Guidelines for safe surgery: open versus laparoscopic

A rapid review commissioned by RACS

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Royal Australasian College of Surgeons

Clinical Expert COVID-19 Working Group

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Version Number	**Date Changed**	**Reason for Change**
1	9 April 2020	Original version
2	11 August 2020	Updates on valveless trocar systems, open aerodigestive tract procedures, ultrasonic scalpels, experimental measures to decrease aerosolisation in the operating theatre and perioperative airway management Appendix added on high-efficiency particulate air filters
3	30 November 2021	Disclaimer and exclusion of liability added.

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Recommendations on safe surgery during the COVID-19 pandemic: laparoscopic vs open

[9 April 2020]

1. With respect to testing for COVID-19 and Personal Protective Equipment (PPE) 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 aerosolisation.

3. There is demonstrated value in having negative pressure theatres where available, however if unavailable then local protocols to reduce the risk to operating room staff should be followed.

4. 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 influence viral transmission. Limited use of lower energy devices may reduce the viral load and would seem more desirable to use.

5. Specifically for laparoscopic surgery, desufflation of pneumoperitoneum must be performed via an appropriate suction device attached to a HEPA filter to prevent venting into the operating room (e.g., an insufflation-filtration device) should be used if available, otherwise other methods need to be employed to reduce any potential release. Similarly, if using a valveless trocar system, extra care should be taken to minimise or capture any aerosol or droplet production from transient increases in intra-abdominal pressure (e.g. the patient coughing or straining during anaesthesia).

6. The COVID-19 virus has been observed in faecal cultures; viral component staining and replication products have been detected in gastrointestinal epithelium; 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.

These recommendations were developed by the Clinical Expert COVID-19 Working Group after review of the evidence synthesis prepared by the RACS Evidence Synthesis Team.

Executive Summary

Introduction: The Royal Australasian College of Surgeons requested a review of safe surgery in the COVID-19 crisis. The overarching focus was on laparoscopic versus open surgery. The detailed areas considered for review included aerosol generating procedures (AGP) and virus contamination of the surgical plume, as well as risk of transmission to the surgical team. The aim was to produce advice in a short timeframe; however, it is planned to continue to revisit the evidence base frequently to assess if any new evidence impacts the advice provided in the recommendations of 9 April 2020.

Method: The Health Technology Assessment team (ASERNIP-S) with the support of Research, Audit and Academic Surgery staff conducted this review. A rapid review methodology was used with evidence sourced from PubMed (inception to 1 April 2020), Departments of Health, Surgical Colleges, and other health authorities e.g., WHO, Centers for Disease Control and Prevention (USA) and major teaching hospitals. Study/article selection was done by a single reviewer (MM) and checked by a second reviewer (DRT). Results are presented in a narrative format.

Results: There is no current evidence of COVID-19 contamination of surgical plumes generated during laparoscopic or open surgery; however, evidence of genetic material of other infectious viruses (e.g., human immunodeficiency virus (HIV), Hepatitis B) has been identified using RT-PCR or other molecular biology methods. In addition to respiratory samples, COVID-19 has been detected in other clinical specimens including faeces and blood. Regarding virus viability, there is limited evidence that viruses can survive laser ablation. However, no articles reported direct transmission of viruses to healthcare workers in the surgical setting. The cellular debris generated by AGPs is of a size equal to a bio-aerosol, which can remain airborne and travel a distance in excess of 100 metres. The limits of detection of the current COVID-19 assays means that a significant number of tests return false negative results. Further, using respiratory sample conversion to negative in patients recovering from COVID-19 may be problematic, as some patients with negative respiratory readings continue to shed the virus in faeces. Finally, the need for appropriate precautions to adequately protect surgical teams, to mitigate the risk of disease transmission during surgery, was discussed. For laparoscopy, the issue of pneumoperitoneum management to prevent surgical plumes venting into the operating room was raised.

Conclusions: AGPs can generate bio-aerosols that contain viral materials, which should be considered a potential source of disease transmission. Risk can be mitigated by using lower energy ablation devices, where possible, to produce fewer or no surgical plumes. All bio-aerosols should be trapped and treated as biohazards. For laparoscopic procedures, the pneumoperitoneum should be maintained at a lower pressure to reduce the risk of gas leak. On desufflation, gas should be vented via an appropriate filter and capture device.

To guide clinical practice, this report provides a series of recommendations, developed by an expert working group.

Introduction:

The SARS-CoV-2 (COVID-19) pandemic has and continues to require RACS Fellows to adapt rapidly, for the continued provision of appropriate high quality surgical care. The pandemic situation due to COVID-19, and its associated rapid information production, has created uncertainty in the healthcare community due to an inundation of information through both the media and literature, which may or may not have been peer reviewed. A simple Google search for information on SARS-CoV-2 (COVID-19) and surgery returns an overload of information. [1] To support surgeons in making sense of this information, Correia et al. (2020) [1] recommends surgical colleges and societies take the lead, along with the World Health Organization and National Health Departments, to provide reliable and trustworthy information to help address concerns during the pandemic. Surgery on patients with COVID-19 has been associated with considerable postoperative morbidity and mortality,[2] and thus these operations should only proceed in scenarios of urgency with adequate PPE[3] and intraoperative precautions.[4] Accordingly, appropriate preoperative screening[5] and triage[6] have become essential to ensure the safety of both surgical patients and staff.

A topic that has caused uncertainty is whether laparoscopic procedures should be replaced by open procedures, where possible, with the aim to protect the surgical team from potential infection. Indeed the Royal College of Surgeons of Edinburgh have recommend that, where possible, laparoscopic surgery should be avoided in favour of more conservative care. [7] Other organisations have indicated that elective endoscopic and surgical cases be postponed, and they provide practical measures for laparoscopy to protect the surgical team. These measures include: that incisions for trocar insertion are made as small as possible, pneumoperitoneum pressure is minimised, ultrafiltration is used if available, and appropriate measures are taken for the capture of deflated peritoneal air or any surgical plumes generated during surgery to limit the risk of aerosol production. [8] Similarly, if using a valveless trocar system, extra care should be taken to minimise or capture any aerosol or droplet production from transient increases in intra-abdominal pressure (e.g. the patient coughing or straining during anaesthesia). Further, as there is limited evidence about the relative safety of laparoscopic compared with open surgery and the mitigation of general risk of surgery in the COVID-19 crisis, surgeons should reinforce the need for strong occupational protection. [9]

To produce recommendations on the safety of laparoscopic surgery in the COVID-19 crisis, the Royal Australasian College of Surgeon (RACS) directed its Health Technology Assessment team (ASERNIP-S) to undertake a rapid review on this topic.

