy safety	Laparoscopic procedures have a theoretical risk of generating aerosols particularly during creation of pneumoperitoneum, and while using energy devices due to smoke generation	negative pressure ventilation, Minimal personnel use, adequate PPE for personnel, regional anaesthesia should be preferred, negative-pressure ventilation
Guraya, UAE	Article Review	laparoendoscopic surgical protocols	Laparoendoscopic procedures increase	Limiting the number of operating room

[19]			the risk of aerosol exposure, disease transmission and contamination	personnel, use of disposable instruments, small trocar incisions, negative pressure environment, and setting energy devices at low modes
Author, country	Type of paper	Main topic	Main points	Preventive recommendations
Mallick, UK [20]	Article Review	Gynecological laparoscopy	Laparoscopic procedures have a theoretical risk of generating aerosols particularly during creation of pneumoperitoneum, the risk of contomntion may be higher than open surgery	Laparoscopic procedures have a theoretical risk of generating aerosols particularly during creation of pneumoperitoneum
Mintz, Italy [21]	Article Review	risk of COVID‐19 transmission: laparoscopy vs. laparotomy	Surgical smoke created by electrosurgical and ultrasonic devices has the same composition both in laparoscopy and laparotomy.	The risk of COVID‐19 transmission by laparoscopic smoke may be lower than for laparotomy
Serban, Romania [22]	Systematic Review	Safety of laparoscopy	The reports of SARS-CoV-2 infected patients who underwent laparoscopic surgery revealed the presence of the virus, in digestive wall and stools in 50% of cases but not in bile	Implementing standardized filtration systems for smoke evacuation during laparoscopy

			or peritoneal fluid	
Somashekhar, India [23]	Article Review	Recommendation to increase laparoscopy safety	Health care workers should also protect themselves by following the guidelines and recommendations while treating the patients	Limiting the number of operating room personnel, use of disposable instruments, small trocar incisions, negative pressure environment, and setting energy devices at low modes
Uecker, USA [24]	Original article	Quantifying the gas leaked from dynamic interactions between laparoscopic instruments and the trocar port	Dynamic interactions and insertion/removal events between laparoscopic instruments and ports appear to contribute to consistent leakage of insufflated gas into the operating room	Minimizing laparoscope and instrument removal and replacement would be one strategy to mitigate gas leakage during laparoscopic surgery
Author, country	Type of paper	Main topic	Main points	Preventive recommendations
Veziant, France [25]	Article Review	Safety of laparoscopy	There is no expert consensus on the actual or extrapolated presence of ambient SARS-CoV-2 in the pneumoperitoneum as factual evidence is lacking	Prefer the ‘‘closed’’ technique for obtaining pneumoperitoneum, reduce the pneumoperitoneum pressure as, reduce the power of electrosurgery, using laparoscopic smoke aspiration systems, particle filters, using intracorporeal anastomosis, fully aspirate the

				pneumoperitoneum before removing the last trocar
Vigneswaran, USA [26]	Article Review	Safety of laparoscopy versus open surgery	Laparoscopic procedures have a theoretical risk of generating aerosols particularly during creation of pneumoperitoneum, and while using energy devices due to smoke generation	negative pressure ventilation, Minimal personnel use, adequate PPE for personnel, regional anaesthesia should be preferred, negative-pressure ventilation
Zago, Italy [27]	Original article	Filter systems to improve safety of laparoscopy	Assembling of two easily available and low-cost filter systems to prevent potential dissemination of Coronavirus via the aerosol	Both filter systems were proved to be effective in smoke evacuation, without affecting laparoscopic visualization
Zakka, UK [28]	Article Review	Laparoscopy energy device and risk for virus contamination	Investigations of other viruses have demonstrated aerosolization through energy devise use	Appropriate personal protective equipment, evacuation and filtration of surgical plume, limiting energy device use if appropriate, and adjusting endoscopic and laparoscopic practice
Zampolli, USA [29]	Article Review	Urological laparoscopy	There is no society consensus on restricting laparoscopic or robotic surgery. However, there is expert consensus on modification of	Modifications of standard practices during minimally invasive surgery such as using lowest intra-abdominal pressures possible, controlled smoke evacuation systems, and

