THE SURGEON 19 (2021) E452–E461

COVID-19 infection risk by open and laparoscopic surgical smoke: A systematic review of the literature

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ARTICLE INFO

Article history:
Received 16 December 2020
Received in revised form
10 February 2021
Accepted 15 February 2021
Available online 3 March 2021

Keywords:
COVID-19
Coronavirus
Infection
Surgery
Surgical smoke
Virus
Surgical plumes
Viral transmission
Risk

ABSTRACT

Background: The current COVID-19 pandemic has greatly changed the way surgery is delivered. In particular, current guidelines and policies have highlighted the need to use high level Personal Protective Equipment to reduce the risk of viral infection during open and laparoscopic surgical procedures. In particular, it was felt that the laparoscopic approach was at higher risk of viral transmission due to the chimney effect of the smoke escape from the trocars during and after the procedure. However, with this being a new and largely unknown viral agent, guidelines have been based on speculation and extrapolation from previous studies conducted in completely different situations, and led to anxiety amongst surgeons and theatre staff. We decided to conduct a systematic review of the Literature to try to clarify whether inhalation of surgical smoke can increase the risk of COVID-19 infection.

Methods: A thorough search of the relevant Literature was performed following the PRISMA guidelines and the most relevant papers on this topic were selected for qualitative analysis. Duplicates, review, personal opinions and guidelines have been excluded. Quantitative analysis has not been performed due to the lack of homogeneous high-quality studies.

Results: Literature search identified 740 papers but only 34 of them were suitable for qualitative analysis. The quality of those studies is generally quite low. We were not able to find any evidence directly linking surgical smoke with viral transmission, other than in patients with active HPV infection.

Discussion: Inhalation of surgical smoke can be generally hazardous, and therefore the use of PPE during surgical operations must be recommended in any case. However, the present systematic review of the existent Literature did not identify any significant evidence of the risk of viral transmission with the surgical smoke, therefore the current guidelines restricting the use of laparoscopy and/or diathermy during the current Covid-19 pandemic may be considered excessive and non-evidence based.

Introduction

COVID-19 is a coronavirus causing a severe pandemic and globally affecting all aspects of healthcare at present. The practice of surgery, both elective and emergency, has significantly changed over the last few months, as attempts have been made to minimise the risks of potential transmission of COVID-19 infection. The use of personal protective equipment (PPE) has been advocated by national and international guidelines as the best method to reduce the risk to theatre staff, particularly in Aerosol Generating Procedures

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https://doi.org/10.1016/j.surge.2021.02.003
1479-666X/

(AGP).[1] Surgical guidelines, probably published in the haste of the first wave of the COVID-19 pandemic, went further to recommend avoiding laparoscopic surgery as much as possible, fearing that the chimney effect of high flow intraperitoneal gas escape during and after the procedure would increase the risk of viral transmission. They also recommended minimal use of diathermy to reduce smoke creation, with the assumption that surgical plume may cause viral spread and infection.[2] While it has been demonstrated that intubation and other procedures on the upper airways are to be considered AGP, and therefore at high risk for viral transmission, it is not clear if a laparotomy or laparoscopy is in fact an AGP. In other terms, it is not clear if the surgical plume must be considered "aerosol". Furthermore, while the risks linked to the inhalation of the surgical smoke have been discussed for many years, it is not yet clear whether this carries an additional transmission risk of viral infection, particularly with regards to non-blood borne viruses such as COVID-19.

We decided to conduct a systematic review of the Literature with the aim of answering the following questions:

1. Is there any infective risk for surgeons and theatre staff exposed to surgical smoke?
2. Is there any evidence of the presence of active virus in the surgical smoke in patients with ongoing viral infection?
3. Are non-blood borne viruses present in the surgical smoke?
4. Is COVID-19 present in the surgical smoke? If so, what is the risk of infection?

Materials and methods

The study was conducted according to the PRISMA guidelines.[3] A thorough search of the relevant literature has been performed within the most common medical database – Pubmed – and addressed with the following queries:

(virus OR Covid) AND (fumes OR fume), (virus OR Covid) AND (surgical smoke OR surgical plume), (virus OR Covid) AND diathermy, (virus OR Covid) AND (surgical AND smoke), (virus OR Covid) AND (surgical AND plume).