The aim of this review is to evaluate the potential risk of laparoscopic as compared to open surgery during which surgical plumes may be produced, and the risk of contamination with COVID-19. Additionally, the topic of safe desufflation following laparoscopic surgery is covered. The best evidence gathered during the short timeframe of this rapid review, was presented to a panel of expert laparoscopic surgeons who developed a series of recommendations about the safety of laparoscopic surgery in the era of COVID-19.

Methods

A rapid review methodology was adapted to search for of all levels of evidence regarding surgery and risk of infection by COVID-19. Searching for peer reviewed publications was limited to PubMed from inception to 30 March 2020. The search strategy is provided in Appendix A (Tables 1A – 7A).

The search strategy has been saved, and automated alerts from PubMed established to provide weekly notifications of COVID-19 articles relevant to surgery (laparoscopic and open). This approach will ensure the currency of the evidence database. The review team will appraise new evidence, updating the Working Group as necessary i.e., where any new evidence is deemed to have a potential impact on previously issued recommendations. If so, the review will be updated and new recommendations provided regarding risks related to laparoscopic or open surgery by COVID-19.

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 e.g., WHO, Centers for Disease Control and Prevention (USA) and major teaching hospitals. Further, relevant articles were also sourced through the RACS COVID-19 Working Group.

Study selection was performed by two ASERNIP-S researchers (MM and DRT) using the Rayyan online tool. Study extraction used a standard template with each extraction performed by a single reviewer (MM, JD, NP, DS, LT, PW) and a sample of extractions checked by DRT.

All levels of evidence were considered, and inclusion was not limited by language. Non-English articles were translated using Artificial Intelligence translation tools, which may affect the interpretation of results.

Included studies report primary research, reviews and opinion pieces that are either in print or published. Supplementary searches have also been done to fill any evidence gaps identified during meetings with the Working Group.

The synthesis of the evidence includes studies which describe procedures that produce aerosols with the potential of viral contamination. When possible, conclusions on the viability of aerosolised virus is made. These reports have been summarised to highlight general principles of transmission and possible methods to mitigate that risk.

Results

Detection of COVID-19 patients

Reverse transcription polymerase chain reaction (RT-PCR) method is the current laboratory-based diagnostic test performed to confirm COVID-19 infection. [10] Lippi et al (2020) reviewed the limitations of current laboratory diagnostics for COVID-19. [11] Their review highlighted a significant false negative rate (up to 30%) using the RT-PCR tests for COVID-19 and that reliability is variable depending the pre-analytical handling of samples, selection of primers, and quality of reagents and equipment. Further, Lippi et al suggested that limits of detection for the RT-PCR test prevents the identification of COVID-19 positive patients with a low viral load, either at the initial phase of infection or following symptom relief. [11]

An observational cohort study reported by To et al (2020) [12] demonstrated that 30 patients with a median age of 65 years had their highest viral load in samples of posterior oropharyngeal saliva in the first week after symptom onset. The patient viral load then declined to a point lower than the limit of detection, but they may continue to shed the virus. Further, Wang et al (2020) identified COVID-19 in clinical specimens other than respiratory samples, including faeces from 29% of patients and in blood for a small number of patients; however, COVID-19 was not detected in urine. This group also cultured faeces from four patients with high viral load (RT-PCR copy number) and demonstrated live virus in two patients without diarrhoea, confirming the plausibility of faecal oral transmission. [13] Further, the study by Xiao et al (2020) [14] confirmed gastrointestinal infection with COVID-19, showing infectious virus isolated from faeces and gastrointestinal epithelial cells stained positive for the nucleocapsid protein of the virus. Viral shedding from faeces was demonstrated in 20% of patients who had negative conversion for viral RNA in the respiratory tract post-infection. Given that SARS-CoV-2 has been detected in both the respiratory and digestive tract, a recent article by a group associated with Stanford University stated that 'high-risk procedures' during the COVID-19 pandemic should include any open aerodigestive tract procedure (e.g. nasopharyngeal/oropharyngeal/ENT, trachea, lung/bronchoscopy, endoscopy of the GI tract, surgery of the bowel with gross contamination).[15]

Current cytology tests have demonstrated detection of immune response to COVID-19 from day 5 to 10 post-diagnosis, which could be used as a confirmatory test for diagnosis. [16-18]

Laparoscopy: desufflation of pneumoperitoneum

Creating and maintaining a pneumoperitoneum alters the normal physiology of the peritoneum. Inflation is usually achieved using carbon dioxide (CO_2) at pressure with defined temperature and humidity. [19] On desufflation a surgical plume is created which is a source of biological contamination including blood cells, cell debris and potentially viruses e.g., human immunodeficiency virus (HIV). [20] Although Eubanks and co-workers (1993) did not test for HIV in either the surgical plume or samples of peritoneal fluid, they recommended that surgical teams should observe appropriate precautions to avoid contact with all tissues and bodily fluids. [20] These recommendations were echoed by Yu et al (2020) for managing the pneumoperitoneum in patients with COVID-19. [18]

Eubanks et al (1993) also commented on the increased popularity of laparoscopic surgery in the HIV era and that laparoscopy was assumed by some to be safer than open procedures because of containment of surgical plumes and associated particles within the pneumoperitoneum. [20] They state this assumption is dangerous; that contact with biological materials should be avoided and they advised that desufflation is performed into an appropriate suction irrigator system at procedure conclusion.

Some advice on laparoscopic surgery as related to COVID-19 has been provided by Surgical Colleges and Associations. For example, The Royal College of Surgeons of Edinburgh (Scotland), in their 25 March 2020 guidance for general surgery, recommended that laparoscopy should not generally be used. Their recommendation is to consider non-operative treatment or use open procedures. [7] Their guidance also refers to the advice of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) on the release of COVID-19 in surgical plumes.[i] SAGES advises that there is a potential for viral release under pressure on desufflation and surgeons should consider use of a filtration device to mitigate this risk. High-efficiency particulate air (HEPA) filters (Appendix B), or other types of filter with similar capability, can potentially be used for this purpose.

