Review Article

Severe acute respiratory syndrome coronavirus 2 infection risk during elective peri-operative care: a narrative review

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Summary

The protection of healthcare workers from the risk of nosocomial severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection is a paramount concern. SARS-CoV-2 is likely to remain endemic and measures to protect healthcare workers against nosocomial infection will need to be maintained. This review aims to inform the assessment and management of the risk of SARS-CoV-2 transmission to healthcare workers involved in elective peri-operative care. In the absence of data specifically related to the risk of SARS-CoV-2 transmission in the peri-operative setting, we explore the evidence-base that exists regarding modes of viral transmission, historical evidence for the risk associated with aerosol-generating procedures and contemporaneous data from the COVID-19 pandemic. We identify a significant lack of data regarding the risk of transmission in the management of elective surgical patients, highlighting the urgent need for further research.

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Introduction

The infection of healthcare workers during the coronavirus disease 2019 (COVID-19) pandemic has been widely reported and is an issue of great concern to clinicians and policymakers. Community surveillance in the UK suggests an increased incidence of SARS-CoV-2 infection among patient-facing healthcare workers [1]. Of confirmed COVID-19 infections in China, 3.8% were healthcare workers and higher proportions have been reported in Italy and Spain [2]. Up to 11 May 2020, 203 healthcare worker deaths had been reported in the UK [3]. Whilst none of these were anaesthetists or intensivists, 53 out of 1718 (3.1%) healthcare workers performing or involved in tracheal intubation of patients with confirmed or suspected COVID-19 subsequently reported laboratory-confirmed SARS-CoV-2 infection [4].

More than 20% of all severe acute respiratory syndrome (SARS) patients were healthcare workers [5] and nosocomial SARS infection was prominent among healthcare workers looking after patients who required respiratory support [6]. Following the SARS epidemic, the World Health Organization (WHO) published a list of aerosol-generating procedures [7], a concept originally developed to protect against transmission of tuberculosis, an obligate airborne pathogen [8]. The WHO subsequently commissioned a systematic review of the evidence for the association between aerosol-generating procedures and nosocomial SARS coronavirus 1 (SARS-CoV-1) transmission [9]. This incorporated 10 retrospective observational studies, five case-control and five cohort studies. Given its genesis, the evidence is inevitably associative and imprecise. Nonetheless, there was a consistent and strong signal (pooled OR of 6.6) that tracheal intubation was associated with an increased risk of transmission of SARS-CoV-1 to healthcare workers. Understandably, this has been given considerable weight by policymakers during the current pandemic [10–12].

The possibility that this increased risk may, in part, be due to airborne transmission has informed not only the use of personal protective equipment (PPE) but also procedural modifications of the peri-operative pathway. Guidance continues to evolve [13] and, although not all are explicitly advised in national or international guidelines, these have included: tracheal intubation and extubation in the operating theatre to avoid contamination of anaesthetic rooms; an 'aerosol clearance time' defined in terms of room ventilation during which no one should enter, and some suggest even leave, the room following an aerosol-generating procedure; avoiding manual (bag-mask) ventilation before tracheal intubation; and, by inference, avoiding intra-operative positive pressure ventilation via supraglottic airway devices. These may be associated with adverse consequences or resource cost, some of which are outlined in Table 1.

Unlike SARS-CoV-1, SARS-CoV-2 is likely to become an endemic threat. Healthcare systems face the challenge of increasing activity to accommodate the backlog that has built up due to service disruption [14] whilst protecting patients and staff from nosocomial infection. However, there is limited evidence concerning transmission risk in the elective peri-operative setting. Here, we review the evidence from SARS and contemporaneous data from COVID-19 to inform assessment and management of the risk of SARS-CoV-2 transmission to healthcare workers involved in elective peri-operative care.

