

Guidelines for safe surgery: open versus laparoscopic

A rapid review commissioned by RACS

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9 April 2020

Clinical Expert COVID-19 Working Group

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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 such as the ConMed AirSeal® (or equivalent) should be used if available, otherwise other methods need to be employed to reduce any potential release.
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.

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. ² 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 ports are as small as possible, pneumoperitoneum pressure is at a minimum and ultrafiltration is used if available, as well as appropriate measures taken for capture of deflated peritoneal air or any surgical plumes generated during surgery to limit the risk of aerosol production. ³ 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. ⁴

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. ⁵ Lippi et al (2020) reviewed the limitations of current laboratory diagnostics for COVID-19. ⁶ 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. ⁶

An observational cohort study reported by To et al (2020) ⁷ 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. ⁸ Further, the study by Xiao et al (2020) ⁹ 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.

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. ¹⁰⁻¹²

Laparoscopy: desufflation of pneumoperitoneum

Creating and maintaining a pneumoperitoneum alters the normal physiology of the peritoneum. Inflation is usually achieved using carbon dioxide (CO₂) at pressure with defined temperature and humidity. ¹³ 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). ¹⁴ 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. ¹⁴ These recommendations were echoed by Yu et al (2020) for managing the pneumoperitoneum in patients with COVID-19. ¹⁵

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. ¹⁴ 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.² 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.¹ 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.

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 laparoscopic⁴ or open surgery.¹⁶ 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.¹⁶

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.¹⁷ 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.¹⁸ 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.¹⁹⁻²¹

No reports were identified that reported on COVID-19 aerosolisation by ablation, although CO₂ circulating in the pneumoperitoneum may generate aerosols that contain COVID-19.¹⁵ Aerosols 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 SARS²²; 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-19.²³ Generation of aerosols in the OR are a possible source of infection and a risk to the surgical team.

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

¹ SAGES <https://www.sages.org/recommendations-surgical-response-covid-19> Accessed 3 April, 2020

Damrose (2013) supports the evidence that HPV DNA can be found in surgical plumes generated by CO₂ 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

The virus 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).²⁵ 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.²⁶ 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.²⁶ Given the extended survival of COVID-19 on this medium²⁵, disinfection of this surface may be required to reduce the risk of fomite transmission.

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

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

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

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

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]