Surgical plumes and potential carriage of COVID-19

The review identified studies that investigated whether viral particles could be identified in either the gas captured at desufflation of the pneumoperitoneum or in surgical plumes generated during any surgical approach.

Ultrasonic scalpels or electrical energy devices used in surgery can produce large amounts of surgical plumes in either laparoscopic [9] or open surgery. [21] Particle size in the resultant surgical plume is dependent on the energy source and can vary between 0.007 to 0.42 µm for electrocautery, 0.1 to 0.8 µm for laser and 0.36 to 6.6 µm for ultrasonic scalpels.[21] Active smoke evacuators should be applied when using ultrasonic scalpels, particularly for procedures on the upper airway.[22]

Taravella et al (1999) studied the impact of excimer laser ablation, that produces particles of 0.25µm, on the survival of live polio virus vaccine. [23] They demonstrated live virus after ablation; however, this study was performed *in vitro*. Similarly, Moreira et al (1997) demonstrated the survival of viable herpes simplex and adenovirus from infected cultured cell monolayers when ablated by excimer laser. [24] The virus survival was influenced by the viral load; however, whether results from experiments conducted *in vitro* translate to a clinical risk is unknown.

Reports identified in this review confirmed that viral particles (human papillomavirus (HPV), HIV, Hepatitis B, herpes simplex, adenovirus-5) are present in the surgical plume; however, their presence was determined using molecular techniques.[25-27]

No reports were identified that reported on COVID-19 aerosolisation by ablation, although CO_2 circulating in the pneumoperitoneum may generate aerosols that contain COVID-19. [18] Aerosols

[i] SAGES https://www.sages.org/recommendations-surgical-response-covid-19 Accessed 3 April, 2020

thus generated would be released into the operating room (OR) on desufflation in the absence of appropriate capture devices. Further, aerosols have been confirmed to be responsible for airborne transmission of SARS [28]; bio-aerosols range in size from 0.3 to 100µm, and particles up to 5µm can stay airborne and can travel distances of more than 100 metres, thus may be a transmission route for COVID-19 . [29] Generation of aerosols in the OR are a possible source of infection and a risk to the surgical team. Specific time-points within surgical procedures that have an increased potential for aerosol generation (e.g. intubation, access to upper respiratory tract) should ideally be identified preoperatively to allow for optimal preparation and staff safety.[30]

The review team did not identify any publications that document direct infection of either surgeons or other members of the surgical team by viruses. One review by Manson and Damrose (2013) supports the 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. 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 acknowledge this potential, albeit small, risk and highlighted the need for suction devices to capture HPV contaminated surgical plumes to ensure protection against infection. [24]

Survival of COVID-19 in the environment

SARS-CoV-2 remains viable in aerosols for 3 hours with a half-life of 1.1 to 1.2 hours; it survives on stainless steel and plastic for up to 72 hours (half-life 5.6 to 6.8 hours). [31] These data demonstrate plausible aerosol and fomite transmission of COVID-19 via materials that are common in the OR. Such contamination can be contained within the OR through establishing a negative pressure environment. [32] Park J et al (2020) reported on an infection control measure established during the Middle East Respiratory Syndrome (MERS) outbreak which included lining the transit route between wards and the OR with plastic. [32] Given the extended survival of COVID-19 on this medium [31], disinfection of this surface may be required to reduce the risk of fomite transmission. Reusable equipment within the OR should be covered with impermeable coverings (to facilitate cleaning, ideally at least 20 mins from the end of the procedure).[33] Where possible, separate ORs and access routes should be used for COVID-19 patients. It should be ensured that any ventilation within the OR is unobstructed. Each centre should adopt a clear perioperative protocol for the management of patients both in and around the OR, especially for emergency situations.[34]

Some experimental ideas to potentially decrease the aerosol transmission of SARS-CoV-2 within the OR have been discussed within the literature. Most notably, measures such as the 'aerosol box'[35] and variations of a 'surgical tent'[36, 37] have shown small-scale promise, however a lack of large studies of strong design mean that there is insufficient evidence for their widespread implementation to be advocated.

Attention must also be paid to perioperative airway management that could potentially result in

the aerosolisation of SARS-CoV-2 within either the operating theatre or postoperative recovery area.[38] Intubation prior to the commencement of surgery should be conducted with only those who are necessary within the OR (i.e. anaesthetist and an assistant), and with full PPE in suspected or confirmed COVID-19 patients due to the potential of aerosol generation. In the immediate postoperative setting, oxygen delivery via high-flow nasal cannula has been associated with a small risk of bio-aerosol dispersion, however this can potentially be diminished through the patient wearing a surgical mask over the oxygen delivery device.[39]

Implications of key findings

1. Preoperative testing for COVID-19 in urgent surgery patients may not be practical. This is based on the time taken to run tests and the known issue of false negatives that is innate to the RT-PCR test, which is only correct once viral load increases above the limit of detection. A single negative test result prior to surgery could give a false sense of security, which may affect the clinical decision to operate as well as the donning of appropriate personal protective equipment (PPE).
2. There is limited evidence that COVID-19 is present in surgical plumes. However, other viruses have been detected in surgical plumes generated during laparoscopic and other aerosol generating procedures. Surgeons and their teams must be made aware of the health and safety risk of exposure to surgical plumes and don appropriate protective equipment to mitigate the risk.
3. There is a risk of viruses remaining viable following laser ablation. This may be affected by the energy source and the particle size of resultant debris. However, no reports of disease transmission to members of a surgical team were identified in this review. An occupational risk is present that can be mitigated by managing the OR environment, reducing the release of surgical plumes as well as the surgical team following appropriate precautions to avoid contamination.
4. Clinical specimens other than respiratory samples can contain the COVID-19 virus; live virus has been isolated from faecal samples; however, whether the virus contained in other clinical samples is viable remains to be determined.
5. Of concern for managing urgent surgical patients are those patients asymptomatic for COVID-19 who are unlikely to be tested unless specific risk criteria are met. A risk stratification based on clinical information, patient history and age as well as the possibility of contact with known COVID-19 patients should be developed to assess the COVID-19 risk when considering surgery.

