

## Review Article

## Preventing exposure to COVID-19 in the operation theatre and intensive care unit

Rangraj Setlur, Alok Jaiswal, Nikahat Jahan

Department of Anaesthesia and Critical Care, Armed Forces Medical College, Pune, Maharashtra, India

## Abstract

The COVID-19 pandemic has gripped the world since January 2020 and has changed our lives in unprecedented ways. It has changed the way we work in the Operation Theatres and Intensive Care Units mainly because of the high risk of disease transmission to the healthcare workers. In order to reduce the risk of disease transmission, an understanding of the means of transmission of the virus is essential to develop a rational strategy that allows patients to receive treatment without placing either the patient or healthcare workers at risk. It should be cautioned that this is a rapidly changing field and there is a paucity of randomised controlled trials related to various aspects of the disease. It is therefore advisable to revise any recommendations in this article, as and when new evidence emerges.

**Keywords:** COVID-19, intensive care unit, operation theatre

*By Medicine life may be prolonged, yet death will seize the doctor too.*<sup>[1]</sup>

## Introduction

A number of guidelines from various societies have been released in the past few months regarding the safe practice of medicine in the Operation Theatre (OT) and the Intensive Care Unit (ICU) in the era of the COVID-19 pandemic.<sup>[2-4]</sup> The danger is real: In Wuhan, where the infection first arose, more than 3000 healthcare workers were infected by 24 Feb 2020, within a few months of the start of the epidemic.<sup>[5]</sup> This poses not only a risk to healthcare workers<sup>[6,7]</sup> who have

a higher chance of contracting the illness than the general public, but also to the general public, who can come to the hospital for an unrelated illness and then contract coronavirus infection while in the hospital.<sup>[8]</sup> In order to reduce both these risks, an understanding of the means of transmission of the virus is essential to develop a rational strategy that allows patients to receive treatment without placing either the patient or healthcare workers at risk. It should be cautioned that this is a rapidly changing field. This can be seen from the list of references, many of which are arXiv preprints which have undergone moderation, but not the sort of formal peer review which would have taken place in a less emergent setting. It is therefore advisable to revise any recommendations in this article, as and when new evidence emerges.

Address for correspondence: Dr. Rangraj Setlur,  
Department of Anaesthesia and Critical Care, Armed Forces Medical  
College, Pune - 411 040, Maharashtra, India.  
E-mail: rangraj@gmail.com

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## Transmission of the COVID-19 Virus

### Aerosol transmission

Respiratory infections can be transmitted through droplets of different sizes: When the droplet particles are  $>5\text{--}10\ \mu\text{m}$  in diameter they are referred to as respiratory droplets, and when they are  $<5\ \mu\text{m}$  in diameter, they are referred to as droplet nuclei.<sup>[9]</sup> The predominant mode of transmission is by respiratory droplets, although there has been a report of airborne transmission of viral RNA. This however was in a closed area, and the relevance is uncertain.<sup>[10]</sup> The distinction is important, as respiratory droplets are present within one meter of a patient while coughing or sneezing. Airborne transmission on the other hand, can occur in specific aerosol generating procedures such as endotracheal intubation, bronchoscopy, open suctioning, administration of nebulized treatment, manual ventilation before intubation, turning the patient to the prone position, disconnecting the patient from the ventilator, non-invasive positive-pressure ventilation, tracheostomy, High Flow Nasal Oxygen (HFNO) and cardiopulmonary resuscitation (CPR). It is evident from this list that Anaesthesia and Intensive Care staff are at particular risk.

### Fomites

Respiratory droplets and secretions can settle on surfaces, which in turn can act as fomites from which infection can be transmitted. The stability of the virus on these surfaces is an important variable. A recent study<sup>[11]</sup> showed that the virus after aerosolisation could be recovered in a viable form as long as 72 hours later from plastic and stainless steel surfaces. On copper, the viability period reduced to 4 hours, and on cardboard, no viruses were recovered after 24 hours. As it is next to impossible to completely clean every surface in an OT or ICU, a high degree of care should be used for an extended period when handling surfaces and items in these areas where a patient has been treated.