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			standard practices to minimize any risk of transmission	minimizing energy device usage

Results

Special features of risk for viral contamination during laparoscopy

Maintaining a proper pneumoperitoneum is essential for laparoscopic surgery. However, due to this necessity, the risk for aerosolization through gas (CO_2) leaks or at exsufflation can increase. Based on some evidences, comparing laparoscopy and laparotomy showed higher concentration rate of micro-particles in operating room environment about 10 minutes after applying ultrasound or electro cutters for laparoscopic dissection (9-12). Thus, it seems that the risk for contamination of healthcare staff with particles such as viruses is considerably higher than in open surgery (13). In other words, leaked aerosolmay include high concentrations of different types of viruses especially the viruses sourced from the patient host. Such likelihood can also increased more in the case with poorly controlled exsufflation or occurring gas leakage during laparoscopic surgery (12-14, 16-20). In contrast with the pointed increased risk, some others contend that the scheduling operation with the closed surgical site (like laparoscopy or any minimally invasive surgeries) can reduce the risk for contamination as compared to open surgeries (17,18). To understand the contamination process related to laparoscopic surgery in detail, deeply attention to different steps of this procedure is necessary. Laparoscopic surgery contains of different procedural steps including intubation, maintaining a suitable and safe pneumoperitoneum, using both ultrasonic and electrical scalpels, smoke evacuation, extracting tissues specimens, pneumoperitoneum reversal, removing trocars, and finally closing the incision (20-26). At first, establishing a pneumoperitoneum is the main step for laparoscopy. In this step, the use of electrical equipment or ultrasonic scalpels is common that naturally lead to produce a large amount of smokes as well as low-temperature aerosols (10-14). Besides, the application of high power energy source (such as ultrasonic, monopolar or bipolar sources) is necessary for laparoscopic surgery that can be own an effectively origin for producing smoke (10,12). In addition, the gases produced in pneumoperitoneum are mainly immobile and thus the aerosols produced during the procedure tend to be concentrated leading higher capacity of infected particles in abdominal cavity (10,11). Interestingly, accidentally occurring any small incision in abdominal wall, releasing trocar valves or changing the clamps may expose the staff to more produced aerosols and thus higher risk for contamination (17,18). Along with the pointed mechanisms, the use of laser systems and electrocautery can flare smoke generation (16). In this regard, the procedures of cutting, removing tissues, vaporizing, and coagulating that lead to heating the target tissues can result in dispersion of the fine claws in the air and leading greater risk for infectious loads. It should be noted that the size of particles scattered is directly dependent to the load of energy used vaporization and cutting (18-23). In the regard, the largest particles are frequently generated by ultrasonic scalpels followed by laser tissue ablation (24). Such particles can travel larger distance from the production point, can penetrate easily the lungs

and thus can induce inflammatory and infectious responses. The smokes produced by using electrocautery and lasers can also induce various mutagenic and cytotoxic reactions in the tissues (17-22). Moreover, removal of specimens, if the sample itself is a reservoir for infectious particles doubles the spread of infection during the procedure. Overall, such smokes and aerosols can potentially threaten the personnel to a variety of infections (20,22). As an enhancer of the spread of infection, operating theatres naturally have an air positive pressure as compared to the surrounding air (20-24). This positive pressure is essential for preventing the flow of air from less sterile areas into a more sterile one. However this high pressure condition may accelerate and facilitate the aerosols spreading leading increase the risk for airborne viral transmission (25,26). Despite all the above evidence, no trace of the risk of spreading the SARS-CoV-2 virus and its increased risk following laparoscopy has been reported. However, high rate of the spread of other viruses has been well understood. In this regard, high rates of other pathogens such as hepatitis B virus, human immunodeficiency virus, and human papillomavirus in smokes and aerosols generated by laparoscopic devices have been reported (12-16). According to the literature, the presence of hepatitis B virus and human papillomavirus in surgical smokes has been found in up to 40% and 90% of smoke plumes especially following loop excision biopsy of the tissues (10-16). But reviews of recent studies have acknowledged two points. First, there is no strong evidence of an increased risk of transmitting the SARS-CoV-2 virus through laparoscopic surgery which may be due to the lack of interventional and experimental studies to evaluate the effect of laparoscopic intervention on staff contamination by this infection (22-26). Second, studies comparing the effect of open surgery and laparoscopy on the transmission of Covid-19 infection to personnel have not shown a difference between the two types of procedures (27,28).However, the lack of such findings based on the physiopathological processes described does not mean that there is no risk of transmission of the virus and therefore it is essential to take the necessary measures for preventing transmission of infection trough smokes and aerosols.