Limitations of the review:

The limitation to a single database for sourcing peer reviewed publications may have overlooked some articles. In addition, the expedited publication of peer reviewed articles means the currency of information related to COVID-19 will change rapidly. To mitigate this limitation, the review team has established automated alerts to identify relevant evidence on this topic.

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Appendix A: Search strategy

Table 1A: Search Strategy: PubMed results based on combination of individual search strings*

No.	Query	Results
1	laparoscopic surgery[1] AND aerosol producing procedures[2] AND aerosol [not chemotherapy][3] AND smoke evacuation[4] AND viruses[5] AND particular transfer[6]	0
2	(laparoscopic surgery OR aerosol producing procedures) AND smoke evacuation AND viruses AND particular transfer AND aerosol [not chemotherapy]	1
3	laparoscopic surgery AND aerosol [not chemotherapy] AND smoke evacuation AND viruses AND particular transfer	2
4	laparoscopic surgery AND aerosol [not chemotherapy] AND smoke evacuation AND viruses	3
5	(laparoscopic surgery OR aerosol producing procedures) AND smoke evacuation AND viruses AND aerosol [not chemotherapy]	3
6**	laparoscopic surgery AND smoke evacuation AND viruses	375
7	(laparoscopic surgery OR aerosol producing procedures) AND smoke evacuation AND viruses	502
8	laparoscopic surgery AND aerosol (not chemotherapy) AND viruses	823
9	(laparoscopic surgery OR aerosol producing procedures) AND viruses AND aerosol [not chemotherapy]	925
10	smoke evacuation AND viruses	2, 942
11	aerosol [not chemotherapy] AND viruses	3, 149
12	laparoscopic surgery AND viruses	30, 754
13	particular transfer AND viruses	33, 898

***Individual concept search strings**

1. **Laparoscopic surgery – Table 2A**
2. **Aerosol producing procedures – Table 3A**
3. **Aerosol [not chemotherapy] – Table 4A**
4. **Smoke evacuation -Table 5A**
5. **Viruses – Table 6A**
6. **Particular transfer – Table 7a**

****Combination screened for study inclusion by MM and checked by DRT.**

Table 2A: Search string for laparoscopic surgery [Inception 29 March 2020]

No.	Query	Results
1	Surgical procedures, operative [mh]	3, 103, 056
2	Surgi* [tiab]	1, 010, 475
3	Surge*[tiab]	1, 343, 482
4	Minimally invasive surgical procedures [mh]	508, 408
5	Ablation techniques [mh]	113, 721
6	Ablat*[tiab]	109, 611
7	Argon plasma coagulation [mh]	433
8	Diathermy [mh]	15, 306
9	Diathermy [tiab]	3, 680
10	Electrosurgery [mh]	4, 403
11	Electrosurg*[tiab]	3, 676
12	Electrocoagulation [mh]	11, 856
13	Electrocauter*[tiab]	3, 615
14	Electro-surg*[tiab]	95
15	Electro-cauter*[tiab]	64
16	(Energy-based surgical instruments)	44
17	Hand-assisted laparoscopy [mh]	326
18	Laparoscopy [mh]	96, 540
19	Laparoscopes[mh]	3, 710
20	Laparoscp*[tiab]	9
21	Laser Coagulation [mh]	7, 502
22	Lasers, Excimer [mh]	4, 764
23	Laser, Gas [mh]	2, 226
24	Laser, Solid-State [mh]	5, 523
25	Laser Therapy [mh]	60, 103
26	Pneumoperitoneum [mh]	3, 763
27	Pyrolysis [mh]	402
28	Pyrolys*[tiab]	10, 242
29	Ultrasonic Surgical Procedures [mh]	81, 129

No.	Query	Results
30	Ultrasonic therapy [mh]	11, 895
31	(Ultrasonic scalpels)	57
32	(laser surg*)	4, 232
33	(Key hole surg*)	8
34	(Keyhole surg*)	116
35	(Key-hole surg*)	8
36	(YAG laser)	19, 392
37	(YAG-laser)	19, 392
38	(Yttirum aluminum garnet laser)	1
39	**1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 PR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39**	4, 144, 882
40	**2 OR 3**	405, 936
41	Laser [tiab]	258, 721
42	**41 AND 42**	7, 392
43	Abdomi* [tw]	360, 338
44	**41 AND 44**	3, 0084
45	Pelvi*[tw]	162, 092
46	**41 AND 46**	14, 446
47	Ultrasonic [tiab]	48, 388
48	Scalpe* [tiab]	4, 581
49	**41 AND 48 AND 49**	167
50	**40 OR 43 OR 45 OR 47 OR 50**	4, 144, 882

Joint
(((Surgical procedures, operative [mh]) OR Surgi* [tiab]) OR Surge*[tiab]) OR Minimally invasive surgical procedures [mh]) OR Ablation techniques [mh]) OR Ablat*[tiab]) OR Argon plasma coagulation [mh]) OR Diathermy [mh]) OR Diathermy [tiab]) OR Electrosurgery [mh]) OR Electrosurg*[tiab]) OR Electrocoagulation [mh]) OR Electrocauter*[tiab]) OR Electro-surg*[tiab]) OR Electro-cauter*[tiab]) OR (Energy-based surgical instruments)) OR Hand-assisted laparoscopy [mh]) OR Laparoscopy [mh]) OR Laparoscopes[mh]) OR Laparoscp*[tiab]) OR Laser Coagulation [mh]) OR Lasers, Excimer [mh]) OR Laser, Gas [mh]) OR Laser, Solid-State [mh]) OR Laser Therapy [mh]) OR Pneumoperitoneum [mh]) OR Pyrolysis [mh]) OR Pyrolys*[tiab]) OR Ultrasonic Surgical Procedures [mh]) OR Ultrasonic therapy [mh]) OR (Ultrasonic scalpels)) OR (laser surg*)) OR (Key hole surg*)) OR (Keyhole surg*)) OR (Key-hole surg*)) OR (YAG laser)) OR (YAG-laser)) OR (Yttirum aluminum garnet laser))) OR (((((((((Ultrasonic [tiab]) AND Scalpe* [tiab])) AND ((Surgi* [tiab]) OR Surge*[tiab]))) OR ((Pelvi*[tw]) AND ((Surgi* [tiab]) OR Surge*[tiab]))) OR ((Abdomi* [tw]) AND ((Surgi* [tiab]) OR Surge*[tiab]))) OR ((((Surgi* [tiab]) OR Surge*[tiab])) AND Laser [tiab]))

