SPECIAL ARTICLE

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Safe surgery during the coronavirus disease 2019 crisis

David R. Tivey ,*† Sean S. Davis ,† Joshua G. Kovoor ,‡ Wendy J. Babidge ,*† Lorwai Tan ,*
Thomas J. Hugh ,§¶ Trevor G. Collinson,‖ Peter J. Hewett,† Robert T. A. Padbury**†† and Guy J. Maddern *†

*Research Audit and Academic Surgery, Royal Australasian College of Surgeons, Adelaide, South Australia, Australia
†University of Adelaide, Discipline of Surgery, The Queen Elizabeth Hospital, Adelaide, South Australia, Australia
‡University of Adelaide, Adelaide, South Australia, Australia
§Northern Clinical School, University of Sydney, Sydney, New South Wales, Australia
¶Surgical Education, Research and Training Institute, Royal North Shore Hospital, Sydney, New South Wales, Australia
‖General Surgeons Australia, Adelaide, South Australia, Australia
**Flinders University, Adelaide, South Australia, Australia and
††Division of Surgery and Perioperative Medicine, Flinders Medical Centre, Adelaide, South Australia, Australia

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Correspondence
Professor Guy J. Maddern, Royal Australasian College of Surgeons, 199 Ward Street, North Adelaide, Australia. Email: college.asernip@surgeons.org

D. R. Tivey BSc (Hons), PhD; **S. S. Davis** MBBS; **W. J. Babidge** BAppSci (Hons), PhD; **L. Tan** BSc (Hons), PhD; **T. J. Hugh** MD, FRACS; **T. G. Collinson** MS, FRACS; **P. J. Hewett** MBBS, FRACS; **R. T. A. Padbury** PhD, FRACS; **G. J. Maddern** PhD, FRACS.

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Abstract

Background: Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has created a global pandemic. Surgical care has been impacted, with concerns raised around surgical safety, especially in terms of laparoscopic versus open surgery. Due to potential aerosol transmission of SARS-CoV-2, precautions during aerosol-generating procedures and production of surgical plume are paramount for the safety of surgical teams.
Methods: A rapid review methodology was used with evidence sourced from PubMed, Departments of Health, surgical colleges and other health authorities. From this, a working group of expert surgeons developed recommendations for surgical safety in the current environment.
Results: Pre-operative testing of surgical patients with reverse transcription-polymerase chain reaction does not guarantee lack of infectivity due to a demonstrated false-negative rate of up to 30%. All bodily tissues and fluids should therefore be treated as a potential source of COVID-19 infection during operative management. Caution must be taken, especially when using an energy source that produces surgical plumes, and an appropriate capture device should also be used. Limiting the use of such devices or using lower energy devices is desirable. To reduce perceived risks association with desufflation of pneumoperitoneum during laparoscopic surgery, an appropriate suction irrigator system, attached to a high-efficiency particulate air filter, should be used. Additionally, appropriate use of personal protective equipment by the surgical team is necessary during high-risk aerosol-generating procedures.
Conclusions: As a result of the rapid review, evidence-based guidance has been produced to support safe surgical practice.

Introduction

Following its identification in December 2019,[1] coronavirus disease 2019 (COVID-19) has rapidly developed into a global health emergency.[2] The novel human coronavirus that causes COVID-19 has since been named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[3]

The reallocation of medical resources towards the potential need to manage COVID-19 has significantly disrupted surgical care worldwide. Surgical teams are already at considerable risk of contracting infectious diseases through the potential exposure to bodily tissue and fluids.[4–6] There are understandably concerns around the safety of conducting surgery during this pandemic. COVID-19 has already impacted practice of all surgical specialties in Australia and New Zealand. All bar the most urgent elective procedures were initially cancelled to ensure availability of hospital resources, which may be needed if the outbreak escalated.