Principle recommendations for preventing virus transmission

According to the likelihood of transmitting Covid-19 virus through smokes and aerosols generated by laparoscopic devices (despite not proving), many recommendations have been released recently by the different societies for reducing virus transmission risk among healthcare workers (12-29):1) As the patients-based measures, medical treatments or postponing the surgery should be considered to decrease the risk for horizontal transmission of virus to the personnel. Of course, this will mainly be related to elective surgery or with mild lesions. 2)The patients suspected to Covid-19 should be preoperatively assessed for the disease by reliable molecular and virology screening tests. 3) The laparoscopic operations should be performed by high qualified endo surgeons complete aware of safe laparoscopic procedures and able to perform the procedure in the shortest possible time. 4) The use of personal protective equipment is the basis for preventing the transmission of infection. The common measures for such prevention include disposable gloves and fluid-resistant gowns, filtering face piece class 2 or 3 or N95 respirator

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and disposable eye protects. 5) To minimize the exposure to the source of infection in wards and operating rooms, minimizing the number of staff required for surgery or related care should also be considered. 6) Due to this fact that the presence of positive pressure ventilation may increase the chance for aerosols distribution, the operating pressure should be lowered as much as possible. In fact, a negative pressure environment is ideal to reduce dissemination of the virus beyond the operating theatre although such facilities are not widely available. 7) High precaution and attention should be taken within insufflations to prevent the risk for aerosol dispersion. Also, paying attention to port sites to prevent explosive dispersion of body fluids both at the insertion/removal of trocars and specimen retrieval is necessary. 8) In order to minimize the gas leaks, limiting the number of size of incisions along with exchange of instruments can help to such leakage. 8) The use of electrosurgical devices with low power setting also leads to lower generation rate of surgical smokes. 9) Using suitable smoke evacuation filters to remove CO2 pneumoperitoneum, smokes and aerosols from surgical environment is very helpful to minimize the exposure to virus contamination. Using high-efficiency particulate air filters or ultra-low particulate air filters can remove particles even in the size of 0.3 microns (like viruses) by 99.9% efficiency rate, while N95 respirator mask filters can remove less than 95% of larger particles. 10) Due to this fact that SARS-CoV-2 colonization may occur along the cell lines of the gastrointestinal and respiratory tracts, cares should be strongly taken within endotracheal intubation and ventilation. 11) Continuous air changing in the operating room can also protect the surgical staff and patients against virus transmission.

Discussion and Conclusion

Up to know, no consistent evidence has been obtained on exposing the healthcare personnel especially operating room staff to higher risk for SARS-CoV-2 contamination following laparoscopic or laser-based procedures as compared to open surgeries. However, in line with risky condition for transmitting other viral particles during these procedures, all required measures and protocols should be applied to minimize the risk for SARS-CoV-2 transmission during such procedures (20-26). Because of the likelihood of transmitting SARS-CoV-2 through aerosols and smoke generation during laparoscopic surgeries, personnel protection against virus exposing along with using instrument to removing and evacuating from operating room, applying low energy device and air negative pressure condition can minimize the risk for exposure to SARS-CoV-2 virus among personnel (16-22). Overall, postponing such operations if possible is the main fundament for personnel protection. As recommended by the Royal College of Surgeons, laparoscopic surgery should not in general consider and also based on the guideline released by the Society of American Gastrointestinal and Endoscopic Surgeon, conducting such procedures is allowed only by using filters for the released CO2 or other smokes and aerosols during laparoscopic or robotic surgeries (27-29). In final, as concluded by the American College of Surgeons, no information is available supporting the priority of laparoscopic to open surgery regarding the transmission of SARS-CoV-2 virus to personnel (29). Overall, further studies are

needed to assess the risk for transmitting virus to healthcare professionals through generating laparoscopy-related smokes and aerosols.