Table 3A: Search string for other aerosol producing procedures [Inception 29 March 2020]

No.	Query	Results
1	Airway extubation [mh]	1, 442
2	Extubati* [tiab]	10, 499
3	Bronchoscopy [mh]	24, 881
4	Bronchoscop* [tiab]	27, 063
5	Cardiopulmonary resuscitation [mh]	17, 624
6	Resuscitati*[tiab]	58, 204
7	Continuous positive airway pressure [mh]	6, 910
8	(Positive airway pressure)	18, 166
9	(Positive-airway-pressure)	13, 486
10	High-frequency ventilation [mh]	2, 810
11	Interactive ventilation [mh]	241
12	Intubation [mh]	52, 647
13	Intubation, intratracheal [mh]	38, 316
14	Intubat* [tiab]	55, 206
15	Noninvasive ventilation [mh]	1, 969
16	Positive-pressure respiration [mh]	25, 506
17	Respiration, artificial [mh]	75, 544
18	Respirat* [tiab]	485, 334
19	Sputum [tw]	37, 986
20	Thoracic surgery, video-assisted [mh]	6, 813
21	Thoracic surgical procedures [mh]	329, 985
22	Thoracic surg* [tiab]	16, 446
23	Thoracostomy [mh]	1, 431
24	Thoracotomy [mh]	11, 004
25	Thoraco* [tiab]	58, 526
26	Thymectomy [mh]	7, 910
27	Thymectomy [tiab]	5, 639
28	Tracheostomy [mh]	7, 270

No.	Query	Results
29	Tracheotomy [mh]	8, 338
30	Tracheo*[tiab]	37, 250
31	Ventilators, mechanical [mh]	8, 976
32	Ventilat*[tiab]	162, 314
33	(Bi-level positive airway pressure)	310
34	BiPAP [tiab]	657
35	CPAP [tiab]	8, 153
36	HFOV [tiab]	728
37	NIV [tiab]	2, 973
38	**1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37**	**1,0982,299**
39	Procedur*[tw]	1, 445, 712
40	Surgi* [tiab]	1, 010, 475
41	Surge*[tiab]	1, 343, 482
42	**39 OR 40 OR 41**	**2, 831, 244**
43	(Aerosol generat*)	635
44	**42 AND 43**	**91**
45	**38 OR 44**	**1, 098, 319**

Joint
((Airway extubation [mh]) OR Extubati* [tiab]) OR Bronchoscopy [mh]) OR Bronchoscop* [tiab]) OR Cardiopulmonary resuscitation [mh]) OR Resuscitati*[tiab]) OR Continuous positive airway pressure [mh]) OR (Positive airway pressure)) OR (Positive-airway-pressure)) OR High-frequency ventilation [mh]) OR Interactive ventilation [mh]) OR Intubation [mh]) OR Intubation, intratracheal [mh]) OR Intubat* [tiab]) OR Noninvasive ventilation [mh]) OR Positive-pressure respiration [mh]) OR Respiration, artificial [mh]) OR Respirat* [tiab]) OR Sputum [tw]) OR Thoracic surgery, video-assisted [mh]) OR Thoracic surgical procedures [mh]) OR Thoracic surg* [tiab]) OR Thoracostomy [mh]) OR Thoracotomy [mh]) OR Thoraco* [tiab]) OR Thymectomy [mh]) OR Thymectomy [tiab]) OR Tracheostomy [mh]) OR Tracheotomy [mh]) OR Ventilators, mechanical [mh]) OR Ventilat*[tiab]) OR (Bi-level positive airway pressure)) OR BiPAP [tiab]) OR CPAP [tiab]) OR HFOV [tiab]) OR NIV [tiab])) OR (((Aerosol generat*)) AND (((Surge*[tiab]) OR Surgi* [tiab]) OR Procedur*[tw]))

Table 4A: Search string for aerosol (not chemotherapy) [Inception 29 March 2020]

No.	Query	Results
1	Aerosol [mh]	30, 986
2	Aerosol propellants [mh]	701
3	Bio-aerosol [tiab]	46
4	Bioaerosol [tiab]	907
5	By-product [tw]	9, 795
6	By-products [tw]	11, 702
7	Byproduct [tw]	5, 745
8	Byproducts [tw]	6, 275
9	Carbon dioxide [mh]	86, 910
10	Carbon dioxide [tIab]	51, 219
11	CO2	87, 660
12	Carbon monoxide [mh]	17791
13	Carbon monoxide [tiab]	27, 214
14	CO	3, 760, 484
15	Chemical safety [mh]	145
16	Contaminan*[tw]	55, 045
17	Debris [tw]	19, 884
18	Droplet [tw]	23, 229
19	Droplets [tw]	30, 027
20	Dust [tw]	43, 799
21	Emissions [tiab]	43, 335
22	Fragmen*[tiab]	384, 849
23	Organic chemicals [mh]	4, 307, 986
24	Particl* [tiab]	32, 1573
25	Particle size [mh]	84, 125
26	Particulate matter [mh]	61, 170
27	Plume [tw]	4, 178
28	Smoke [tw]	55, 160
29	Vapor [tw]	36, 489

30	Vapour [tw]	9, 289
31	**1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 PR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31**	**8, 511, 056**
32	Chemotherapy-induced febrile neutropenia [mh]	373
33	Consolidation chemotherapy [mh]	525
34	Induction chemotherapy [mh]	2, 596
35	Maintenance chemotherapy [mh]	1, 604
36	Chemotherapy, Adjuvant [mh]	73, 647
37	Chemotherapy, cancer, regional perfusion [mh]	3, 739
38	Antineoplastic combined chemotherapy protocols [mh]	13, 778, 055
39	Chemotherapy [tiab]	352, 055
40	Chemo [tiab]	21, 019
41	**32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40**	**448, 278**
42	**31 NOT 42**	