Transmission

According to the WHO, SARS-CoV-2 is predominantly transmitted by contact with infected respiratory fluids or exposure to infected respiratory droplets [15]. Environmental contamination is widespread [16, 17] and this can be mitigated by hand hygiene, gloves, aprons and environmental decontamination. Exposure to infective droplets emitted by coughing may be mitigated by wearing a fluid-resistant surgical mask [18]. Airborne transmission is via aerosols, particles "*that remain infectious when suspended in air over long distance and time*" [19] and may, therefore, transmit infection further than the 2-metre range of larger droplets [20, 21]. Aerosol deposition is also an important source of surface contamination [22].

Airborne viral transmission is complex, uncertain and controversial [21]. Respiratory bio-aerosols are generated by wind shear forces arising from the passage of air over infected mucosa in the respiratory tract. The number and size distribution of aerosols and their viral content vary according to the site and force of generation, environmental conditions and the degree of viral shedding at the site of aerosol generation. The infectivity of aerosols depends upon the aerosol viral load, where they deposit in the respiratory tract and tissue tropic factors (such as, in the case of SARS-CoV-2, cellular angiotensin-converting enzyme-2 (ACE-2) receptor expression) [23].

Airborne viral spread has been demonstrated in animal models [24] and healthy human volunteers [25] and epidemiological studies suggest that this is a transmission route in other viruses [20, 26]. SARS-CoV-2 infects and replicates in both lower respiratory tract and nasopharynx [27]. Under experimental conditions, the persistence of viable SARS-CoV-2 in aerosols for up to 3 h has been

Table 1 Potential consequences of precautions to reduce coronavirus 2019 (COVID-19) risk

Theatre efficiency	Human factors	Other consequences
Increased surgical and anaesthetic preparation time	Modification in usual process risks potential increase in human error	Perceived benefit of tracheal tube instead of SAD may increase risk of aerosol generation (e.g. coughing on extubation)
Delay in starting case because of post-intubation aerosol clearance time	Masks and visors may hinder performance and communication	PPE removal ('doffing') carries a risk of self-contamination
Delay to preparing for next case from aerosol clearance time	Increased anxiety from COVID-19 'infodemic'	Emphasis on airborne element of infection control precautions may distract attention from the risk of contact/droplet transmission
PPE donning and doffing time	Potential reduction in breaks to reduce PPE use	

SAD, supraglottic airway device; PPE, personal protective equipment.

demonstrated [28]. SARS-CoV-2 ribonucleic acid (RNA) has been detected in air samples from clinical environments [22]. Other studies were unable to detect SARS-CoV-2 in air samples but swabs from air outlets were positive [16]. It is important to note that presence of detectable SARS-CoV-2 RNA does not necessarily imply the presence of viable virus and there are no reports to date of viable SARS-CoV-2 isolated from air samples collected in the clinical environment. There is no direct evidence of SARS-CoV-2 airborne transmission but there is epidemiological evidence that airborne SARS-CoV-1 transmission may have occurred, both in the community and in the healthcare environment.

For example, modelling of airflow dynamics correlated with the SARS-CoV-1 transmission dynamics in an apartment block, where spread by contact or respiratory droplet was unlikely [29]. Similarly, the transmission of SARS-CoV-1 to medical students who were not in direct contact with an infected patient correlated with airflow modelling [30]. In both cases, defective engineering created environmental conditions that may have contributed to these events (in the first, faulty drain seals allowing faecal aerosols to be drawn into the air conditioning; in the second, imbalance between ventilation inflow and outflow) and they are not necessarily representative of normal transmission dynamics [31, 32].

Whilst the predominant route of SARS-CoV-2 transmission may be contact/droplet-mediated, environmental conditions – including those associated with aerosol-generating procedures – may promote 'opportunistic' airborne transmission [33].

Aerosol-generating procedures

Aerosol-mediated airborne transmission has been a source of great anxiety among healthcare workers. National guidelines recommend 'airborne precautions' [34] for those involved in aerosol-generating procedures but contact/-droplet precautions for most other clinical activity [11, 12, 35].