References

[1] Sommerstein R, Fux CA, Vuichard-Gysin D, Abbas M, Marschall J, Balmelli C, Troillet N, Harbarth S, Schlegel M, Widmer A; Swissnoso. Risk of SARS-CoV-2 transmission by aerosols, the rational use of masks, and protection of healthcare workers from COVID-19. Antimicrob Resist Infect Control. 2020 Jul 6;9(1):100. doi: 10.1186/s13756-020-00763-0.

[2] El-Hage W, Hingray C, Lemogne C, Yrondi A, Brunault P, Bienvenu T, Etain B, Paquet C, Gohier B, Bennabi D, Birmes P, Sauvaget A, Fakra E, Prieto N, Bulteau S, Vidailhet P, Camus V, Leboyer M, Krebs MO, Aouizerate B. Health professionals facing the coronavirus disease 2019 (COVID-19) pandemic: What are the mental health risks? Encephale. 2020 Jun;46(3S):S73-S80. doi: 10.1016/j.encep.2020.04.008. Epub 2020 Apr 22.

[3] Cascella M, Rajnik M, Cuomo A, Dulebohn SC, Di Napoli R. Features, Evaluation, and Treatment of Coronavirus. 2020 Oct 4. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan.

[4] Jin YH, Huang Q, Wang YY, Zeng XT, Luo LS, Pan ZY, Yuan YF, Chen ZM, Cheng ZS, Huang X, Wang N, Li BH, Zi H, Zhao MJ, Ma LL, Deng T, Wang Y, Wang XH. Perceived infection transmission routes, infection control practices, psychosocial changes, and management of COVID-19 infected healthcare workers in a tertiary acute care hospital in Wuhan: a cross-sectional survey. Mil Med Res. 2020 May 11;7(1):24. doi: 10.1186/s40779-020-00254-8.

[5] Howard BE. High-Risk Aerosol-Generating Procedures in COVID-19: Respiratory Protective Equipment Considerations. Otolaryngol Head Neck Surg. 2020 Jul;163(1):98-103. doi: 10.1177/0194599820927335. Epub 2020 May 12.

[6] Morrell ALG, Tustumi F, Morrell-Junior AC, Morrell AG, Ribeiro DMFR, Corsi PR, Morrell AC. Laparoscopic or robotic intraoperative management to minimize aerosol dispersion: Adaptations to the context of the COVID-19 pandemic. Rev Col Bras Cir. 2020 Jun 3;47:e20202558. doi: 10.1590/0100-6991e-20202558.

[7] De Simone B, Chouillard E, Di Saverio S, Pagani L, Sartelli M, Biffl WL, Coccolini F, Pieri A, Khan M, Borzellino G, Campanile FC, Ansaloni L, Catena F. Emergency surgery during the COVID-19 pandemic: what you need to know for practice. Ann R CollSurg Engl. 2020 May;102(5):323-332. doi: 10.1308/rcsann.2020.0097. Epub 2020 Apr 30.

[8] Moletta L, Pierobon ES, Capovilla G, Costantini M, Salvador R, Merigliano S, Valmasoni M. International guidelines and recommendations for surgery during Covid-19 pandemic: A Systematic Review. Int J Surg. 2020 Jul;79:180-188. doi: 10.1016/j.ijsu.2020.05.061. Epub 2020 May 23.

[9] O C Alabi 1, J E Okohue 2, A AAdewole 3, J I Ikechebelu 4. Association of gynecological endoscopy surgeons of Nigeria (AGES) advisory on laparoscopic and hysteroscopic procedures during the COVID-19 Pandemic. Niger J ClinPract. 2020 May;23(5):747-749. doi: 10.4103/njcp.njcp_163_20.