The method of transmission should be considered in the context of two other variables – the effect of the infective dose, and the secondary attack rate. There is some evidence that an increased viral load is associated with an increased severity of disease.<sup>[12]</sup> This is especially concerning, as there is also evidence that asymptomatic patients can have viral loads as high as symptomatic patients<sup>[13]</sup> indicating that an asymptomatic carrier poses as high a risk for disease transmission as a symptomatic patient. As many as 10–23 days may elapse from symptom onset to RT-PCR positivity.<sup>[14]</sup> There are therefore a significant number of patients likely to present with false negative results on RT-PCR.<sup>[15]</sup> This false negative rate increases substantially with antibody based tests, which in any case have widely varying rates of sensitivity and

specificity.<sup>[16]</sup> The implication of these facts is that healthcare workers are at especially high risk of contracting the disease from asymptomatic patients with high viral loads, who may initially test negative. It is therefore imperative to maintain high levels of precautionary measures while dealing with all patients, not just patients who are symptomatic or who test positive.

### Broad principles for preventing spread of infection in the hospital

The following points are general in nature, to reflect the fact that prevention of spread of infection is part of a hospital wide strategy, and that this strategy starts well before the patient enters the ICU or OT.

#### *Use of a systems engineering approach*

It is essential when using risk mitigation strategies to view the whole process as an integrated system, with precautions taken at every level.<sup>[17]</sup> These include the following steps:

- Segregating patient and healthcare workers into two streams – suspected COVID-19 positive patients and healthcare workers dealing with them, and other patients with their healthcare workers
- Stratification of PPE according to the risk of the task, with full PPE reserved for aerosol generating environments such as endotracheal intubation
- Frontline testing of suspected patients at the hospital entry point, with a syndromic approach as well as, if indicated, a nasopharyngeal swab, to enable them to be segregated into appropriate groups
- Limiting the size of teams dealing with positive patients, staggering times to minimise cross contamination between staff, and limiting work times of staff caring for positive patients<sup>[18]</sup>
- Ensuring the supply of PPE and masks to those healthcare workers who need them. It is critical for healthcare workers to have faith in the system, and this faith is rapidly destroyed if there is a perception that they are being sent to take care of potentially infected patients without adequate protection
- Minimisation of visitors to the hospital
- A protocolised handing over and taking over process, with observation by a trained person of donning and doffing procedures
- Minimisation of movement for imaging procedures.

### Prevention of spread of infection in the operation theatre and ICU

Several society and national guidelines were examined while writing this review. Most of the guidelines follow a common logic which implicitly follow the systems engineering approach outlined above. Indian readers are encouraged to

read the excellently written Indian Society of Anaesthesia Guidelines<sup>[2]</sup> which are extremely comprehensive. Certain broad principles which emerged were:

### Reducing transmission in the operation theatre

As far as possible, it is advisable to manage COVID-19 positive patients in a dedicated operation theatre complex, which is physically separated from the rest of the operation theatres. If possible, two operation theatres may be used for obstetric and non-obstetric cases.<sup>[2]</sup> The transfer route should be clearly demarcated and be as short as possible.<sup>[19]</sup> All personnel should have donned and checked personal protective equipment before the patient enters. The OT door should always be closed, and unnecessary personnel should be discouraged. If possible, the OTs should be negative pressure rooms.<sup>[20]</sup> If negative pressure rooms are not available, the recirculation system of the air handling unit should be disabled, and the exhaust fan should run at a higher exhaust rate than the air conditioning influx rate. If these measures are not possible, the air conditioning system should stand alone, and the exhaust through natural exfiltration. A separate donning and doffing area should be available, with bathing facilities. These operation theatres should be stripped down to essentials to minimise fomites, and all available areas should be covered with disposable plastic sheeting which is to be changed after each patient. Disposable equipment is to be used where possible. Viral filters should be placed both between the tracheal tube and the breathing circuit, and between the expiratory limb and the anaesthesia machine. Staff should be minimised during the procedure, especially during the period of intubation, and prior to intubation, the patient's mouth should be covered with a surgical mask.