Although initially believed to only be capable of droplet and contact transmission,[7] it has since been demonstrated that SARS-CoV-2 is capable of being transmitted in aerosols, which depending on inoculum shed, can remain viable in aerosols for hours.[8] This is of concern to surgeons who intra-operatively utilize energy-based surgical instruments such as electrocautery, laser tissue ablation and ultrasonic (harmonic) scalpel tissue dissection, which create aerosolized ultrafine particles (surgical plume).[9–11] Similarly, the safety of conducting laparoscopic surgery during the COVID-19 crisis has also been questioned due to the theorized potential for SARS-CoV-2 aerosolization during desufflation of pneumoperitoneum, as was found with HIV.[12]

To ensure the safety of surgery during this crisis, there is a need to develop evidence-based guidance for surgeons. Important considerations include the appreciation of risks with laparoscopy and use of energy-based surgical instruments, with the potential for contamination and transmission in the operating theatre. The aim of this rapid review is to produce key recommendations to guide safe surgical practices in the current environment.

Methods

Searches for peer-reviewed publications for the rapid review were limited to PubMed from inception to 30 March 2020 (Tables S1–S7). PubMed results were supplemented with grey literature searches using the Google search engine. Searching was limited to websites of Departments of Health, Surgical Colleges and other health authorities, for example World Health Organization, Centers for Disease Control and Prevention (USA), and major teaching hospitals.

Study selection (using the Rayann online tool[13]) and study extraction were performed by a select research panel. All levels of evidence were considered, and inclusion was not limited by language. Non-English articles were translated using Artificial Intelligence translation tools. Included studies report primary research, reviews and opinion pieces that are in either print or published.

Selected studies were presented to a panel of expert surgeons who developed a key set of recommendations regarding surgical safety in the current environment. These recommendations were focused within the crucial themes of pre-operative testing laparoscopic surgical risks, risks in the surgical plume and the potential for contamination and transmission in the operating room.

Results and discussion

Detection of COVID-19 patients: pre-operative testing

Reverse transcription-polymerase chain reaction (RT-PCR) is the current laboratory-based diagnostic test performed to confirm COVID-19 infection.[14–16] RT-PCR has been demonstrated to carry a high false-negative rate (up to 30%), with its accuracy highly dependent on pre-analytical handling of samples, selection of primers and quality of reagents and equipment. Additionally, it has been suggested the RT-PCR limits of detection prevent identification of low viral loads in patients within the initial asymptomatic or post-symptomatic phase. This prevents detection of COVID-19 positive patients during times where viral shedding continues to occur.[17] Furthermore, viral shedding from faeces has been demonstrated in 20% of patients who had negative RT-PCR for viral RNA in the respiratory tract post-infection.[18] Another study used RT-PCR to detect the SARS-CoV-2 RNA genome in peritoneal fluid and nasal swabs.[19] The method used amplified the number of copies of three targets at the levels of detection of the assay. From this method the amount of the viral RNA genome could be inferred. Results showed that the viral load in the peritoneal fluid was higher than the upper respiratory material. Viral isolation was not, however, performed, to provide stronger evidence of infectivity.

Pre-operative COVID-19 testing is not feasible for patients requiring emergency surgery given the time taken for a result. Although testing may be feasible in patients requiring less urgent surgery, the associated false negative rate for RT-PCR is concerning, which may lead to exposure for the surgical team and possible poor postoperative outcomes for the patient. Where testing is feasible in the surgical patient, surgeons should follow local protocols based on epidemiological and clinical criteria.

Laparoscopic surgical risks

There have been concerns raised regarding the safety of laparoscopic surgery during the current COVID-19 crisis. An intercollegiate guidance statement from general surgery colleges across Great Britain, Ireland and Scotland recommended that open surgery should be conducted instead of laparoscopic surgery at this time.[20] Due to similar concerns, an international joint statement was released by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the European Association of Endoscopic Surgery and other Interventional Techniques (EAES), which suggested that COVID-19 particles might be released under pressure upon desufflation. SAGES recommends that a concerted effort be made to capture deflated peritoneal air or any surgical plumes generated during surgery and to consider the use of a filtration device to further mitigate this risk.[21–23]

