



# Anesthesiologist behavior and anesthesia machine use in the operating room during the COVID-19 pandemic: awareness and changes to cope with the risk of infection transmission

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## Abstract

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) disease [coronavirus disease 2019 (COVID-19) infection] first appeared in December 2019 in China and is now spreading worldwide. Because SARS-CoV-2 can be transmitted via aerosols and surface contaminations of the environment, appropriate use of anesthesia machines and appropriate behavior in the operation room (OR) are required specifically in relation to this disease. The use of high-performance hydrophobic filters with a high rate of virus rejection is recommended as the type of viral filter, and surgical team behaviors that result in aerosol splashes should be avoided. Appropriate hand hygiene by the anesthesiologist is crucial to prevent unexpected environmental contamination. When the anesthesia machine is used instead of an intensive care unit ventilator, it is important to keep the fresh gas flow at least equal to the minute ventilation to prevent excessive humidity in the circuit and to monitor condensation in the circuit and inspiratory carbon dioxide pressure. In addition, both the surgical smoke inherent in thermal tissue destruction and the surgical team's shoe soles may be factors for the presence of SARS-CoV-2 in the operating room. Ensuring social distancing—even with a mask in the OR—may be beneficial because healthcare providers may be asymptomatic carriers. After the acute crisis period of COVID-19, the number of cases of essential but nonurgent surgeries for waiting patients is likely to increase; therefore, optimization of OR scheduling will be an important topic. Anesthesiologists will benefit from new standard practices focusing on the prevention of COVID-19 infection.

**Keywords** Severe acute respiratory syndrome coronavirus 2 · COVID-19 · Anesthesia machines · Operating room

## Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) disease [coronavirus disease 2019 (COVID-19) infection] first appeared in December 2019 in China [1] and is now spreading worldwide. As of June 4, 2020, approximately 6.2 million people have been infected and 370,000 deaths have been confirmed [World Health Organization. Coronavirus disease (COVID-19) outbreak situation. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019> (accessed date: 4 June 2020)] Although there

are encouraging signs, which is halting the increase in the number of new patients in some regions, preparation is still required for the so-called second wave [2] of COVID-19 infection that is expected in near future.

Because SARS-CoV-2 can be transmitted from patients by aerosols [3, 4], anesthesiologists are at high risk for infection. In this context, the literature on the anesthetic management of confirmed/suspected COVID-19 patients mainly focuses on airway management, choice of anesthetic techniques according to planned surgical procedure, patient transport and operation room (OR) managing plan, and the use of personal protective equipment [5–9]. There is also an accumulation of actual cases of infected patients, especially those of pregnant women, which have been frequently reported [10, 11].

Based on this knowledge, high-risk procedures, especially aerosol-generating surgeries, have been postponed.

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In essential surgeries, certain screening measures including reverse-transcription polymerase chain reaction tests or chest computed tomography are performed to exclude infectious patients. However, there is a theoretical possibility that patients could become newly infected after these preoperative screenings, resulting in their entry into the OR while in the asymptomatic state with an infection risk for the surgical team. Thus, anesthesiologists must work now to embed improved clinical behaviors for shared experiences during the pandemic. The volume of findings and recommendation is becoming so large that a short review is necessary to understand the background knowledge, especially for anesthesiologists with few experiences during the first waves of COVID-19 pandemic. Therefore, this article provides a short narrative review of the potential for SARS-CoV-2 transmission associated with the anesthesia machine and the OR if they are used inappropriately.

## Anesthesia machine

### Prevention of anesthesia machine-associated SARS-CoV-2 transmission

Several guidelines and recommendations have proposed the appropriate use of anesthesia machines to prevent patient-to-patient and patient-to-healthcare worker infections caused by viruses in the anesthesia circuit. For patients with confirmed or suspected COVID-19 infection, recommendations are use of (1) a high-performance hydrophobic filter (artificial nose) with a high rate of virus rejection (viral filtration efficiency > 99.99% [12]), and (2) use of a viral filter at the expiratory gas inlet of the anesthesia machine from the expiratory circuit to protect the machine from viruses passing through the artificial nose [12, 13]. The sampling port of expiratory gas should be connected so that it reaches the analyzer after passing through the artificial nose [13]. Regarding the selection of artificial noses, mechanical filters, which stop particles because of their small pores, perform better than electrostatic filters, which capture charged particles, and are less affected by water vapor [12].

If the anesthesia machine is protected by a filter, it can be used for subsequent patients [12], although it must be cleaned once the internal components become contaminated. The carbon dioxide absorber should be replaced between surgical cases [14], as well as all single-use devices. Adhering to these guidelines/recommendations will be easy if surgical supplies are sufficient. In addition, it is desirable to prevent surgical team behaviors that result in aerosol splashes, such as unwanted disconnection of the respiratory circuit just described.