### Practices to reduce transmission of infection in the operation theatre

A recent article reviewed the evidence based practices which could reduce transmission of infection in the operation theatre.<sup>[21]</sup> They range from common sense recommendations such as making sure that the alcohol sanitisers are as close to the patient as possible, to evidence-based practices for deep cleaning of the operation theatre with surface disinfectants and ultraviolet light (UV-C), to some which the authors of this article feel are more controversial such as extending shift times to 12 hours to economise on PPEs. It should be stated here, that recommendations such as these should not be applied blindly, but be considered in the context of the realities of the on ground situation where the anaesthetist is working. Ultraviolet light sterilisers vary widely in efficacy depending on the age and condition of the emitting tubes, and a greater emphasis on surface cleansing with disinfectants may be more efficacious in places where validated and regularly serviced ultraviolet sterilisers are not available.

### Safety in venting of waste anesthetic gases

The Anesthesia Patient Safety Foundation has considered the problem of safety of venting anaesthesia gases, and advised that as long as an airway mounted filter and an expiratory limb filter are mounted on the circuit, further processing of scavenged and vented gas is not required. Filters are rated by their Viral Filter Efficiency. A VFE of 99.99% means that only one 3 micron particle in 10,000 ( $10^4$ ) will pass through the filter under standard test conditions that control flow rate. Two filters mounted in series on the airway, as well as the expiratory limb will have a VFE of one particle passing in  $10^8$ .<sup>[22]</sup>

#### *Safety in the preop and postop areas*

It is advisable to omit preoperative waiting areas as far as possible, and wheel the patient directly from the ward into the operation theatre. If this is not possible, then some practical measures which may be useful would be to ensure that the patient wears a surgical mask at all times, and if oxygen is necessary then it should be provided by a disposable oxygen mask which is placed over the surgical mask, and is disposed safely after use along with its tubing. Documentation and interventions such as starting an IV are best reserved for the operation theatre, in order to minimise the number of staff who come in contact with the patient. By the same token, postoperative rooms are also best avoided, and the patient should be allowed to recover fully in the operation theatre itself, and moved from there directly to the ward or the OT. This practice is commonplace in Japan, even in normal times, and has been shown to shorten recovery times.<sup>[23]</sup>

#### *Personal protective equipment*

Effective and rational provisioning of personal protective equipment is of paramount importance in preventing the spread of COVID-19 in hospital settings. A number of government mandated specifications exist to ensure quality standards for personal protective equipment.<sup>[9,24]</sup> In the ICU and OTs there is a high incidence of aerosol generation, and so healthcare providers need to be protected by appropriate use of requisite PPE. PPE meant for healthcare providers comprises of face shields, goggles, mask, gloves, coverall/gowns, head covers and shoe covers. Each component has a rationale for its use, and the type of PPE worn is stratified according to the perceived risk, with personnel involved in aerosol generating procedures wearing the full set of PPE.<sup>[25]</sup>

Patients who are COVID-19 positive should ideally only undergo lifesaving surgery. Various surgical associations have released guidelines regarding precautions to be taken in view of possible risks of transmission of virus by the insufflation procedure of laparoscopy and the vapour plumes of electrocautery.<sup>[26]</sup> The correct use of the equipment is as important as the actual

equipment, and all staff should undergo training in donning and doffing of personal protective equipment.

#### *Face shields and goggles*

Use of face shields and goggles protect against the contamination of the mucous membrane of the mouth, eyes and the nose from the droplets of the infected person due to coughing and sneezing and also due to aerosol generated during patient care.<sup>[27]</sup> It should be remembered that a face shield is no substitute for a high performance filtering mask, and should be used with and not in place of a mask. Goggles should also allow for the accommodation of the prescription glasses. They should ideally be made of anti-fogging plastic.

#### *Masks*

It is crucial for healthcare provider to wear fluid resistant (Type – IIR) facemasks. The masks meant for healthcare provider are essentially of two types:

- Triple Layer Medical Mask
- High Performance Filtering Masks.

#### *Triple layer mask*

These should be fluid resistant, disposable, three layered medical mask of non-woven material with nose piece, having filter efficiency of 99% for 3 micron particle size. As triple layer masks do not fit closely around the mouth and nose, and do not go through the same quality control processes, they do not afford the same degree of protection as high performance filtering masks.