Other relevant articles were identified from the references of those already selected. After removing the duplicates, titles and abstracts of those remaining were screened to confirm their relevance to our clinical questions. Articles with no available abstracts were advanced to the next step. A further full-text selection to confirm eligibility was performed on the remaining articles, and the most relevant ones selected for qualitative analysis. Reviews, personal opinions and guidelines have not been used for qualitative analysis but some of them were used in the discussion. Quantitative analysis was not performed due to the lack of homogeneous, high-quality studies.

Results

The results of the Literature search are reported in Fig. 1 according to the PRISMA guidelines.[3] Thirty-four articles were selected for final review. Four of them were experimental studies on animals (2 of these were associated with clinical cohort studies), 4 were case reports, 17 were clinical cohort studies and 9 were experimental laboratory studies.

Is there any infective risk for surgeons and theatre staff exposed to surgical smoke?

Although numerous studies demonstrate the presence of infective material in surgical smoke, these studies fail to demonstrate the infectivity of such cells. One study investigating the smoke plumes secondary to CO2 laser resurfacing demonstrated the potential for bacterial transmission via surgical smoke, but no infectivity was demonstrated with viral transmission.[4]

In terms of investigating the potential for viral transmission via surgical smoke plumes generated from electrocautery, the evidence currently available is that of four separate case reports. The first reports a case of laryngeal papillomatosis originating from HPV 6 and 11 in a surgeon with no identifiable risk factors, apart from a clear occupational history of treating anogenital condylomas caused by the same viral strain5. The second case report[6] discussed a similar case of laryngeal papillomatosis in a gynaecology operating room nurse, who had assisted in both electrosurgical and laser surgical excisions of anogenital condylomas. Table 1.

Another paper highlighted a case of HPV-16 positive tonsillar squamous cell carcinoma in a 53-year old gynaecologist who had a 20 year history of exposure to laser plumes, and another case of base of tongue cancer in a gynaecologist with a similar 30 year history of occupational exposure, with no other identifiable risk factors.[7] None of the other available studies showed any evidence to suggest an infective risk to theatre staff, and no studies were performed in non-blood borne or non-local tissue viruses.

Is there any evidence of the presence of active virus in the surgical smoke in patients with ongoing viral infection?

In this review, a total of seven studies[8–14] were found demonstrating no detection whatsoever of infective cells in surgical smoke plumes. Only one of these studies[8] tested the plumes generated from electrocautery, whilst the remaining studies used laser plumes.

Four studies successfully demonstrated the presence of virus in smoke extraction devices, however, they did not demonstrate actual infectivity of the virus.[15–18] Three of these studies related to gynaecological procedures using CO2 laser and loop electrosurgical excision procedure plumes, whilst the fourth was an experimental study using an excimer laser. None of these studies were related to laparoscopic surgery or electrocautery techniques. One study suggested that viable viral DNA can be found in surgical plumes, but this was only demonstrated with short term cultures of particulate debris found in plume collection tubing itself, which were no longer viable at 28 days.[19]

Another study demonstrated the infectivity of HIV infected cells found in cool aerosols generated by certain surgical power tools, but showed no infectivity amongst cells in electrocautery smoke.[20,21]