The WHO list of aerosol-generating procedures is based on epidemiological evidence of transmission to healthcare workers caring for SARS patients [30, 36–44]. This evidence is related to the risk of transmission while caring for patients with respiratory failure and critical appraisal of how this SARS data apply to the risk of SARS-CoV-2 transmission in the elective peri-operative environment is necessary. Table 2 summarises the raw data from the WHO-commissioned systematic review by Tran et al. [9] related to transmission risk associated with tracheal intubation. Tracheal intubation has been highlighted here because it is the most relevant aerosol-generating procedure in the context of elective peri-operative care. Other procedures, such as extubation, rely on this evidence by extension. Moreover, it is notable as an example of the methodology that tracheal intubation is a discrete and identifiable event and was common among SARS patients. It is therefore liable to proxy assumptions: for example, if the majority of SARS patients had developed appendicitis, such methodology might identify appendicectomy as an aerosol-generating procedure.

The studies were limited by heterogeneous populations, poorly defined and variable exposure and recall bias. Across eight studies, there were 76 infections associated with tracheal intubation among a population of 2250 healthcare workers. The number of healthcare workers exposed to tracheal intubation is relatively small compared with those who were not, such as non-clinical staff. Across all studies, 22 patients transmitted SARS-CoV-1 to 99 healthcare workers. In the second-largest study, the 26 healthcare workers who developed SARS all looked after seven – and 23 looked after only four – of the 45 SARS patients whose tracheas were intubated [41]. In the largest case-control study caring for a "*super-spreading patient*" (no definition offered in the paper) was associated with healthcare worker infection, and in multivariate analysis, this association was stronger than tracheal intubation [36].

This evidence, therefore, rests on a small number of infections associated with a yet smaller number of highly infectious patients, among a heterogeneous population of healthcare workers, matched in some cases according to profession, in others by presence during rather than performance of the procedures under investigation. All identify other measures of proximity or contact with patients which are associated with increased transmission risk of a comparable order of magnitude to that of being involved in tracheal intubation.

The authors discuss the "*difficulty in identifying the specific part of a given procedure, which may be complex and involve several manoeuvres, that imparts the greatest risk of transmission*." They "*acknowledge that the findings presented may have been influenced by direct and indirect contact transmission*" and conclude that their "*findings serve to highlight the lack of precision in the definition for aerosol generating procedures*" [9].

A recent systematic review led by Health Protection Scotland appraised the evidence base for the WHO list of aerosol-generating procedures [45]. They only identified four additional reports relating to transmission risk during tracheal intubation. Three are case reports and in each of these they found that "*The multiple factors that could have*

Table 2 Summary of the raw data incorporated by Tran et al. [9] of evidence relating aerosol-generating procedures to SARS-CoV-1 infection among healthcare workers

Study design	Study	Population	Tracheal intubation exposure definition	Healthcare workers involved in tracheal intubation		Healthcare workers not involved in tracheal intubation		OR for case-control or RR for cohort studies (95%CI)	Total number of source patients	Other significant proximity/contact measure [OR]/(RR)
				Infected	Not infected	Infected	Not infected			
Case-control Cases Identified as infected healthcare workers Controls Demographically matched healthcare workers working during the study period	Chen et al. [36]	2 hospitals in Guangzhou 239 doctors, 373 nurses, 55 health attendants, 38 lab technicians, 53 others[i]	"*Performing tracheal intubation*"	16	17	75	640	8.0* (3.9–16.6)	NA	"*Often avoiding face to face contact*" [0.3]
	Pei et al. [37]	3 hospitals in Beijing 103 doctors, 241 nurses, 12 nursing staff, 19 workers, 43 technicians, 19 administrators, 6 others	"*Doing tracheal intubation*"	28	9	119	287	7.5* (3.4–16.4)	NA	"*Participating in first aid of critical patients*" [1.7]
	Teleman et al. [38]	Single hospital in Singapore 65 doctors and nurses, 21 other healthcare workers	"*Performed/ assisted in tracheal intubation*"	2	4	34	46	0.7 (0.1–3.9)	3	"*Contact with respiratory secretions*" [21.8]
	Liu et al. [39]	Single hospital in Beijing 171 medical staff, 245 nursing staff, 61 other occupation	"*Contact: intubation*"	6	6	45	420	9.3* (2.9–30.2)	NA	"Contact: respiratory secretions" [3.3]
	Ma et al. [40]	This study is based on the same dataset used by Liu et al. [39]. The exposure definition used is different: it reports a risk estimate for exposure to a composite of four procedures (intubation, tracheotomy, airway care, and cardiac resuscitation). To avoid duplication and false comparison, its data are not presented here								