[10] Michael El Boghdady 1, Beatrice Marianne Ewalds-Kvist 2. Laparoscopic Surgery and the debate on its safety during COVID-19 pandemic: A systematic review of recommendations. Surgeon. 2020 Aug 11;S1479-666X(20)30104-9. doi: 10.1016/j.surge.2020.07.005. Online ahead of print.

[11] Sami A Chadi 1, Keegan Guidolin 1 2, Antonio Caycedo-Marulanda 3, Abdu Sharkawy 4, Antonino Spinelli 5 6, Fayez A Quereshy 1, Allan Okrainec 1. Current Evidence for Minimally Invasive Surgery During the COVID-19 Pandemic and Risk Mitigation Strategies: A Narrative Review. Ann Surg. 2020 Aug;272(2):e118-e124. doi: 10.1097/SLA.0000000000004010.

[12] Gautier Chene 1, Lionel Bouvet 2, Emanuele Cerruto 3, Erdogan Nohuz 3. How can we minimize the potential risk of viral contamination during laparoscopic procedures for suspected or infected COVID-19 patients? Eur J ObstetGynecolReprod Biol. 2020 Oct 16;255:63-66. doi: 10.1016/j.ejogrb.2020.10.011. Online ahead of print.
[13] Gautam Ram Choudhary 1, Deepak Kumar Ranjan 2. Simple Device Design for Plume Management after Pneumoperitoneum in Laparoscopy in COVID-19 Outbreak. Indian J Surg. 2020 Jun 25;1-2. doi: 10.1007/s12262-020-02477-4. Online ahead of print.
[14] Karina M. da Costa1,2 | Amulya K. Saxena. Coronavirus disease 2019 pandemic and identifying insufflators with desufflation mode and surgical smoke evacuators for safe CO2 removal. Asian J Endosc Surg. 2020;1–5.
[15] Robert Adrianus de Leeuw 1, Nicole Birgit Burger 1, Marcello Ceccaroni 2, Jian Zhang 3, JurriaanTuynman 4, Mohamed Mabrouk 5, Pere BarriSoldevila 6, Hendrik JaapBonjer 4, PimAnkum 7, Judith Huirne 7. COVID-19 and Laparoscopic Surgery: Scoping Review of Current Literature and Local Expertise. JMIR Public Health Surveill. 2020 Jun 23;6(2):e18928. doi: 10.2196/18928.
[16] Sameh Hany Emile &Hytham K. S. Hamid (2020): A critical review of the safety of minimally invasive surgery in the era of COVID-19, Minimally Invasive Therapy & Allied Technologies, DOI: 10.1080/13645706.2020.1838549
[17] Nader Francis 1 2, Jonathan Dort 3, Eugene Cho 4, Liane Feldman 5, Deborah Keller 6, Rob Lim 7, Dean Mikami 8, Edward Phillips 9, Konstantinos Spaniolas 10, Shawn Tsuda 11, Kevin Wasco 12, Tan Arulampalam 13, MarkarSheraz 14, Salvador Morales 15, Andrea Pietrabissa 16, HoracioAsbun 17, Aurora Pryor 18. SAGES and EAES recommendations for minimally invasive surgery during COVID-19 pandemic. SurgEndosc . 2020 Jun;34(6):2327-2331. doi: 10.1007/s00464-020-07565-w. Epub 2020 Apr 22.
[18] Nikhil Gupta 1, Himanshu Agrawal 2. COVID 19 and laparoscopic surgeons, the Indian scenario – Perspective. Int J Surg. 2020 Jul;79:165-167. doi: 10.1016/j.ijsu.2020.05.076. Epub 2020 May 29.
[19] Salman Y Guraya 1. Transforming laparoendoscopic surgical protocols during the COVID-19 pandemic; big data analytics, resource allocation and operational considerations. Int J Surg. 2020 Aug;80:21-25. doi: 10.1016/j.ijsu.2020.06.027. Epub 2020 Jun 23.
[20] R Mallick 1, F Odejinmi 2, T J Clark 3. Covid 19 pandemic and gynaecological laparoscopic surgery: knowns and unknowns. Facts Views Vis Obgyn. 2020 Apr 1;12(1):3-7.
[21] YoavMintz 1, Alberto Arezzo 2, Luigi Boni 3, LudovicaBaldari 3, Elisa Cassinotti 3, Ronit Brodie 1, Selman Uranues 4, MinHua Zheng 5, Abe Fingerhut 6 7. The risk of COVID-19 transmission by laparoscopic smoke may be lower than for laparotomy: a narrative review. SurgEndosc . 2020 Aug;34(8):3298-3305. doi: 10.1007/s00464-020-07652-y. Epub 2020 May 26.
[22] DragosSerban 1 2, Catalin Gabriel Smarandache 1 2, Corneliu Tudor 2, Lucian Nicolae Duta 2, Ana Maria Dascalu 1, CătălinAliuș 2. Laparoscopic Surgery in COVID-19 Era-Safety and Ethical Issues. Diagnostics (Basel). 2020 Sep 4;10(9):673. doi: 10.3390/diagnostics10090673.
[23] S P Somashekhar 1, Rudra Acharya 2, S Manjiri 3, SumitTalwar 4, K R Ashwin 1, C Rohit Kumar 1. Adaptations and Safety Modifications to Perform Safe Minimal Access Surgery (Minimally Invasive Surgery: Laparoscopy and Robotic) during the COVID-19 Pandemic. SurgInnov. 2020 Oct 7;1553350620964323. doi: 10.1177/1553350620964323. Online ahead of print.
[24] John M Uecker 1 2, Austin Fagerberg 1, Naser Ahmad 1, Alexander Cohen 3, Mitchell Gilkey 1, FarshidAlembeigi 3, Christopher R Idelson 4. Stop the leak!: Mitigating potential exposure of aerosolized