#### *High performance filtering masks*

These masks are graded based on the filtering efficacy against an aerosol load. The filtering occurs due to the presence of polypropylene microfilter and an electrostatic charge. These masks include N-95, FFP1/FFP2/FFP3 masks. N-95 masks refers to the fact that under test conditions the respirator can block 95% (the 95 category) of aerosol test particles and that they are not resistant to oil (The N category).<sup>[28]</sup> They are certified under 42CFR 84 of NIOSH and United states CDC. They should have good breathability and are usually of a duckbill/cup-shaped design, which prevents collapse against the mouth. FFP1/FFP2/FFP3 refers to the protection factor based on the degree to which the mask will reduce concentration of biohazardous material. This is 4-, 10- and 20-fold for FFP1/FFP2/FFP3 masks respectively. Both N-95 and FFP grade masks must be checked for proper fit test by confirming seal. WHO recommends that they can be used for 04 h continuously if not physically damaged without any effect on the efficacy.<sup>[25]</sup> Various suggestions have been made regarding the use of ultraviolet light, dry heat and hydrogen peroxide plasma vapour to reprocess these masks if there is a shortage.<sup>[28]</sup> This is obviously less than ideal, due to the

chances of decreased efficiency of filtration with reuse, and the change of masks poses a risk of contaminating ones hands.

High performance masks are generally considered to be more effective than medical masks. However a meta-analysis comprising of four RCTs found that compared with N-95 respirators, the use of medical masks did not increase the risk of contracting laboratory confirmed viral respiratory infection, although they did reduce clinical respiratory illness.<sup>[29]</sup>

#### *Gloves*

The choice between latex and nitrile gloves is controversial as different studies have yielded varying results with regards to permeability<sup>[30,31]</sup> and the decision may finally be governed by the quality of the product being manufactured rather than the material.

#### *Gowns/shoe cover/head covers*

These should be made up of fluid resistant material and adhere to ISO 16603 class 3 exposure standards.

#### *Safe intubation practices*

Several methods have been described to reduce the exposure of the intubator to aerosols. These include an aerosol box<sup>[32,33]</sup> with portholes cut in, to cover the patient's head during the process of intubation, and transparent plastic drapes during both intubation and extubation.<sup>[34,35]</sup> These devices may reduce the spread of aerosols, but they also increase the difficulty of airway manipulation in an already difficult situation, as all the people involved in airway manipulation are encumbered by wearing full personal protective equipment. It is therefore essential that the airway is managed by the most experienced person available. The use of videolaryngoscopy may increase the distance between the face of the intubator and the patient, thereby reducing the chances of spread.<sup>[36]</sup> However, sufficient experience should be gained before using a videolaryngoscope in an emergency.

## **Reducing Transmission in the ICU**

The general principles of reducing exposure in the operation theatre (minimising staff, wearing PPE, minimising exposure during aerosol generating procedures, etc.) hold true in the ICU as well. There are, however, a few specific features which deserve mention.

### **Creation of surge capacity ICUs**

Nations around the world have had to prepare for the cresting of the epidemic wave that has overwhelmed medical resources even in countries which have reasonably robust medical systems like Italy and Spain. These ad hoc ICUs necessarily function with limited resources. However, healthcare worker

safety should not be compromised. An inventory for safe creation of ICU resources has been created for India, which includes the minimal safety features required.<sup>[37]</sup>

### Establishment of reasonable shift hours

Working in PPEs is extremely fatiguing, and during the period of wearing the PPE, the healthcare worker cannot eat, drink or use the bathroom. A survey showed that an uninterrupted 6-hour shift with a 1-hour overlap was perhaps the most reasonable system,<sup>[38]</sup> as it allowed for a shift which was humanly feasible without the wastage of PPE which would occur by breaking the shift into two halves.