Pneumoperitoneum for laparoscopic surgery is achieved using gas, usually carbon dioxide (CO_2), at pressure with defined temperature and humidity.[24] On desufflation there is a potential for biological contaminants, including blood cells, cell debris and potentially viruses,[12,23] to be released in the outflow of gas. Generated aerosols escape into the operating theatre on desufflation in the absence of appropriate capture devices. Further, aerosols have been confirmed to be responsible for airborne transmission of SARS.[25] Bio-aerosols range in size from 0.3 to 100 μm, and particles up to 5 μm remain airborne and can travel distances of more than 100 m, which may be a transmission path for SARS-CoV-2.[26] Generation of aerosols in the operating theatre are a possible source of infection and a risk to the surgical team. Such airborne transmission was reported during the 2003 severe acute respiratory syndrome (SARS) outbreak, and this has also been suggested as a possible SARS-CoV-2 transmission route.[8,25–27] Established recommendations relating to HIV suggest avoiding contact with desufflation plumes and to desufflate into an appropriate suction irrigator system at procedure conclusion.[12]

No evidence has been identified in the current review which suggests viral transmission is more likely with laparoscopy compared with open surgery. Despite this lack of evidence, aerosolization of viral particles can precipitate airborne transmission and as such, multiple precautions must be taken, especially around insufflation and desufflation of a pneumoperitoneum. Incisions for trocar insertion should be made as small as possible, and the pneumoperitoneum pressure should be minimized.[21] Desufflation of the pneumoperitoneum in laparoscopic surgery ideally should be performed via an appropriate suction device attached to a high-efficiency particulate air (HEPA) filter to prevent venting into the operating room. Filters that are classified as 'HEPA' have the ability to remove at least 99.97% of airborne particles measuring 0.3 μm or greater from the air that is filtered.[28] Other filters with classifications of comparable efficiency may be used if HEPA filters are not available. If using a valveless trocar system, extra care should be taken to minimize or capture any aerosol or droplet production from transient increases in intra-abdominal pressure during surgery, such as the patient coughing or straining while under anaesthesia.

Surgical plumes and potential carriage of COVID-19

Viral particles (human papillomavirus (HPV), HIV, hepatitis B, herpes simplex virus, adenovirus-5) have been detected in surgical smoke using molecular techniques.[29–34]

Electrosurgical dissection is commonly used in surgical procedures to dissect tissue and maintain haemostasis. The devices used for this purpose, such as electrocautery, laser and ultrasonic scalpels, can produce large amounts of surgical plume in both laparoscopic and open surgery.[33,35] Particle size in the resultant plume varies between each energy source.[33] *In vitro* studies have found live polio virus following laser ablation,[32] while Moreira *et al*. demonstrated survival in cell culture of viable herpes simplex virus and adenovirus.[34] Whether these *in vitro* results translate into a clinical risk is yet to be determined. No report has demonstrated SARS-CoV-2 aerosolization into surgical plume using laser ablation, although CO_2 in the pneumoperitoneum may generate aerosols upon desufflation which could contain COVID-19.[23]

The review team did not identify any publications documenting direct infection of either surgeons or other members of the surgical team by viruses. One review by Manson and Damrose provided evidence that HPV DNA can be found in surgical plumes generated by CO_2 lasers and cites a case report of possible patient to surgeon transmission.[36] This assumption was based on a common HPV serotype; however, the review authors questioned the transmission because that HPV serotype was the most common in laryngeal papillomatosis and the infection of both patient and surgeon could be coincidental. The authors nevertheless acknowledge this potential, albeit small, risk and highlighted the need for suction devices to capture HPV contaminated surgical plumes to ensure protection against infection.

HPV could potentially infect the upper respiratory mucosa through surgical laser plume smoke;[37] however, there is no available evidence to indicate previous systemic infection of any surgical team member with COVID-19 or other viruses.

Although viruses have been detected in surgical plume previously, there is limited evidence of SARS-CoV-2 presence and no reports of systemic disease transmission to members of a surgical team for any virus. Despite this, the potential for occupational exposure in the operating theatre should be considered and managed where appropriate. It is also important to consider that viruses may remain viable even following laser ablation of tissue. Limited use of lower energy devices may reduce the potential viral load if present in surgical smoke. Additionally, an appropriate capture device should be used during all smoke generating procedures.

