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# A systematic review of viral transmission risk to healthcare staff comparing laparoscopic and open surgery

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## ABSTRACT

**Background:** Throughout the United Kingdom, there have been sweeping changes to the practice of medicine due to the COVID-19 pandemic. For the surgical speciality, there have been changes to both elective and emergency practice. Concern regarding potential aerosolisation during invasive procedures have been raised – including the use of pneumoperitoneum to facilitate laparoscopy. The aim of this study is to systematically review the data available to date regarding the potential risk posed to theatre staff by laparoscopy.

**Method:** A systematic review and meta-analysis was carried out in accordance with PRISMA guidelines. Only publications in peer-reviewed journals were considered. PubMed, Ovid Embase, SCOPUS, and Cochrane Library were searched. The search period was between 1st January 1980 and 27th April 2020. Bias was assessed using the ROBINS-I tool.

**Results:** 4209 records were identified, resulting in 9 unique studies being selected. The included studies examined viral DNA aerosolisation generated by electrosurgery and CO<sub>2</sub> laser ablation, with one study examining viral DNA aerosolisation following laparoscopy. Each of these demonstrated that viral DNA (Hepatitis B Virus and Human Papilloma Virus) was detectable in the surgical smoke plume.

**Conclusion:** The data and analysis reported in this study reflect the most up-to-date evidence available for the surgeon to assess risk towards healthcare staff. It was constrained by heterogeneity of reporting for several outcomes and lack of comparable studies. There is currently insufficient data to recommend open or a minimally invasive surgical approach with regard to theatre team safety in the COVID-19 era.

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## Introduction

The 2019 coronavirus (COVID-19) pandemic has had a major effect on the National Health Service (NHS) and everyday clinical practice. Efforts to increase hospital capacity for patients with COVID-19 and reduce the spread of the virus, both in community and hospital settings, has led to widespread changes to surgical practice.

The World Health Organisation (WHO) recommend droplet and contact precautions with the use of personal protective equipment (PPE) as well as rigorous adherence to doffing and hand hygiene to reduce spread.<sup>1</sup> Studies have differing estimates on the infectivity of COVID-19

with the Centre for Disease Control and Prevention (CDC) calculating an estimated  $R_0$  of 5.7.<sup>2</sup> One case report documented a surgical patient in Wuhan who was found to infect 14 healthcare workers before he became pyrexial and developed symptoms himself.<sup>3</sup> To date COVID-19 has also been detected in blood, peritoneal fluid and faeces.<sup>4</sup> Although no transmission by any means other than respiratory droplets has been reported, live viral particles have been isolated from stool raising the potential of faeco-oral transmission too.<sup>5,6</sup>

The previous outbreak of SARS (2002) led to changes in PPE worn during surgery. However, comparatively SARS only had 8096 confirmed cases and 774 deaths as opposed to over 6.4 million confirmed cases of COVID-19 and 382,867 deaths to

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date.<sup>7</sup> Other examples of precautions taken to limit viral transmission during surgery include those with blood borne viruses such as HIV and Hepatitis B. With regard to blood borne transmission, laparoscopy may be beneficial as it reduces exposure to blood and body fluids, whilst reducing the risk of surgeon and assistant injury.<sup>8</sup> However, Kwak et al. were able to identify hepatitis B in the surgical smoke produced during laparoscopy and therefore recommended evacuation of pneumoperitoneum into a closed system in a controlled manner.<sup>9</sup>

Specific concerns have been raised around aerosol generating procedures in particular and protecting staff, many of which occur commonly in theatre. Use of laparoscopy is also felt to carry risk of aerosol formation and is a concern to the surgical team and healthcare professionals in the theatre environment. The Royal Colleges of Surgeons have released guidance regarding the use of PPE during surgery and have specifically suggested that laparoscopic surgery should only be performed where the clinical benefit to patient substantially outweighs the risk of potential viral transmission to healthcare workers during the COVID-19 pandemic.<sup>10</sup> Whilst other countries and societies recognise the risk laparoscopy may pose to theatre staff, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) highlight the importance of considering the benefits to patients of minimally invasive surgery, such as enhanced recovery and reduced length of hospital stay. They also suggest that filtration of aerosolised particles may be even more difficult during open as opposed to laparoscopic surgery.<sup>11</sup>

## Aim

To date there has not been a systematic review of viral transmission risk comparing laparoscopic with open surgery. The aim of this study is to conduct an objective, systematic review of studies reporting on viral transmission risk comparing laparoscopic and open surgery.