(continued)

Table 2 (*continued*)

Study design	Study	Population	Tracheal intubation exposure definition	Healthcare workers involved in tracheal intubation: Infected	Healthcare workers involved in tracheal intubation: Not infected	Healthcare workers not involved in tracheal intubation: Infected	Healthcare workers not involved in tracheal intubation: Not infected	OR for case-control or RR for cohort studies (95%CI)	Total number of source patients	Other significant proximity/ contact measure [OR]/(RR)
Cohort Healthcare workers exposed to confirmed SARS-CoV-1-infected patients	Raboud et al. [41]	20 hospitals in Ontario, 45 intubations 93 doctors, 283 nurses, 89 respiratory therapists, 67 radiology technologists, 38 housekeepers, 28 personal service assistants, 14 lab technicians, 3 paramedics, 2 pharmacists, 2 ward clerks, 2 porters, 2 physiotherapists, 4 others	"*In the room*"	12	132	14	466	2.9* (1.4–6.1)	7	"*In the room*" while recording an ECG (3.5)
	Fowler et al. [42]	Single hospital, Toronto 15 doctors, 66 nurses, 18 nursing aids, 18 respiratory physiotherapists, 3 physiotherapists, 2 others	"*Performing*"/"*assisting*"/"*present*"	6	8	2	60	13.3* (3.0–59.0)	7	During intubation: nurses present (21.4) Physicians present (3.8)
	Loeb et al. [43]	Single hospital in Toronto 32 nurses	Not clear, likely in the room	3	1	5	23	4.2* (1.6–11.1)	3	Time to event analysis: increased shifts increased risk
	Scales et al. [44]	Single hospital in Toronto 6 infections (2 doctors, 3 nurse, 1 respiratory therapist), other healthcare worker roles not itemised	"*Present during*"	3	2	3	11	2.8 (0.8–9.6)	1	Time with patient: <31 min vs. ≥31 min [12.9]
	Wong et al. [30]	*Not applicable to tracheal intubation but reports a cohort of medical students exposed to a single inpatient; 16 developed SARS but one case cannot be confidently ascribed to exposure to the index patient*				15	—	—	1	—
		Total number healthcare workers infected by identifiable patients				99	Total number identifiable source patients		22	

OR, odds ratio; RR, relative risk; NA, not available; ECG, electrocardiograph.
*$p < 0.05$.

led to infection transmission in this case make it very difficult, if not impossible to identify the most high risk elements." The other study that they singled out [42] was included in the WHO systematic review. Health Protection Scotland could only identify "*weak evidence for an increased risk of respiratory infection transmission*" from performing tracheal intubation.

However, There is a consistent signal throughout these studies that involvement in tracheal intubation of SARS patients with respiratory failure was associated with an increased risk of viral transmission. In a recent international study, 10.7% healthcare workers involved in tracheal intubation during the COVID-19 pandemic reported lab-confirmed SARS-CoV-2 infection or hospitalisation or self-isolation due to COVID-19 symptoms [4]. How the risk of infection associated with tracheal intubation is mediated, however, is not clear.