Joint
((((((((((((((((((((((((((((((Aerosol [mh]) OR Aerosol propellants [mh]) OR Bio-aerosol [tiab]) OR Bioaerosol [tiab]) OR By-product [tw]) OR By-products [tw]) OR Byproduct [tw]) OR Byproducts [tw]) OR Carbon dioxide [mh]) OR Carbon dioxide [tIab]) OR CO2) OR Carbon monoxide [mh]) OR Carbon monoxide [tiab]) OR CO) OR Chemical safety [mh]) OR Contaminan*[tw]) OR Debris [tw]) OR Droplet [tw]) OR Droplets [tw]) OR Dust [tw]) OR Emissions [tiab]) OR Fragmen*[tiab]) OR Organic chemicals [mh]) OR Particl* [tiab]) OR Particle size [mh]) OR Particulate matter [mh]) OR Plume [tw]) OR Smoke [tw]) OR Vapor [tw]) OR Vapour [tw])) AND ((((((((Chemotherapy, Adjuvant) OR Chemo [tiab]) OR Chemotherapy [tiab]) OR Antineoplastic combined chemotherapy protocols [mh]) OR Chemotherapy, cancer, regional perfusion [mh]) OR Maintenance chemotherapy [mh]) OR Induction chemotherapy [mh]) OR Consolidation chemotherapy [mh]) OR Chemotherapy-induced febrile neutropenia [mh])

Table 5A: Search string for smoke evacuation [Inception 29 March 2020]

No.	Query	Results
1	Suction [mh]	12, 356
2	Suction [tiab]	16, 654
3	Vacuum [mh]	5, 609
4	Vacuum [tiab]	36, 486
5	Air filters [mh]	312
6	Micropore filters [mh]	2, 249
7	Ultrafiltration [mh]	10, 056
8	Filt*[tiab]	266, 881
9	Ultrafiltrat* [tiab]	17, 413
10	Filtrat* [tiab]	128, 693
11	Evacuat* [tiab]	20, 893
12	HEPA [tiab]	1, 676
13	ULPA [tiab]	10
14	(Effluent flow)	4, 611
15	**1 OR 2 OR 3 Or 4 OR 5 OR 6 OR 7 Or 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14**	**369, 351**

Joint
((((((((((((Suction [mh]) OR Suction [tiab]) OR Vacuum [mh]) OR Vacuum [tiab]) OR Air filters [mh]) OR Micropore filters [mh]) OR Ultrafiltration [mh]) OR Filt*[tiab]) OR Ultrafiltrat* [tiab]) OR Filtrat* [tiab]) OR Evacuat* [tiab]) OR HEPA [tiab]) OR ULPA [tiab]) OR (Effluent flow)

Table 6A: Search string for viruses [Inception 29 March 2020]

No.	Query	Results
1	(Avian flu)	9, 082
2	(Bird flu)	5, 025
3	(Hendra virus)	561
4	(ross river virus)	644
5	(Swine flu)	3, 573
6	Adenoviridae [mh]	35, 803
7	Adenoviridae infections [mh]	7, 605
8	Adenoviridae [tiab]	176
9	Bornaviridae [mh]	818
10	Bornaviridae [tiab]	68
11	Bronchiolitis, Viral [mh]	1, 519
12	Caliciviridae [mh]	6, 344
13	Caliciviridae infections [mh]	3, 951
14	Caliciviridae [tiab]	422
15	Central Nervous System Viral disease [mh]	27, 723
16	Common cold [mh]	4, 184
17	Corona virus[tiab]	245
18	Coronaviridae [mh]	12, 706
19	Coronaviridae infections [mh]	10, 762
20	Coronaviridae [tiab]	290
21	Coronavirus[tiab]	10, 918
22	CoV [tiab]	5, 397
23	COVID [tiab]	1, 290
24	Dengue [mh]	12, 472
25	Dengue Virus [mh]	8, 689
26	DNA Virus Infections [mh]	244, 577
27	DNA viruses [mh]	276, 473
28	Enterovirus [mh]	22, 759
29	Enterovirus infections [mh]	51, 571

No.	Query	Results
30	Enterovirus [tiab]	8, 166
31	H1N1 [tiab]	17, 100
32	H5N1 [tiab]	6, 462
33	Hendra Virus [mh]	243
34	Hepatitis [tiab]	217, 422
35	Hepatitis viruses [mh]	70, 518
36	Hepatitis, Viral, Human [mh]	138, 829
37	Herpe* [tiab]	89, 280
38	Herpesviridae infections [mh]	118, 206
39	HIV [mh]	97, 720
40	HIV[tiab]	309, 053
41	HIV/AIDS[tiab]	29, 798
42	Influenza [tiab]	948, 541
43	Influenza, human [mh]	48, 309
44	MERS[tiab]	4, 119
45	Middle East Respiratory Syndrome Coronavirus [mh]	980
46	Orthomyxoviridae [mh]	56, 350
47	Orthomyxoviridae infections [mh]	61, 351
48	Orthomyxoviridae [tiab]	292
49	Papillomaviridae [mh]	32, 274
50	Paramyxoviridae [mh]	34, 086
51	Paramyxoviridae [tiab]	775
52	Paramyxoviridae infections [mh]	36, 854
53	Parvovirinae [mh]	13, 750
54	Parvovirinae [tiab]	53
55	Picornavirus [mh]	39, 900
56	Picornavirus infections [mh]	62, 897
57	Picornavirus [tiab]	1, 840
58	Pneumonia, Viral [mh]	5, 726
59	Poxviridae infections [mh]	13, 344

No.	Query	Results
60	Poxviridae [tiab]	331
61	Reoviridae [mh]	15, 911
62	Reoviridae infections [mh]	11, 884
63	Reoviridae [tiab]	748
64	Rhabdoviridae [mh]	13, 221
65	Rhabdoviridae infections [mh]	11, 915
66	Rhabdoviridae [tiab]	436
67	RNA Virus Infections [mh]	614, 057
69	RNA viruses [mh]	442, 346
70	Ross River Virus [mh]	418
71	SARS Virus [mh]	2, 914
72	SARS[tiab]	8, 834
73	Sexually Transmitted Diseases, Viral [mh]	227, 331
74	Skin Disease, Viral [mh]	28, 947
75	Togaviridae infections [mh]	14, 065
76	Togaviridae [mh]	13, 022
77	Togaviridae [tiab]	502
78	Tumor Virus Infections [mh]	67, 572
79	Viral[tiab]	350, 729
80	Virion [mh]	25, 262
81	Virus Disease [mh:noexp]	38, 107
82	Virus[tiab]	663, 361
83	Viruses [mh:noexp]	22, 794
84	Viruses[tiab]	163, 777
85	Zika virus infections [mh]	4, 532
86	Zika virus[mh]	7, 255
87	Zika[tiab]	0
88	**1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46 OR 47 OR 48 OR 49 OR 50 OR 51 OR 52 OR 53 OR 54 OR 55**	**1, 536, 583**