## Methods

This systematic review was conducted in accordance to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.<sup>5</sup>

### Study eligibility criteria

Any original study examining airborne viral transmission secondary to incisional surgical procedure. Operative interventions were either laparoscopic or open procedures, irrespective of site, presentation (elective or emergency), duration, or hospital setting (inpatient or outpatient).

Primary data to be extracted were risk of particle aerosolisation and risk of viral transmission. Only papers published in indexed medical journals were included, with English as language of publication. Age of publication was restricted to the last four decades (1st January 1980–27<sup>th</sup> April 2020) as this would encompass research during the HIV/AIDS and SARS emergence eras. There were no geographical limitations.

### Information sources and search

Four databases: PubMed MeSH, Ovid Embase, SCOPUS, and Cochrane Library were searched. The search strategy for these has been outlined in [Table 1](#).

### Study selection and data collection process

Two independent authors reviewed all titles, placing any screened citations into an Excel database. Duplicates were eliminated, and if possible using the abstracts available, a decision was made on its inclusion. The full text was then assessed and disagreements between reviewers were resolved by consensus, or if necessary, arbitration by a senior author. If a study had been reported by more than one publication, the last publication which reported the trial was used as the reference publication in this review. Once each author had completed data extraction, the data files were electronically compared and discrepancies in data entry were investigated and resolved.

### Data items

The following variables were recorded in an Excel spreadsheet: Basic information - First author, publication year, and country of origin. Demographic information was recorded if available. Treatment information: Type of open or laparoscopic procedure, timing, instrumentation, and protective equipment used were also recorded. Pathogen type, detection method, and quantitative data resulting from this were recorded. The authors synthesised the results into prose and tabular form.

### Risk of bias in individual studies and across studies

Two authors independently assessed the potential bias using the ROBINS-I tool.<sup>12</sup>

### Summary measures and synthesis of results

The rates of patient reported outcomes were shown as crude rates and if appropriate, mean scores.

## Results

### Study characteristics

Three studies with unique populations met inclusion criteria. The PRISMA flow diagram of search results is presented in [Fig. 1](#).

There were 9 unique studies containing 389 study participants, with one study not including sample size and one study depicting sample size as the number of operations. Of the 389 study participants described, 324 were tested or presumed infected for the viral pathogen in question. Eight studies examined Human Papilloma Virus (HPV) aerosolisation and one studied Hepatitis B Virus (HBV) aerosolisation. One study examined virus aerosolisation during laparoscopic procedures, with the other eight studies examining open procedures. Four studies examined aerosolisation by

**Table 1 – Journal database and clinical trial database search strategies.**

Journal Databases	
PubMed MeSH	"Surgical Procedures, Operative"[Mesh] AND "Disease Transmission, Infectious"[Mesh]
Ovid Embase	(Surgery and Viral Transmission).af.1980
SOCPLUS	Surgery AND Viral AND Transmission
Cochrane Library	Surgery AND viral transmission

electrosurgery and three by CO<sub>2</sub> laser ablation. One study compared aerosolisation by CO<sub>2</sub> laser ablation with electro-surgery and one study compared CO<sub>2</sub> laser ablation with that of multi-layered argon plasma coagulation. A table (Table 2) of techniques, devices and results of each individual study is presented below.

### Patient characteristics

Analysis of patient characteristics of these studies is limited. Of the 4 studies which reported the sex of their population, 3 were female only and 1 comprised male and female study participants. Study specific patient characteristics are included in Table 3.