Operating room contamination and transmission

SARS-CoV-2 remains viable in aerosols for 3 h and survives on stainless steel and plastic for up to 72 h.[8] This demonstrates plausible aerosol and fomite transmission of SARS-CoV-2 via materials that are common in the operating theatre. Such contamination can be contained through establishing a negative pressure environment.[38] Additionally, SARS-CoV-2 has also been identified in faeces, gastrointestinal epithelium and blood, raising plausibility for faecal-oral or blood borne transmission in the operating theatre. COVID-19 has not been detected in urine.[18,39] Personal protective equipment (PPE) is essential in reducing transmission via all routes. The appropriate level of PPE is dependent on the surgical activity being performed and may include the need for a fit tested surgical P2/N95 respirator or equivalent. Necessary surgical PPE has been described elsewhere and is the subject of an ongoing RACS review.[40,41]

SARS-CoV-2 has been found in respiratory secretions, gastrointestinal epithelium, faeces, peritoneal fluid and blood. It is undetermined if the virus particles remain viable in these tissues and as such, all tissues and bodily fluids should be treated as a potential virus source. General measures for aerosolizing

Table 1 Recommendations for safe surgery during coronavirus disease 2019 (COVID-19)

1. With respect to testing for COVID-19 and personal protective equipment use, the recommendation is that local protocols for risk stratification should be followed.
2. There is no current evidence that laparoscopy presents a greater risk to the surgical team in the operating room than open surgery with respect to viruses, but it is important to maintain a level of caution due to the possibility of aerosolization.
3. During all procedures a reduction in occupational exposure to surgical plume is advisable using an appropriate capture device. There is evidence that all energy sources which produce a surgical plume during surgery may facilitate viral transmission. Limited use of lower energy devices may reduce the viral load and should be the preferred option.
4. Specifically for laparoscopic surgery, desufflation of pneumoperitoneum must be performed via an appropriate suction device attached to a high-efficiency particulate air filter to prevent venting into the operating room, for example an insufflation-filtration device. Otherwise other methods need to be employed to reduce any potential release.
5. SARS-CoV-2 has been observed in faecal cultures; viral component staining and replication products have been detected in gastrointestinal epithelium; RT-PCR has detected the SARS-CoV-2 RNA genome in peritoneal fluid; there is equivocal evidence of viral presence in blood, while early studies so far have not found evidence of presence in urine. However, all tissues and bodily fluids should be treated as a potential virus source.

procedures are an important consideration, for example negative pressure operating theatre where possible and appropriate PPE at all times.

Based on this evidence-based rapid review recommendations are provided in Table 1, which include the types of surgery and protection of surgical staff in the operating room.

Conclusions

Due to the SARS-CoV-2 potential of droplet, contact and aerosol transmission and the possibility of its presence in many bodily tissues and fluids, there should be safety measures taken during operative management.

Pre-operative testing of surgical patients with RT-PCR does not guarantee lack of infectivity due to the possibility of false-negative results in up to 30% of patients. Additionally, in emergency situations it is unlikely that testing can be performed ahead of surgery being performed. The recommendation is to follow local protocols based on epidemiological and clinical criteria.

There is no current evidence that laparoscopy presents a greater risk to the surgical team than open surgery; however, essential safety measures must be considered. Desufflation of pneumoperitoneum should be performed with an appropriate suction irrigator system, attached to a HEPA filter, due to the possibility of aerosolization.

During all surgical procedures, a reduction in occupational exposure to surgical plume is advisable, using an appropriate capture device. Limited use or use of lower energy devices is recommended. In addition to these measures, appropriate use of PPE by all surgical staff, as per the local institutional guidelines, provides further protection.

Evidence-based recommendations have been produced following this rapid review of the literature, to help guide safe surgical practices during the COVID-19 crisis.

Limitations of the review

Limitations of this review include the restriction to a single database for sourcing peer-reviewed publications. As such, some articles may have been overlooked. In addition, the expedited publication of peer-reviewed articles means the currency of information related to COVID-19 will change rapidly.

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Conflicts of interest

None declared.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. Search strategy: PubMed results based on combination of individual search strings.
Table S2. Search string for laparoscopic surgery [inception 29 March 2020].
Table S3. Search string for other aerosol producing procedures [inception 29 March 2020].
Table S4. Search string for aerosol (not chemotherapy) [inception 29 March 2020].
Table S5. Search string for smoke evacuation [inception 29 March 2020].
Table S6. Search string for viruses [inception 29 March 2020].
Table S7. Search string for particular transfer [inception 29 March 2020].