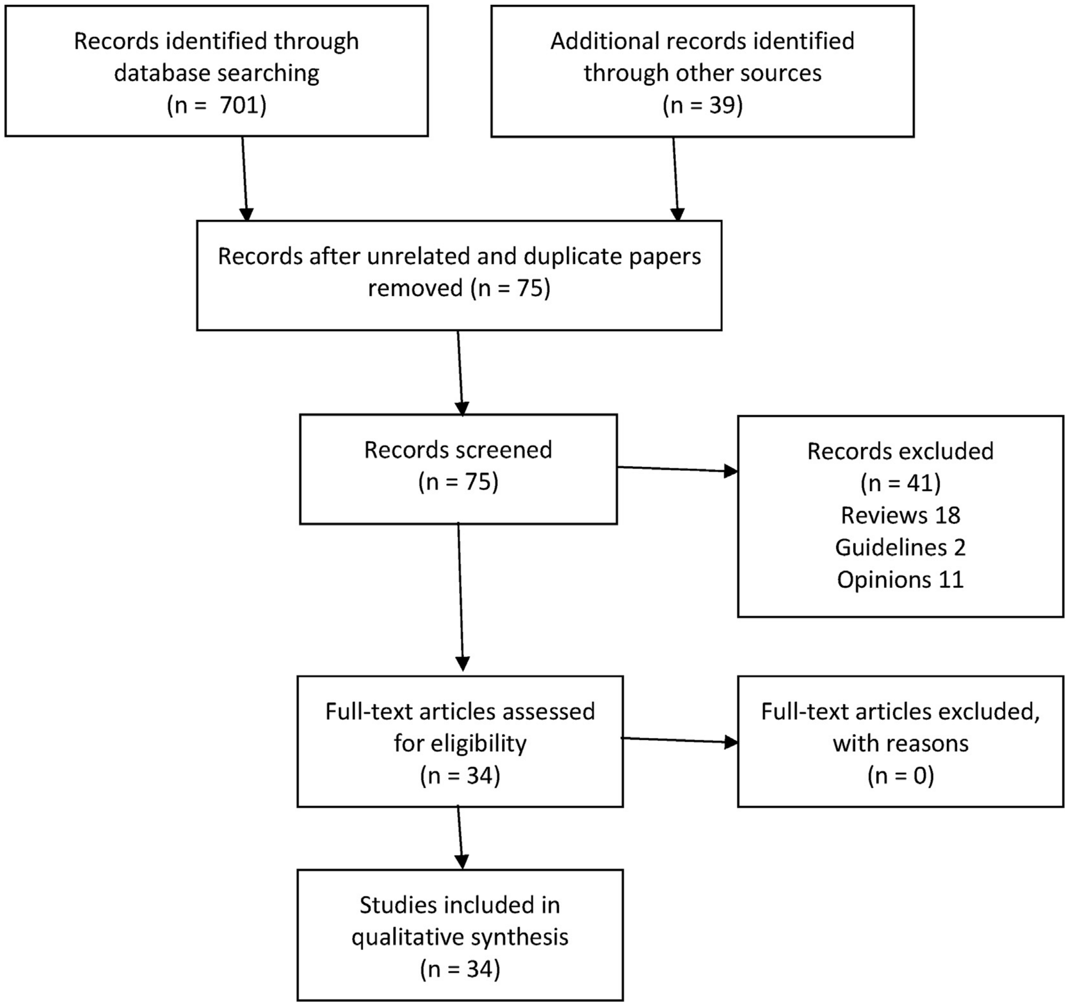

Fig. 1 – PRISMA 2009 flowchart.

In terms of laparoscopic surgery, one study identified hepatitis B virus in surgical plumes amongst patients who had undergone laparoscopic abdominal surgery.[22] Although the infectivity of the virus was not tested, this study suggested that surgical plumes may transmit certain blood borne viruses such as HBV.

Are non-blood borne viruses present in the surgical smoke?

Four animal studies investigating the infectivity of viruses via laser smoke plume have previously been performed, one of which showed no evidence of viral presence or transmission.[8] Two studies demonstrated viral infectivity amongst particles identified in surgical smoke secondary to CO2 laser cautery specifically. The first study demonstrated infectivity of laser plume particles by using the plume to re-inoculate bovine papillomavirus-induced cutaneous fibropapillomas,[23] whilst the second used laser plume to reinfect mice with papillomavirus.[24] The last study only demonstrated the presence of viral particles, but also showed no infectivity of these particles.[25]

With regards to human transmission risk, a large study performed at the Mayo Clinic reported a slightly higher incidence of nasopharyngeal verrucae amongst surgeons treating patients with verrucae.[26] Overall wart incidence amongst the surgeons, however, was no higher than the general population. A similar study concluded that the higher incidence of verrucae amongst operating surgeons was more likely secondary to direct contact rather than via plume transmission, as verrucae were noted to be highest on surgeons' hands, with no verrucae being found in the upper airway, as had previously been suggested.[27]

Another study confirmed infectivity of bovine papillomavirus, but did not demonstrate the same for human papillomavirus.[28] Interestingly, this paper highlighted that higher titres of Papillomavirus DNA were recovered from laser vapour than electrocoagulation vapour, in keeping with the theory that electrocoagulation may result in particles too small for adequate titres needed for viral transmission.

Taravella et al. demonstrated that oral polio vaccine virus, unlike varicella zoster virus, can survive excimer laser ablation, although no demonstration of its infective potential was made.[14,18]

Is COVID-19 present in the surgical smoke? If so, what is the risk of infection?