### Risk of bias within studies

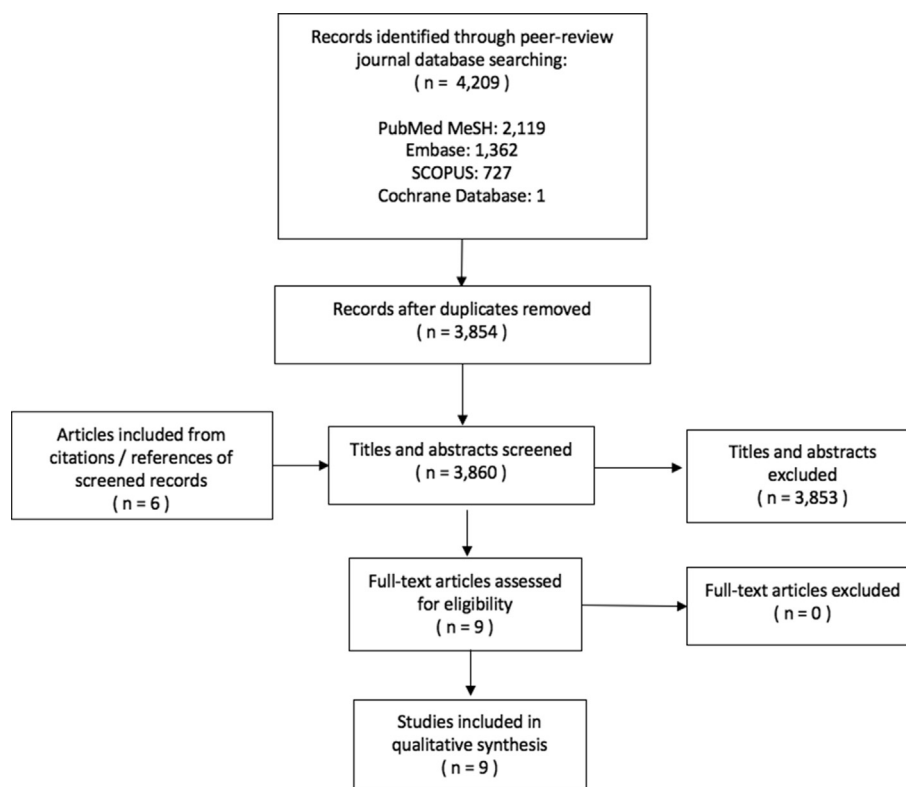
Risk of bias was assessed using the ROBINS-I risk of bias tool. A low risk of bias overall was found in 6 studies, with none

having a critical risk.<sup>12,16,18–21</sup> Due to access restrictions or information not being specified in the original manuscript, there were 3 studies that overall risk of bias could not be described.<sup>12,14,17</sup> Risk of bias in the measurement of outcomes was recorded in two studies, which had not specified the testing method for viral quantification.<sup>12,17</sup> The risk of bias assessment is presented in Table 4.

## Discussion

To date this is the first systematic review assessing the risk of viral transmission during laparoscopic or open surgery. The results in this study demonstrate that aerosol generated during procedures may contain viral DNA. They demonstrated that HPV and HBV viral DNA was detectable following CO<sub>2</sub> laser ablation and electro-surgery (both open and laparoscopic).