The elective peri-operative environment is different from the acute settings from which this evidence is drawn. The preconditions and purpose of tracheal intubation for elective surgery are different from emergent/urgent tracheal intubation for respiratory failure. Pre-admission measures such as self-isolation, symptomatic screening and viral RNA testing before admission aim to reduce the risk that patients undergoing elective surgery are infected with SARS-CoV-2 and the risk of healthcare worker exposure to the virus in the elective peri-operative environment. However, it is important to note that these measures do not eliminate these risks. In order to provide effective and efficient protection to healthcare workers in this environment, it is imperative to consider how and why involvement in tracheal intubation and related airway procedures is associated with increased risk of viral transmission.

Cough – the aerosol in the room

Coughing is the common denominator of a number of defined aerosol-generating procedures, including tracheal intubation, extubation and bronchoscopy. Indeed, the tuberculosis guidelines which introduced the term refers to "*cough-inducing and aerosol-generating procedures*" [8]. The recent re-iteration [46] that tracheal intubation is aerosol-generating was based on simulated tracheal intubation of a 'coughing' manikin [47]. Modelling studies confirm that the risk of airborne transmission depends upon cough frequency [48]. Air sampling demonstrates increased bioaerosol concentrations during coughing on bronchoscope insertion [49].

Coughing is not a procedure but its exclusion from discussions of aerosol-generating procedures may also reflect the misconception that it does not produce aerosols, which originates from early studies that were technically insensitive to smaller particles [50]. Any respiratory activity, including breathing, produces aerosols and more recent studies have demonstrated that coughing produces large numbers of both droplets and aerosols [51, 52]. The dichotomy between droplets that deposit within a short distance and aerosols that travel further may be an over-simplification [53, 54].

AvianAvian Influenza (H1N1) viral titres in air samples taken during tracheal intubation were not significantly higher than background levels in ICUs [55] although this study may have been under-powered to detect this difference [45]. Another study found no link between influenza aerosols in sampled air and aerosol-generating procedures [56]. In Canada, use of neuromuscular blocking drugs for tracheal intubation increased during the second SARS outbreak which may have contributed to the decrease in healthcare worker infections [57] and support the notion that coughing is the prime aerosol (and/or droplet) generator.

The studies upon which the WHO list of aerosol-generating procedures is based do not provide any direct evidence that tracheal intubation itself increases the risk of SARS transmission.

Rather, these data imply that proximity and time in proximity to symptomatic, infectious, acutely unwell SARS patients, particularly to their airway, confers risk of transmission. These studies also identified other activities, for example, electrocardiogram (ECG) recording or urinary catheterisation, that were associated with similar (or higher) risk though less consistently and with less confidence than tracheal intubation.

Conceptually and evidently, it is not tracheal intubation that generates aerosol but coughing, breathing and talking. Provided adequate neuromuscular blockade, tracheal intubation is not associated with coughing. However, healthcare workers involved in tracheal intubation, which by necessity brings them into close proximity to the airway, will be exposed to aerosols during preoxygenation and induction of anaesthesia or due to leaks during manual ventilation.

Theoretically, aerosols travel freely in air currents, but data suggest their effect distance is more limited. Air sampling in an emergency department whilst performing routine care showed that the infective aerosol concentration reduced significantly with distance [58]. These studies highlight local short-range airborne transmission in close proximity to an infected patient [59]. The impact of proximity has been modelled theoretically [53], simulated experimentally [60] and informs the UK government's social distancing policy [61].

To date, there are no studies of bio-aerosol sampling in the elective peri-operative environment. Sampling in these clinical environments – at varying distance from spontaneously breathing and coughing patients, during routine care, during and after aerosol-generating procedures and related airway manoeuvres – would allow a better appreciation of airborne exposure and risk. It would be prescient to plan these studies in preparation for the anticipated next COVID-19 surge.

Protecting healthcare workers and patients

Defining a safe, pragmatic and consistent policy that avoids unnecessary resource, human factor or other cost is difficult. It is contingent on the exposure risk which changes over time and varies according to environment [62]. By contrast to SARS-CoV-1 [63], asymptomatic transmission of SARS-CoV-2 may be common [64–66] and prevalence and risk of transmission are higher in the community [67].