The primary route of transmission of COVID-19 is via respiratory droplets.[29,30] In keeping with this knowledge, recent studies have established that viral particles can be detected in

Table 1

First Author	Title	Details	type of study	virus	Short outcome of the study
Abramson AL, DiLorenzo TP, Steinberg BM.	Is papillomavirus detectable in the plume of laser-treated laryngeal papilloma?	Arch Otolaryngol Head Neck Surg. 1990 May; 116(5):604–7.	Cohort	HPV	No virus detectable on the smoke
Andre P, Orth G, Evenou P, Guillaume JC, Avril MF.	Risk of papillomavirus infection in carbon dioxide laser treatment of genital lesions.	J Am Acad Dermatol. 1990 Jan; 22(1):131–2. No abstract available.	Case report	HPV	HPV DNA detected in smoke in 2/3 patients
Baggish MS, Poiesz BJ, Joret D, Williamson P, Refai A	Presence of Human Immunodeficiency Virus DNA in Laser Smoke	Lasers Surg Med 1991; 11:197–203	Lab	HIV	HIV DNA is present in surgical smoke
Bellina JH, Stjernholm RL, Kurpel JE.	Analysis of plume emissions after papovavirus irradiation with the carbon dioxide laser.	J Reprod Med. 1982 May; 27(5):268–70.	Cohort	Papova	Surgical plume is biologically inactive
Best SR, Esquivel D, Mellinger-Pilgrim R, Roden RBS, Pitman MJ.	Infectivity of murine papillomavirus in the surgical byproducts of treated tail warts.	Laryngoscope. 2020 Mar; 130(3):712–717. https://doi.org/10.1002/lary.28026. Epub 2019 May 1.	Animal study	PV	Laser plume can transmit viable viral particles.
Calero L, Brusis T.	Laryngeal papillomatosis - first recognition in Germany as an occupational disease in an operating room nurse.	Laryngorhinootologie. 2003 Nov; 82(11):790–3. German.	Case Report	HPV	Although low risk, gynae procedures may pose higher risk of viral particle transmission due to large tissue size
Capizzi PJ, Clay RP, Battey MJ.	Microbiologic activity in laser resurfacing plume and debris.	Lasers Surg Med. 1998; 23(3):172–4.	Cohort		Potential risk of bacterial infection exposure during laser resurfacing. No viral growth.
Dodhia S, Baxter PC, Ye F, Pitman MJ.	Investigation of the presence of HPV on KTP laser fibers following KTP laser treatment of papilloma.	Laryngoscope. 2018 Apr; 128(4):926–928. https://doi.org/10.1002/lary.27018. Epub 2017 Nov 24.	Cohort	HPV	No detectable virus on laser fibres, regardless of pre-sterilisation
Douglas J, McLean N, Horsley C, Higgins G, Douglas M, Robertson E	COVID-19: Smoke testing of surgical mask and respirators	Occupational Medicine	Lab	Covid-19	FFP3 masks are the only masks which offer full protection against coronavirus particles, even in non-aerosol generating procedures.
Ferenczy A, Bergeron C, Richart RM	Carbon dioxide laser energy disperses human papillomavirus deoxyribonucleic acid onto treatment fields.	Am J Obstet Gynecol. 1990 Oct; 163(4 Pt 1):1271-4	Cohort	HPV	CO2 laser energy disperses HPV DNA onto treatment fields and adjacent epithelium
Ferenczy A, Bergeron C, Richart RM.	Human papillomavirus DNA in CO2 laser-generated plume of smoke and its consequences to the surgeon.	Obstet Gynecol. 1990 Jan; 75(1):114–8.	Cohort	HPV	Although HPV DNA may be released during laser vaporization of genital HPV infections (positive HPV DNA in 20% of laser cannisters), contamination of the operator is unlikely provided appropriate equipment for evacuating HPV DNA-positive smoke is used.
Garden JM, O'Banion MK, Bakus AD, Olson C.	Viral disease transmitted by laser-generated plume (aerosol).	Arch Dermatol. 2002 Oct; 138(10):1303–7.	Animal study	PV	Laser plume can transmit viable viral particles
Garden JM, O'Banion MK, Shelnitz LS, Pinski KS, Bakus AD, Reichmann ME, Sundberg JP	Papillomavirus in the vapour of carbon dioxide laser treated verrucae.	JAMA 1988; 259:1199–1202	Animal/Cohort	HPV	Viral DNA is liberated into the air with the vapor of laser-treated verrucae