No.	Query	Results
	OR 56 OR 57 OR 58 OR 59 OR 60 OR 61 OR 62 OR 63 OR 64 OR 65 OR 66 OR 67 OR 68 OR 69 OR 70 OR 71 OR 72 OR 73 OR 74 OR 75 OR 76 OR 77 OR 78 OR 79 OR 80 OR 81 OR 82 OR 83 OR 84 OR 85 OR 86 OR 87 OR 88	
89	Bacteria [tw]	1, 462, 072
90	Parasit*[tw]	1, 754, 070
91	**89 OR 90**	**121, 308**
92	**88 NOT 91**	**1, 415, 275**
93	Animal [tw]	1, 089, 189
94	Plants [tw]	402, 640
95	**93 OR 94**	**1, 473, 216**
96	Human [tw]	3, 280, 161
97	**96 NOT 95**	**3, 028, 945**
98	**92 AND 97**	**405,244**

Joint
((Avian flu)) OR (Bird flu)) OR (Hendra virus)) OR (ross river virus)) OR (Swine flu)) OR Adenoviridae [mh]) OR Adenoviridae infections [mh]) OR Adenoviridae [tiab]) OR Bornaviridae [mh]) OR Bornaviridae [tiab]) OR Bronchiolitis, Viral [mh]) OR Central Nervous system Viral disease [mh]) OR Common cold [mh]) OR Corona virus[tiab]) OR Coronaviridae [mh]) OR Coronaviridae infections [mh]) OR Coronaviridae [tiab]) OR Coronavirus[tiab]) OR CoV [tiab]) OR COVID [tiab]) OR Dengue [mh]) OR Dengue Virus [mh]) OR DNA Virus Infections [mh]) OR DNA viruses [mh]) OR Enterovirus [mh]) OR Enterovirus infections [mh]) OR Enterovirus [tiab]) OR H1N1 [tiab]) OR H5N1 [tiab]) OR Hendra Virus [mh]) OR Hepatitis [tiab]) OR Hepatitis viruses [mh]) OR Hepatitis, Viral, Human [mh]) OR Herpe* [tiab]) OR HIV [mh]) OR HIV[tiab]) OR HIV/AIDS[tiab]) OR Influenza [tiab]) OR Influenza, human [mh]) OR MERS[tiab]) OR Middle East Respiratory Syndrome Coronavirus [mh]) OR Orthomyxoviridae [mh]) OR Orthomyxoviridae infections [mh]) OR Orthomyxoviridae [tiab]) OR Papillomaviridae [mh]) OR Paramyxoviridae [mh]) OR Paramyxoviridae [tiab]) OR Paramyxoviridae infections [mh]) OR Parvovirinae [mh]) OR Parvovirinae [tiab]) OR Picornavirus [mh]) OR Picornavirus infections [mh]) OR Picornavirus [tiab]) OR Pneumonia, Viral [mh]) OR Poxviridae infections [mh]) OR Poxviridae [tiab]) OR Reoviridae [mh]) OR Reoviridae infections [mh]) OR Reoviridae [tiab]) OR Rhabdoviridae [mh]) OR Rhabdoviridae infections [mh]) OR Rhabdoviridae [tiab]) OR RNA Virus Infections [mh]) OR RNA viruses [mh]) OR Ross River Virus [mh]) OR SARS Virus [mh]) OR SARS[tiab]) OR Sexually Transmitted Diseases, Viral [mh]) OR Skin Disease, Viral [mh]) OR Togaviridae infections [mh]) OR Togaviridae [mh]) OR Togaviridae [tiab]) OR Tumor Virus Infections [mh]) OR Viral[tiab]) OR Virion [mh]) OR Virus Disease [mh:noexp]) OR Virus[tiab]) OR Viruses [mh:noexp]) OR Viruses[tiab]) OR Zika virus infections [mh]) OR Zika virus[mh]) OR Zika[tiab]) OR Caliciviridae [mh]) OR Caliciviridae infections [mh]) OR Caliciviridae [tiab]) OR Herpesviridae infections [mh])) NOT ((Parasit*[tw]) OR Bacteria [tw]))) AND ((Human [tw]) NOT ((Plants [tw]) OR Animal [tw]))

Table 7A: Search string for particular transfer [Inception 29 March 2020]

No.	Query	Results
1	Aerosolize [tw]	110
2	Aerosolization [tw]	1, 308
3	Aerosolise [tw]	10
4	Aerosolisation [tw]	202
5	Transmi*[tiab]	503, 058
6	**1 OR 2 OR 3 OR 4 OR 5**	**504, 539**

Joint
((((Transmi*[tiab]) OR Aerosolisation [tw]) OR Aerosolise [tw]) OR Aerosolization [tw]) OR Aerosolize [tw]

Appendix B: High-Efficiency Particulate Air (HEPA) filters

HEPA Filter Definition:

A filter usually designed to remove at 99.97% of airborne particles measuring 0.3 µm or greater from air that is passed through the filter[ii]

HEPA filters are designed to control the number and size of particles entering the operating room.[iii] Filtration targets ultra-fine particles by three distinct mechanisms[iv] which are:

1. Inertial Impaction. Physical impact of particle with the filter fibres.
2. Interception. This mechanism involves smaller sized particles that can easily follow the streamline and can pass through the filter spaces but are captured by the edge of the fibres.
3. Diffusion. This mechanism is the most important part of the True HEPA filter. Particles of less the 0.3µm they do not follow the air streamline and can move randomly Brownian motion. Their high freedom of movement increases the probability that they will encounter the fibres of the filters. With decreasing particle size, the diffusion mechanism becomes more important.

Filter classifications:

Two standards are used to defined filters; these are the European standard (Table 1) and the MERV rating system (Table 2).