When healthcare staff risk was investigated, Weyandt and Zhou have shown that samples taken from the operating surgeons were positive for viral DNA from HPV.<sup>18,21</sup> However, there were differences shown within these studies as Weyandt found that viral DNA obtained from operators was not consistent with that of the patients they were operating on.<sup>18</sup> In contrast to this, Zhou demonstrated consistency between operator and patient viral DNA subtypes.<sup>21</sup> Only a single study investigated the aerosolisation of viral DNA during laparoscopy with HBV DNA being detected in 10 of 11 (90.9%) cases.<sup>19</sup>



**Fig. 1 – PRISMA study selection process flow diagram. In total 4209 records were identified, of which three studies were included in the qualitative synthesis.**

**Table 2 – Details of included studies. LEEP: loop electrosurgical excision procedures, HCS: Healthcare staff, PCR: polymerase chain reaction, +ve: positive, HPV: human papilloma virus, HBV: hepatitis B virus. \* Five colorectal cancer resections, three gastrectomies and three hepatic wedge resections.**

Study	Location	Sample size	Procedure (Open or laparoscopic)	Device	Virus detected	Detection Method	Evidence of transmission to HCS
Swachuk, 1989 <sup>12</sup>	U.S.A.	8	Cutaneous papilloma ablation (Open)	Two Groups 1. CO <sub>2</sub> laser 2. Electrosurgical	HPV 1. 5 of 8 +ve 2. 4 of 7 +ve	PCR	Not studied
Ferenczy 1990 (abstract only available) <sup>14</sup>	U.S.A.	110 (of which 65 HPV +ve on swabbing of lesions)	Cutaneous papilloma ablation (Open)	Laser ablation	HPV 1 of 5 pre-filter canisters +ve after testing 65 patients	Not specified in abstract	Studied -All negative samples from nasopharynx, eyelids and ears of operators
Ferenczy, 1990 (abstract only available) <sup>15</sup>	Canada	43	Cutaneous papilloma ablation (Open)	CO <sub>2</sub> laser ablation	HPV 7 of 43 +ve in treated areas	Dot blot hybridization technique	Not studied
Sood, 1994 <sup>16</sup>	U.S.A.	49 (of which 39 HPV +ve on tissue sampling)	Cervical papilloma LEEP (Open)	Electrosurgical	HPV 18 of 39 +ve	PCR	Not studied
Gloster, 1995 (abstract only available) <sup>17</sup>	U.S.A.	Not specified in abstract	Cutaneous papilloma ablation (Open)	CO <sub>2</sub> laser ablation	HPV	Not documented	No significant difference in surgeons acquiring HPV if failed to use gloves, masks, smoke evacuators, eye protection, gowns Studied –2 paired swabs (before and after treatment) out of 10 +ve
Weyandt, 2011 <sup>18</sup>	Germany	18 operations with multilayer argon plasma coagulation 10 operations with CO <sub>2</sub> laser ablation	Cutaneous papilloma ablation (Open)	Two groups 1. Multilayer argon plasma coagulation 2. CO <sub>2</sub> laser ablation	HPV 1. 2 of 18 +ve 2. 3 of 10 +ve	PCR	Studied –2 paired swabs (before and after treatment) out of 10 +ve
Kwak, 2016 <sup>19</sup>	South Korea	11	Intraabdominal malignancy resection* (Laparoscopic)	Electrosurgical	HBV 10 of 11 +ve	PCR	Not studied
Neumann, 2018 <sup>20</sup>	Germany	24 (all presented HPV, no reported tissue sampling for all patients)	Cervical papilloma LEEP (Open)	Electrosurgical	HPV subtype 16, 39, 53 4 of 24 +ve	PCR	Not studied
Zhou, 2019 <sup>21</sup>	China	134 (all with persistent HPV infections)	LEEP for cervical intraepithelial neoplasia (Open)	Electrosurgical	HPV subtypes 16, 18, 31, 33, 51, 52, 56, 58 1. 40 of 134 +ve 2. 30 of 134 +ve	1. Flow fluorescence in situ hybridization 2. PCR	Studied –2 swabs of 134 +ve for HPV DNA