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Table 1 – (*continued*)

First Author	Title	Details	type of study	virus	Short outcome of the study
Gloster HM Jr, Roenigk RK.	Risk of acquiring human papillomavirus from the plume produced by the carbon dioxide laser in the treatment of warts.	J Am Acad Dermatol. 1995 Mar; 32(3):436–41.	Cohort	HPV	No significant difference in incidence of warts amongst surgeons, although HPV causing anogenital warts may have predilection for infecting the upper airway and may be more hazardous as a result
Hagen KB, Kettering JD, Aprecio RM, Beltran F, Maloney RK.	Lack of virus transmission by the excimer laser plume.	Am J Ophthalmol. 1997 Aug; 124(2):206–11.	Experimental	PRV	Even under conditions designed to maximize the likelihood of virus transmission, the excimer laser ablation plume does not appear capable of transmitting this particular live enveloped virus. Excimer laser ablation of the cornea of a human immunodeficiency virus (HIV)-infected or herpes virus-infected patient is unlikely to pose a health hazard to the surgeon.
Hallmo P, Naess O.	Laryngeal papillomatosis with human papillomavirus DNA contracted by a laser surgeon.	Eur Arch Otorhinolaryngol. 1991; 248(7):425–7.	Case Report	HPV	Possible link to laryngeal papillomatosis after history of anogenital condyloma surgeries performed
Higashi H, Matsumata T, Hayashi J, Yanaga K, Shimada M, Shirabe K, Taketomi A, Kashiwagi S, Sugimachi K	Detection of hepatitis C virus RNA in the ultrasonic dissector irrigating solution used in liver surgery.	Br J Surg. 1994 Sep; 81(9):1346-7	Cohort	HCV	possible transmission of HCV through the irrigating solution when using the Harmonic scalpel
Hughes PS, Hughes AP.	Absence of human papillomavirus DNA in the plume of erbium:YAG laser-treated warts.	J Am Acad Dermatol. 1998 Mar; 38(3):426–8.	Cohort	HPV	No viral DNA detected on erbium:YAG laser after treatment of warts
Johnson GK, Robinson WS.	Human immunodeficiency virus-1 (HIV-1) in the vapors of surgical power instruments.	J Med Virol. 1991 Jan; 33(1):47–50.	Experimental	HIV	HIV may remain viable in cold aerosols
Kashima HK, Kessis T, Mounts P, Shah K.	Polymerase chain reaction identification of human papillomavirus DNA in CO2 laser plume from recurrent respiratory papillomatosis.	Otolaryngol Head Neck Surg. 1991 Feb; 104(2):191–5.	Cohort	HPV	HPV-6 or HPV-11 was identified in 17 of 27 vapor-plume specimens from RRP and in none of three from non-RRP lesions.
Kunachak S, Sithisarn P, Kulapaditharom B.	Are laryngeal papilloma virus-infected cells viable in the plume derived from a continuous mode carbon dioxide laser, and are they infectious? A preliminary report on one laser mode.	J Laryngol Otol. 1996 Nov; 110(11):1031–3.	Cohort	HPV	Papillomavirus infected cells not detectable in plume after CO2 laser irradiation in continuous mode
Kwak HD, Kim SH, Seo YS, Song KJ.	Detecting hepatitis B virus in surgical smoke emitted during laparoscopic surgery.	Occup Environ Med. 2016 Dec; 73(12):857–863. https://doi.org/10.1136/oemed-2016-103724. Epub 2016 Aug 2.	Cohort	HBV	HBV detected in surgical smoke in 10 of the 11 patients

Table 1 – (continued)