COVID-19 during laparoscopic surgery. SurgEndosc. 2020 Sep 24;1-9. doi: 10.1007/s00464-020-08006-4. Online ahead of print.
[25] J Veziant 1, N Bourdel 2, K Slim 3. Risks of viral contamination in healthcare professionals during laparoscopy in the Covid-19 pandemic. J Visc Surg. 2020 Jun;157(3S1):S59-S62. doi: 10.1016/j.jviscsurg.2020.04.010. Epub 2020 Apr 17.
[26] YaliniVigneswaran 1, Vivek N Prachand 2, Mitchell C Posner 2, Jeffrey B Matthews 2, Mustafa Hussain 2 What Is the Appropriate Use of Laparoscopy over Open Procedures in the Current COVID-19 Climate? J Gastrointest Surg. 2020 Jul;24(7):1686-1691. doi: 10.1007/s11605-020-04592-9. Epub 2020 Apr 13.
[27] Mauro Zago 1, Selman Uranues 2, Marco EnocChiarelli 3, SamueleGrandi 3, Luca Andrea Fumagalli 3, Mario Tavola 4, Massimo Chiarugi 5, Diego Mariani 6, Valerie Wienerroither 7, HayatoKurihara 8, Abe Fingerhut 2 9. Enhancing safety of laparoscopic surgery in COVID-19 era: clinical experience with low-cost filtration devices. Eur J Trauma Emerg Surg. 2020 Aug;46(4):731-735. doi: 10.1007/s00068-020-01413-1. Epub 2020 Jun 1.
[28] Kimberley Zakka 1, Simon Erridge 1, Swathikan Chidambaram 1, Michael Kynoch 2, James Kinross 1, Sanjay Purkayastha 1, PanSurg collaborative group. Electrocautery, Diathermy, and Surgical Energy Devices: Are Surgical Teams at Risk During the COVID-19 Pandemic? Ann Surg. 2020 Jun 9;272(3):e257-e262. doi: 10.1097/SLA.0000000000004112. Online ahead of print.
[29] Hamilton C Zampolli 1, Alejandro R Rodriguez 2. Laparoscopic and Robotic Urology Surgery during Global Pandemic COVID19. IntBraz J Urol . 2020 Jul;46(suppl.1):215-221. doi: 10.1590/S1677-5538.IBJU.2020.S113.