The risk of asymptomatic transmission may not be just from patients to healthcare workers, but also from healthcare workers to patients. In one study, SARS-CoV-2 RNA levels were higher in air samples collected in medical staff areas than those collected in patient areas [22]. As with patients, symptomatic screening is not sufficient to exclude healthcare worker infection [68]. COVID-19 prevalence among healthcare workers may be higher than among elective surgical patients. In the Office for National Statistics COVID-19 Infection Survey Pilot, 1.73% of patient-facing healthcare or resident-facing social care workers tested positive compared with 0.35% for people not working in these roles [1].

Data continue to emerge that highlight differences in asymptomatic prevalence at different times and environments during the current pandemic. Thirty-one out of 1032 (3%) asymptomatic healthcare workers at a large regional university hospital in the UK tested positive for SARS-CoV-2 [69]. In our institution, a tertiary oncological centre in central London, which instituted measures in line with national policy to minimise exposure to COVID-19, snapshot PCR testing of 1650 healthcare workers on 30 April and 1 May 2020 revealed three positive individuals [personal communication].

Although routine pre-operative testing reduces the exposure of theatre staff to SARS-CoV-2 positive patients, it does not eliminate this risk as tests may be falsely-negative [70]. Healthcare workers should be supported to make decisions according to their own perception of risk [71] but also have the evidence explained so they understand the rationale of the recommendations. Beyond promoting confidence and calm in a changing world, this also makes space for patient- and situation-specific judgement based on a granular assessment of risk that guidelines are unable to accommodate.

Process and practice in the elective peri-operative environment

It is likely that the act itself of tracheal intubation or extubation does not generate aerosols but, rather, they are associated with aerosol-generating respiratory activities (coughing and breathing), aerosol dispersal via leaks during bag-mask ventilation, and local environmental droplet and fomite contamination. These procedures bring healthcare workers into close proximity to the patient's airway and, therefore, to high concentrations of aerosols generated by breathing and coughing. Those performing or in close proximity during these procedures require aerosol and droplet protection. Alongside PPE, risk may be mitigated by adopting strategies to minimise the risk of coughing during tracheal intubation and extubation [72].

Although manual ventilation has been identified as a risk factor for SARS infection [41], this is not a consistent finding [43,44] and Health Protection Scotland review described the evidence as weak [45]. Again, proximity to the airway may confer the highest risk rather than the procedure per se, and this is supported by manikin studies [73]. Wilson concludes that the risk of aerosol generation during manual ventilation is 'technique dependent' and, accordingly, low volume, low-pressure ventilation with a good seal is described as low risk [53]. Nonetheless, it may be prudent to avoid manual ventilation where possible. The risk of arterial oxygen desaturation after induction of anaesthesia can be minimised by effective pre-oxygenation [74, 75] and measures which facilitate apnoeic oxygenation (for example, maintaining airway patency, minimising air entrainment via mask leak and head-up position [76]).

Recent guidance supports the judicious use of supraglottic airway devices [13]. Some have advocated against the use of supraglottic airway devices in favour of cuffed tracheal tubes on the basis that there may be a lower risk of an aerosol leak during positive pressure ventilation [77]. There is evidence that, when used appropriately, this is not the case. The mean oropharyngeal leak pressure of the i-gel® (Intersurgical, Wokingham, UK) is 25 cmH_2O in non-paralysed patients and 28 cmH_2O in paralysed patients [78]. The leak fraction with the i-gel was no higher when ventilating with peak pressures below 25 cmH_2O compared with a cuffed tracheal tube [79]. Several tests of leak have been shown to be sensitive and reliable in clinical settings [80]. The risk of aerosol generation may be greater on insertion or removal where poor seal or coughing may facilitate generation and dispersal of aerosols. Therefore, perhaps more important than leak fraction is the primary failure rate where supraglottic airway devices do not achieve an adequate seal on insertion. For i-gel, this has been estimated to be 4–7% [81] but in this regard, supraglottic airway devices with an inflatable cuff may be more reliable [82].