First Author	Title	Details	type of study	virus	Short outcome of the study
Matchette LS, Faaland RW, Royston DD, Ediger MN.	In vitro production of viable bacteriophage in carbon dioxide and argon laser plumes.	Lasers Surg Med. 1991; 11(4):380–4.	Experimental	BF	Argon and CO2 lasers can disperse viable bacteriophage
Matchette LS, Vegella TJ, Faaland RW.	Viable bacteriophage in CO2 laser plume: aerodynamic size distribution.	Lasers Surg Med. 1993; 13(1):18–22.	Experimental	BF	CO2 laser plume can rarely contain viable bacteriophage
Neumann K, Cavalar M, Rody A, Friemert L, Beyer DA.	Is surgical plume developing during routine LEEPs contaminated with high-risk HPV? A pilot series of experiments.	Arch Gynecol Obstet. 2018 Feb; 297(2):421–424. https://doi.org/10.1007/s00404-017-4615-2. Epub 2017 Dec 13.	Cohort	HPV	Surgical plume resulting from routine LEEPs for HSIL of the cervix uteri has the risk of contamination with high-risk HPV.
Price JA, Yamanashi W, McGee JM.	Bacteriophage phi X-174 as an aerobiological marker for surgical plume generated by the electromagnetic field focusing system.	J Hosp Infect. 1992 May; 21(1):39–50.	Experimental	BF	Bacteriophage is present in surgical plume.
Rioux M, Garland A, Webster D, Reardon E.	HPV positive tonsillar cancer in two laser surgeons: case reports.	J Otolaryngol Head Neck Surg. 2013 Nov 18; 42:54. https://doi.org/10.1186/1916-0216-42-54.	Case report	HPV	This paper suggests that HPV transmitted through laser plume can result in subsequent squamous cell carcinoma.
Sawchuk WS, Weber PJ, Lowy DR, Dzubow LM.	Infectious papillomavirus in the vapor of warts treated with carbon dioxide laser or electrocoagulation: detection and protection.	J Am Acad Dermatol. 1989 Jul; 21(1):41–9.	experimental	HPV	Greater concentration of viral DNA in laser plume than in diathermy smoke.
Sood AK, Bahrani-Mostafvi Z, Stoerker J, Stone IK	Human papillomavirus DNA in LEEP plume.	Inf Dis Obstet Gynecol 1994; 2:167–170	Cohort	HPV	HPV DNA was detected in 18 (37%) smoke plume filters placed in the suction tubing
Subbarayan RS, Shew M, Enders J, Bur AM, Thomas SM	Occupational exposure of oropharyngeal human papillomavirus amongst otolaryngologists.	Laryngoscope. 2019 Nov 11. https://doi.org/10.1002/lary.28383. [Epub ahead of print]	Animal/Cohort	HPV	None of the patient or mouse tail samples yielded detectable HPV16 DNA in the electrocautery fumes.
Taravella MJ, Weinberg A, Blackburn P, May M.	Do intact viral particles survive excimer laser ablation?	Arch Ophthalmol. 1997 Aug; 115(8):1028–30.	Experimental	VZV	While viral DNA was detected in the material trapped from the laser plume, live virus could not be demonstrated to have survived ablation
Taravella MJ, Weinberg A, May M, Stepp P.	Live virus survives excimer laser ablation.	Ophthalmology. 1999 Aug; 106(8):1498–9.	Experimental	Polio	Live virus was shown in the material trapped from the laser plume.
Weyandt GH, Tollmann F, Kristen P, Weissbrich B.	Low risk of contamination with human papilloma virus during treatment of condylomata acuminata with multilayer argon plasma coagulation and CO2 laser ablation.	Arch Dermatol Res. 2011 Mar; 303(2):141–4. https://doi.org/10.1007/s00403-010-1119-3. Epub 2011 Jan 20.	Cohort	HPV	Both CO_2 laser ablation with plume suction and APC treatment seem to have a low risk of HPV contamination of the operation room.
Wisniewski PM, Warhol MJ, Rando RF, Sedlacek TV, Kemp JE, Fisher JC.	Studies on the transmission of viral disease via the CO2 laser plume and ejecta.	J Reprod Med. 1990 Dec; 35(12):1117–23.	Cohort	HPV	Possible particle transmission as far as 1 m.

Abbreviations: BF: bacteriophage, ENT: Ear, Nose and Throat surgery, Eye: Ophthalmic surgery, Gynae: Gynaecological surgery, HBC: Hepatitis C virus, HPV: Human Papilloma Virus, Papova: Papilloma-Polio-Varicella virus, PRV: Pseudorabies virus, PV: Non-human papilloma virus, VZV: Varicella-Zoster virus.

various body fluids including tears, faces, saliva, and even semen.[31]

Concerns regarding the potential presence of COVID-19's in aerosols have caused much debate and anxiety amongst healthcare workers and the public. Our review established that no evidence currently exists to demonstrate airborne transmission of COVID-19, or the presence of the virus in surgical smoke.