[ii] https://www.merriam-webster.com/dictionary/HEPA [accessed 20 April 2020 @ 13:00h]

[iii] https://www.sciencedirect.com/topics/nursing-and-health-professions/hepa-filter [accessed 20 April 2020 @ 13:00h]

[iv] https://breathequality.com/hepa-filter/ [accessed 20 April 2020 @ 13:30h]

Table1: Filter Classification - European standard[v]

HEPA Class	Efficiency
U17	99.9999%
U16	99.99975%
U15	99.9975%
H14	99.975%
H13	99.97%
E12/H12	99.5%
E12/H12	99.5%
E11/H11	95%
E10/H10	85%

Shaded cells: filter in these classifications are not true HEPA filters

[v] https://breathequality.com/hepa-filter/ [need to double check with other sites]

Table 2:Filter Classification -MERV rating[vi]

MERV rating	Dust efficiency	Particle size (µm)

[vi] https://breathequality.com/hepa-filter/ [need to double check with other sites]

MERV rating	Dust efficiency	Particle size (µm)
20	≥ 99.999%	0.1 - 0.2
19	≥ 99.99%	0.1 - 0.2
18	≥ 99.97%	0.1 - 0.2
17	≥ 99.97%	0.3
16	≥ 99.95%	0.3 - 1.0
15	≥ 95.0%	0.3 - 1.0
14	90 - 95%	0.3 - 1.0
13	89 - 90%	0.3 - 1.0
12	70 - 75%	1.0 - 3.0
11	60 - 65%	1.0 - 3.0
10	50 - 55%	1.0 - 3.0
9	40 - 45%	1.0 - 3.0
8	30 - 35%	3.0 - 10.0
7	25 - 30%	3.0 - 10.0
6	< 20%	3.0 - 10.0
5	< 20%	3.0 - 10.0
4	< 20%	≥ 10.0
3	< 20%	≥ 10.0
2	< 20%	≥ 10.0

MERV rating	Dust efficiency	Particle size (µm)
1	< 20%	≥ 10.0

Shaded cells: filters in these classifications are not true HEPA filters

What are true HEPA filters?

True HEPA filters are those that filter 99.97% of particles that are 0.3µm or larger. Filters rated at H13 (Table 1) and 17 (table 3) or higher on the European or MERV rating systems are considered true HEPA filters.

Insufflator and smoke plume filtration

Based an initial search of the Australian Register of Therapeutic Goods (ARTG) there are a number of insufflators with filtration systems to capture surgical plumes generated during laparoscopy or aerosol generating procedures available in Australia. Supplier websites were searched for technical specifications of filters; typically in-machine or inline filters are high grade HEPA classified as ultra-low particulate air (ULPA). ULPA filters will remove particles equal to or greater than 0.1µm at an efficiency of at least 99.97%. When quoted, filter efficiency can be as high as 99.999%, meaning filters are U17 (European standards) or 20 on the MERV ranking scale.

When fitted, ULPA filters appears to be the industry standard.

Table 3:Insufflators/smoke plume suction devices for laparoscopy/endoscopic surgery available in listed on ARTG Australia*

Manufacturer	ARTG #	Intended purpose
Smith & Nephew Pty Ltd - Insufflator, endoscopic	97810	For use for gas distension of the abdomen for diagnostic & operative laparoscopy
ConMed Linvatec Australia Pty Ltd - Insufflator, endoscopic	273369	A device that delivers a gas for distension of the surgical cavity (e.g. abdomen, rectum or colon) during endoscopic procedures, to maintain a path of entry for surgical instruments, to facilitate endoscopic observation, diagnosis and/or treatment and to evacuate surgical smoke
ConMed Linvatec Australia Pty Ltd - Insufflator, endoscopic	233786	A device (insufflator) that provides CO_2 gas distension of surgical cavities via an endoscope, for diagnostic and/or operative endoscopy, including general laparoscopic, paediatric laparoscopic, bariatric laparoscopic and minimally invasive vessel harvesting procedures.
Smith & Nephew Pty Ltd - Lapflow Insufflator - Insufflator, endoscopic	140700	A device that blows warm and humidified CO_2 gas through an endoscope in order to prevent dew/mist accumulating at the lens, and/or, in order to enlarge the space directly forward of the distal end in order to obtain a better field of view for the operator

Manufacturer	ARTG #	Intended purpose
Zimmer Biomet Pty Ltd - Suction system filter, smoke plume particulate	322263	A device used to extract particulates from the plume of smoke, created during a surgical procedure.
ConMed Linvatec Australia Pty Ltd - Suction system filter, smoke plume particulate	316725	A sterile, single-use, filter device installed within a smoke evacuation suction system, to extract particulates from the plume of smoke created during tissue-burning surgical procedures.
ConMed Linvatec Australia Pty Ltd - Suction system filter, smoke plume particulate	316203	A non-sterile filter device or accessory installed within a smoke evacuation suction system or a central vacuum system, to extract particulates from the plume of smoke created during tissue-burning surgical procedures.
Olympus Australia Pty Ltd - Suction system filter, smoke plume particulate	305297	A filter to be used with the surgical smoke evacuator to trap and remove particulates from the surgical smoke.
ConMed Linvatec Australia Pty Ltd - Suction system filter, smoke plume particulate	294217	Filtered tube sets intended to provide particulate filtration and/or removal of surgical smoke during laparoscopic or endoscopic procedures.
Optimed Technologies Pty Ltd - Suction system filter, smoke plume particulate	287903	A screening device installed within the suction tubing line of a suction system, or the suction tubing used with a central vacuum system, to extract particulates from the plume of smoke created typically through the use of various tissue-burning surgical devices (e.g., laser, electrosurgical diathermy device), This is a non-sterile single-use device.
Rymed Pty Ltd - Suction system filter, smoke plume particulate	284251	Bacterial/Viral filter for use with smoke evacuator
Karl Storz Endoscopy Australia Pty Ltd - Suction system filter,	277365	Intended to entrap any particulate matter that may be carried with the gas.

Manufacturer	ARTG #	Intended purpose
smoke plume particulate		
EMT Healthcare Pty Ltd - Suction system filter, smoke plume particulate	266160	Suction system filter for extracting particulates from the plume of smoke created through the use of various tissue burning electro-surgical diathermy devices.

*ARTG accessed 20 April, 2020 |