An ‘aerosol clearance time’ – waiting for a period of time for room ventilation defined in terms of air changes – has been recommended [83, 84]. United Kingdom national guidance from Public Health England advocates (as ‘pragmatic’) 20 min in a room with 10–12 air changes per hour following an aerosol-generating procedure [85]. This corresponds to approximately four air changes and a clearance of 96–98%. This is similar to the three to five air changes recommended by the Australian and New Zealand College of Anaesthetists [86]. There is evidence to support this where there has been extensive aerosol generation, e.g. intensive care rooms [55] or bronchoscopy suites [49].

If aerosols are generated by associated respiratory activities rather than the act of tracheal intubation or extubation itself, requiring an aerosol clearance time following these procedures but not in other situations, for example, in a recovery ward where patients are breathing and coughing, may seem logically inconsistent. In both environments, patients generate potentially infectious aerosols by breathing and coughing. There are, however, arguments for maintaining aerosol clearance times in the elective peri-operative environment. Foremost is the precautionary principle: there is epidemiological evidence that tracheal intubation and other airway manoeuvres are consistently associated with an increased viral transmission risk and there may be elements of these procedures which increase risk that we do not appreciate.

Current UK guidelines do not recommend airborne precautions for healthcare workers where aerosol-generating procedures are not taking place, for example, in recovery wards, outpatient suites or general practice consultation rooms [11]. Other international authorities, however, advice airborne precautions for all healthcare workers coming into close proximity to an ‘open’ airway and not just after aerosol-generating procedures [87] and this would include healthcare workers in recovery wards and many outpatient and community healthcare environments. This guidance is supported by the evidence presented here which emphasises the importance of proximity to patients’ airways over the procedure itself. A further example of this might be a recent study of 44 anaesthetists who performed awake spinal anaesthesia (not an aerosol-generating procedure) on 49 SARS-CoV-2 positive patients which found that only one out of 37 (2.7%) who used aerosol precaution PPE subsequently tested positive for SARS-CoV-2 compared with four out of seven (57.1%) who used droplet precaution PPE [88]. This may have implications for other regional anaesthetic techniques, a subject which has been recently reviewed by Uppal et al. [89].

The focus on aerosol-generating procedures may also risk neglecting the other practices to reduce transmission that are equally important. These control measures include frequent hand washing [90]; double-gloving during tracheal intubation [91]; surface cleaning of anaesthetic machines; monitors and other equipment in the immediate vicinity after tracheal intubation [92]; and patient use of fluid-resistant surgical mask following extubation [93]. Basic infection control practices are often poorly observed [94]. Sampling studies consistently identify extensive surface contamination warranting greater emphasis on this element of infection control [16, 17]. Evidence-based guidance [92] includes simple, inexpensive measures such as placing alcohol-gel dispensers near anaesthetists which have been shown to dramatically increase hand decontamination [95]. Strict adherence to standard infection control precautions and frequent, thorough surface cleaning may reduce contact transmission [96].

Conclusion

One product of the SARS experience was the concept of the aerosol-generating procedure. This epidemiological evidence, graded as very low quality, provides useful guidance in the management of symptomatic acutely unwell patients. In the elective peri-operative and other healthcare settings, however, restricting airborne precautions to healthcare workers undertaking aerosol-generating procedures may under-estimate risks to those who are in close proximity to patients but not involved in these procedures. The emphasis on aerosol-generating procedures also potentially risks neglecting the primary barriers to COVID-19 transmission of contact precautions and hand washing.

The limitations of this review reflect the limitations of the data. There is very limited evidence related to the risk of SARS-CoV-2 transmission in the elective peri-operative environment. The mechanism of infection transmission and the factors that influence it is inferred from physical studies of aerosol generation and behaviour and clinical studies of other viruses in other settings. As anaesthetists, our understanding of the complexities of aerodynamics and virology is necessarily limited and highlights the need for multidisciplinary research in this area.

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