A recently published article suggested that COVID-19 virus is unlikely to be transmitted via aerosols for various reasons.[32] Firstly, the reproduction number of COVID-19 (estimated to be around 2.5) is far lower than other viruses with known aerosol spread such as measles, which has a reproductive number of around 18. Furthermore, recent reports have highlighted the low secondary attack rate of COVID-19, which suggests that only about 5% of contacts with patients become positive. This has been shown to be largely dependent on the duration and nature of interaction, with transmission studies suggesting that healthcare workers who care for infected patients whilst wearing face masks alone have a less than 3% risk of contracting the virus.[33–35] These findings are in keeping with the current evidence that suggests COVID-19's primary mechanism of transmission is via respiratory secretions.

Discussion

Electrocautery, ultrasonic scalpel tissue dissection and laser tissue ablation are all known to create 'surgical smoke' which has led to numerous studies aimed at identifying its components and its potential for viral, bacterial and even malignant tissue transmission. Surgical smoke, sometimes also referred to as plume, aerosol or vapour, is a surgically generated byproduct of tissue combustion. The quantity of generated surgical smoke varies depending on the procedure being performed, the nature of the tissue and the surgical tool being used. Electrocautery generates particles with a much smaller size (0.07 μm) than laser ablation techniques (0.35–6.5 μm).[36] During surgical procedures, diathermy results in the rupture of target cell membranes as they reach boiling point, which subsequently creates 'surgical smoke' containing water vapour (which constitutes approximately 95%) and a small quantity of charred proteins and organic matter, from within the cells themselves (forming the final 5%).[37] This process causes the release of contaminants such as carbonised cell fragments and gaseous hydrocarbons, including toluene, acrolein, formaldehyde, benzene and hydrogen cyanide. Depending on the tissues and surgical technique, these can be released in variable concentrations, and each pose specific potential health risks. The majority of studies assessing the composition of surgical smoke have been done on gynaecological cases, where the nature and size of the tissue differs significantly from that involved in abdominal or laparoscopic procedures. Although these studies have demonstrated the presence of various 'diathermy emissions,' no studies have been done to investigate the respiratory effects and potential risks these emissions pose to one's health. No evidence currently exists to demonstrate this relationship, although certain cases of occupational asthma have allegedly been linked to diathermy smoke exposure.[38]

Further studies are required in this area and would benefit from careful design to reliably assess staff exposure to surgical smoke and any subsequent reporting of ill health effects.[39]

The COVID-19 pandemic is affecting the way we practice surgery on a daily basis. At the beginning of the pandemic (February and March 2020), governments, healthcare systems, colleges and scientific societies produced policies and guidelines that were based on common sense and extrapolations from previous experiences and previously published studies,[40] due to the total lack of knowledge specific to the new coronavirus. Unfortunately, the panic generated by the pandemic had great repercussions on the practice of surgery, particularly when the official guidelines recommended and endorsed non-evidence based approaches to surgical patients.[41]

Initial guidance following the COVID-19 pandemic resulted in operating theatre access being almost exclusively restricted to emergency procedures, with caution being advised for any laparoscopic procedures due to the perceived risks of aerosolisation of intraperitoneal viral particles and the potential risk this could pose to theatre staff.[42] NHS England postponed non-emergency surgical procedures for three months from the 15th of April, at which time elective operating had already stopped in Wales, Scotland and Northern Ireland.[43] In addition, guidance suggested minimising or postponing scheduled endoscopic and invasive procedures, and emphasised the need for reliance on a daily, data-driven assessment of the changing risk-benefit for each patient throughout the pandemic.[44]

The surgical Royal Colleges of England, Scotland and Ireland, along with the main surgical societies in the UK, provided guidance on the practice of general surgery with the aims of (a) reducing the surgical risk for COVID-19 patients, (b) reducing the infective risk for non-COVID-19 surgical patients, (c) reducing the risk of cross-infection in theatre, wards and endoscopy suites, and (d) reducing the pressure on intensive care units and on the NHS as a whole.[44] The current guidelines from the Royal College of Surgeons highlight the importance of dividing patients based on their infection risk into elective and acute cases, with specific references in terms of testing and undergoing surgery for each.[45,46] Whilst elective patients are still required to isolate for 14 days, and undergo surgery at a COVID-19 cold site, acute patients should have rapid testing prior to surgery, with maintenance of PPE in positive cases, or cases where waiting for test results is not possible.