**Table 3 – Patient characteristics in included studies.**

Study	Sample size	Age (mean or median)	Age (range)	Sex (male or female)
Swachuk, 1989 <sup>12</sup>	8	Not available	Not available	Not available
Ferenczy, 1990 <sup>14</sup>	110	Not available	Not available	Not available
Ferenczy, 1990 <sup>13-21</sup>	43	Not available	Not available	Not available
Sood, 1994 <sup>16</sup>	49	Not available	Not available	Female
Gloster, 1995 <sup>17</sup>	Not available	Not available	Not available	Not available
Weyandt, 2011 <sup>18</sup>	18	Not available	Not available	Not available
Kwak, 2016 <sup>19</sup>	11	55	38 to 74	Male: 8, Female: 3
Neumann, 2018 <sup>20</sup>	24	41	29 to 65	Female
Zhou, 2019 <sup>21</sup>	134	43	24 to 70	Female

**Table 4 – Risk of bias in each study as assessed using the ROBINS-I risk of bias tool.**

Year	Author	Bias due to confounding	Bias in selection of participants into study	Bias in classification of exposures	Bias due to deviation from exposures	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall risk of bias
1989	Swachuk	Low	No information	Low	Low	Low	Low	Low	Low
1990	Ferenczy	No information	No information	Low	Low	Low	Moderate	Low	No information
1990	Ferenczy	Low	No information	Low	Low	Low	Low	Low	No information
1994	Sood	Low	No information	Low	Low	Low	Low	Low	Low
1995	Gloster	Low	No information	Low	Low	Low	Moderate	Low	No information
2011	Weyandt	Low	No information	Low	Low	Low	Low	Low	Low
2016	Kwak	Low	No information	Low	Low	Low	Low	Low	Low
2018	Neurmann	Low	No information	Low	Low	Low	Low	Low	Low
2019	Zhou	Low	No information	Low	Low	Low	Low	Low	Low

The implication of this is that minimisation of exposure via limited use of energy devices, the use of PPE by theatre staff, and smoke extraction mechanisms should be used whenever practically possible. Quantification of the viral load between open and laparoscopic approaches in comparable settings has not yet been studied. Additionally, no studies to date have investigated the viral load of respiratory viruses or the risk of transmission to healthcare staff – so these recommendations remain theoretical.

When the authors further consider the implication of these data to the current COVID-19 pandemic, we note that aerosolisation of detectable viral DNA occurs with both open and laparoscopic surgery. The reason for the initiation of this review was to objectively gather data regarding viral transmission and assess if there was a difference between open or laparoscopic surgery. If such a difference had been found this would have had major implications for the practice of visceral surgery going forward in the COVID-19 era.

With such limited data available, the authors believe that a pragmatic approach must be taken with regard to whether or not open or minimally invasive surgery is appropriate.

Where laparoscopic surgery has been demonstrated to have a clear benefit for patients, it would seem prudent to continue with such an approach, as long as theatre staff are adequately protected with the use of appropriate PPE and effective smoke extraction systems. Additionally, both pre-operative testing for the presence of SARS-CoV-2 and perioperative self-isolation of the surgical patient in the elective setting can also further enhance the safety of the theatre environment.

Adopting a pragmatic approach however does not mean that further investigation into the risk of viral transmission during surgical procedures should be abandoned. Ongoing surveillance and screening efforts should be continued at local level to enhance staff safety. Clinical studies looking specifically at risk of SARS-CoV-2 transmission in the theatre arena should be pursued to better quantify whether or not the risk to theatre staff of contracting COVID-19 is influenced by the surgical approach.

Overall, the limited studies and heterogenous data available in the world literature currently does not allow for meaningful comparison between laparoscopic and open techniques.

## Conclusion

This systematic review has demonstrated that viral transmission during surgical procedures remains a potential source of risk for theatre teams in the healthcare setting. In particular, with the current COVID-19 pandemic, the use of aerosol generating procedures in theatre could lead to transmission of viral DNA. This systematic review has demonstrated that viral DNA is able to be aerosolised during both open and laparoscopic surgical procedures and this has been quantified by several studies. There is currently no high quality evidence that the risk is worse with a minimally invasive approach in comparison to open surgery. There is a need for further investigation regarding aerosolised viral load and the effect of different operative techniques.

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