### Use of NIV and high flow nasal oxygen

Initial recommendations generally suggested avoiding techniques such as NIV and HFNO,<sup>[34]</sup> due to the perception that they would likely lead to greater aerosol generation, and consequently greater risk to healthcare workers. However, recent studies reporting an extremely high mortality with mechanical ventilation<sup>[39]</sup> have led to a reassessment of these recommendations, and a suggestion that high flow nasal oxygen may reduce the need for ventilation, and possibly thereby reduce the mortality of patients. Various simulations have suggested that the risk of aerosolisation is less than originally feared,<sup>[40]</sup> but the quality of evidence is low, and there are multiple questions regarding whether these simulations can be generalised to a clinical situation. Certain common sense precautions include lowering HFNC flows while increasing FiO<sub>2</sub>, placing a mask over the HFNC cannula, not handling the nasal prongs, but instead removing the cannulas from the back, and disposing the nasal cannula in a safe manner in the yellow waste bag.<sup>[36]</sup>

### Other aerosol generating procedures

Perhaps the most important means of reducing exposure is to avoid performing procedures like intubation and bronchoscopy when the staff is fatigued, and concentration levels are lowered. The same logic of intubation and extubation is followed in the ICU, with the caveat that ICU intubations tend to be more challenging due to decreased physiological reserves and suboptimal positioning. Repeated attempts at intubation and intervening to stabilise patients who decompensate because of ill considered drugs during intubation all serve to increase the exposure and risk to staff. Tactics which may help include oxygenating the patient by continuing HFNC till the last moment, using cardiostable drugs like Etomidate, using bougies in all cases, and confirming proper placement of tube by observing fogging of the tube and capnometry rather than auscultation, which is another source of contamination of the anaesthetist's face by a fomite.<sup>[36]</sup>

### Performing tracheostomies

There has been a trend over the past few months to postpone

tracheostomies due to the high aerosol generating potential of the procedure. Ensuring complete neuromuscular blockade, use of glycopyrrolate in high doses, and liberal infiltration with lignocaine and epinephrine to reduce blood spatter, may all decrease the risk of the procedure. There is no evidence regarding the relative risks of percutaneous versus open tracheostomies as far as risk to healthcare worker is concerned. If a percutaneous tracheostomy is performed, it is advisable to turn off ventilation when withdrawing the endotracheal tube, covering the stoma with gauze between the dilatation and insertion of the tube, and performing as many steps as possible (such as dilatation) under a transparent plastic drape.<sup>[37]</sup>

### Suctioning and extubation

Both extubation and suctioning are aerosol generation procedures. Suctioning in particular should be performed using a closed suction system, whether in the OT or the ICU. A logical method of extubation includes limiting the number of staff in the room during extubation, wearing full PPE including face shields, using antitussive drugs prior to extubation such as lignocaine, and using a mask over tube technique, in which a mask with a second airway filter is placed over the tube, all positive pressure is stopped, and the tube is deflated and removed with its own airway filter while the mask with its own airway filter is applied on the face by a second anaesthetist, so that the patients airway is covered by a filter at all times and the staff is not exposed to aerosols.<sup>[41]</sup>

### Code blue and cardiopulmonary resuscitation

Code Blue situations pose a high risk for exposure to staff, and recent guidelines acknowledge this reality. The American Heart Association has revised its guidelines, and encourage minimising participation in CPR efforts, avoiding aerosol generating procedures (for instance, bag mask ventilation, and chest compressions without an airway protected by an endotracheal tube with a viral filter), and most importantly assessing the likely benefit of starting CPR, and whether limitation of efforts are indicated in patients with a low likelihood of survival.<sup>[42]</sup>

### Handling dead bodies

Because of the high mortality rates of patients admitted to the ICU, adequate precautions should be in place to handle dead bodies.<sup>[43]</sup> These include removal of all tubes, drains and catheters on the dead body, disinfection of any consequent puncture holes or wounds with 1% hypochlorite followed by dressing with impermeable material, and plugging of oral and nasal orifices of the dead body to prevent leakage of body fluids. If the family of the patient wishes to view the body at the time of removal from the ICU, they may be allowed to do so with the application of Standard Precautions. The dead body is to be placed in a leak-proof plastic body bag before moving the patient from the ICU to the mortuary.

## Conclusion

We live in strange new times. The COVID-19 pandemic promises to change the way we live, the way we socialise, our economy, and how we practice medicine. It is only natural that we will have to change the way we practice both anaesthesia as well as intensive care medicine to ensure safety both to our patients as well as to our staff and ourselves. This article started with a quotation from Shakespeare. It is only just that we end the article with another, more hopeful line by the same poet; “*Out of this nettle, danger, we pluck this flower, safety.*”<sup>[44]</sup>

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## Conflicts of interest

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