The most recent guidance by the Royal Colleges of the UK provides a detailed approach to restoring elective services in the context of COVID-19.[47] This guidance suggests the integration of 'COVID-19 light' sites into the elective surgical field, aimed at enabling rapid COVID-19 testing for surgical teams. The RCSE have published a checklist that surgical centres can go through prior to reinitiating elective procedures, which includes ensuring adequate theatre staff and facilities, appropriate PPE, availability of additional services, rapid testing facilities and established COVID-19 negative facilities. In terms of PPE, current guidelines advise healthcare workers to wear FFP3 masks during aerosol-generating procedures, otherwise fluid resistant masks. After the initial guidance on avoiding laparoscopy as much as possible during the pandemic, which attracted worldwide criticism, the RCSE has recently advised that surgical units re-establish laparoscopic procedures when all criteria have been met, theatre teams have adequate PPE and where teams consider the benefits outweigh the risks in their local setups.[44,45]

However, RCSE Guidelines still maintain that laparoscopy should only be considered in selected cases where the clinical benefit to the patient exceeds the risk of potential transmission to healthcare workers. Fortunately, this guidance did not get nationwide acceptance and most surgical units have continued to adopt an evidence-based approach, enabling patients to benefit from laparoscopic procedures when required.

The European Society of Coloproctology released a joint statement in May 2020 with EAES and SAGES recommending pre-op COVID-19 testing for all surgical patients, intubation and extubation in negative pressure rooms, and appropriate filtration and ventilation of operating rooms for suspected or confirmed COVID-19 patients.[48] Full PPE as per WHO guidelines was advised for all surgical procedures and electrosurgical units advised to be set to the lowest possible settings for desired effect (as a means of minimising potential aerosolization and smoke formation). Smoke evacuators were advised and surgical equipment used during procedures advised to be cleaned separately from other surgical equipment. Finally, the American College of Surgeons[49] produced specific guidelines that can be used to ensure patient and staff safety across all phases of surgical care.

"Protection" sounds like a mantra in the current guidelines, but it is not exactly clear what we are protecting ourselves from. Epidemiologic and laboratory-based studies have raised the suspicion of Covid-19 transmission through aerosol particles, but it must be emphasised that "demonstrating that speaking and coughing can generate aerosols or that it is possible to recover viral RNA from air does not prove aerosol-based transmission".[32] The same consideration can be made for surgical smoke, whose viral infective properties have yet to be proven.

Our systematic review found no reliable evidence to suggest a risk of COVID-19 transmission via surgical smoke and laparoscopic pneumoperitoneum.

Our literature search found that previously published papers investigating the risk of viral transmission through surgical smoke are mostly non-controlled cohort studies and laboratory studies, with no high-level evidence available on any of the research questions we posed.

Previous case studies suggest the potential risk of HPV transmission via surgical smoke.[5–7] Given that HPV is a local tissue virus, and the nature of surgeries investigated by existing studies involved close proximity of the surgeons to the operating field, the transferability of such evidence to transmission of COVID-19 is highly questionable.[50,51] Hepatitis B Virus, one of the few viruses which has been detected in surgical smoke, has been shown to tolerate higher electrosurgical temperatures than coronaviruses.[52,53] Despite this, no evidence exists to demonstrate the infectivity of such particles.[54]

Whilst multiple guidelines and recommendations have been published throughout the COVID-19 pandemic, clinical studies assessing the surgical aspects of this specific virus have yet to be done. As a result, the majority of current guidelines are based on low level evidence or extrapolation of previous studies, which may not apply to COVID-19 directly.[46]

Furthermore, the available evidence suggesting the presence of HBV, HIV and HPV in surgical laser plumes is low level and cannot be directly extrapolated to COVID-19, or to other forms of plume generation.[53,55–61]

Due to time restraints, initial guidelines for the COVID-19 pandemic had to be inferred from previous studies on influenza, SARS-Cov1 and MERS-CoV-1 viruses.[52] This provided a weak evidence base for a new infection, little about which was known. Our current knowledge of COVID-19 and the risk of cross infection during surgical operations is minimal and, until further evidence exists, guidelines should be based on evidence of the highest level available. In this way, we can ensure that healthcare systems continue to provide the best possible care for their patients. Clinical research investigating the questions discussed above, with specific application to COVID-19, must be conducted as soon as possible so that guidelines can be adjusted according to evidence-based findings rather than unproven extrapolations.

Grant support

None to declare.

Declaration of competing interest

None to declare.

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