During a short period of time in the OR, the anesthesiologist needs to touch several pieces of anesthesia-related

equipment with high frequency, including anesthesia machines, monitoring equipment, and computer mice and keyboards, as well as the patient. Therefore, bacterial and viral contamination of the anesthesia workplace routinely occurs, largely because of activities of anesthesia providers [4]. SARS-CoV-2 can survive for at least 3 days on a variety of materials commonly encountered in ORs, such as stainless steel and plastic [4, 15], which can result in transmission by environmental contamination. Even if the surface of the anesthesia machine is disinfected on a case-by-case basis, it is better that environmental contamination should be kept to a minimum as much as possible. For environmental surface disinfection, the effect of sodium hypochlorite or alcohol with 70–90% concentration has been recognized. In addition, just recently, Japan's Ministry of Economy, Trade and Industry announced that disinfection substances, including some surfactants and hypochlorous acid solutions, are effective at removing SARS-CoV-2 from surfaces [16]. Hand hygiene (HH) with 70% alcohol is effective for SARS-CoV-2. Although one study [17] showed the potential utility of sodium hypochlorite for HH using the avian influenza virus to mock SARS-CoV-2, it is not widely recommended at this stage.

HH should be done at the appropriate time. The World Health Organization recommends performing HH—according to their de facto standard instructions known as “5 moments”—in particular: (1–2) before putting on personal protective equipment and after removing it, (3) when changing gloves, (4) after any contact with patients, their waste, or the environment in the patients' immediate surroundings, (5) after contact with any respiratory secretions [18]. In addition, changing gloves with HH between doffing and donning the gloves is preferred [19]. Unfortunately, the HH of anesthesiologists has been noted to be inadequate [20], presumably because if they try to perform HH based on the WHO criteria of “5 moments” during anesthesia management, their procedures must be frequently interrupted. This lack of HH may be problematic when asymptomatic patients are treated as “noninfectious” patients as described earlier because for these patients anesthesiologists may perform HH less frequently than for patients with suspected or confirmed infections. Although to date no reports have been published of COVID-19 infection transmitted via anesthesia machines, future reports on the effects of using the existing preventive measures should be noted.

### Use of anesthesia machines versus ICU ventilators

The need for the use of anesthesia machines instead of ICU ventilators [21] is likely to decrease in the future because of the increased production of ICU ventilators in early 2020 that was triggered by the COVID-19 pandemic. However, use of anesthesia machines can be a temporary option. When

using anesthesia machines, there are important key points to recognize the differences in the basic gas flow volume and composition of respiratory circuit among machines: (1) to keep the fresh gas flow at least equal to the minute ventilation because low fresh gas flow leads to excessive humidity in the circuit, clogging of filters, and the need to change CO<sub>2</sub> absorbent frequently; (2) to monitor condensation in the circuit; and (3) to monitor the inspiratory carbon dioxide (CO<sub>2</sub>) pressure and replace the CO<sub>2</sub> absorbent appropriately [21]. In many anesthesia machines, passing the daily operation test before the use is required. A “domino switch” technique [22] is introduced, in which an anesthesia machine is replaced with a new machine every day for use as a ventilator. As an example of the effective use of the special functions of individual anesthesia machines, Connor et al. also reported an experience of remotely controlling GE Aisys from a separate room to reduce the risk of infection for medical staff [23]. Although a technique to share an ICU ventilator between two patients was reported [24], no such cases for the anesthesia machine have been reported.

## Management of the operating room

### Avoidance of contamination

When the patients enter or leave the OR, efforts should be made to reduce the chance of transmission of viruses to the surroundings, such as (1) using the OR with the shortest line of movement from the entrance of the surgical department; (2) using a high-quality artificial nose or filter for entry and exit of already intubated patients [12]; (3) applying a surgical mask or N95 mask to the non-intubated patients; and (4) bypassing the postanesthesia care unit [4]. Many papers have mentioned general aerosol-generating procedures and the need for air conditioning in the operating room [25, 26]; therefore, these topics will not be discussed in this paper.

The possibility of viral infection to medical staff by the surgical smoke that is generated from the surgical field during the use of energy devices, for patients with human papillomavirus and other infections, has been a matter of debate, although clinical evidence of actual transmission is lacking [27]. By extrapolating previous discussions regarding other viruses to the cases with SARS-CoV-2, several recommendations have been proposed as precautionary measures to reduce the exposure of medical staff to surgical smoke [28, 29]. Although there is currently no evidence yet to support that SARS-CoV-2 is transmissible through surgical smoke, anesthesiologists should recognize that an awareness of its theoretical risk is warranted.

In terms of the necessity of changing shoes or of the use of shoe covers for the prevention of virus transmission, no description was found in several OR recommendations [13].

Wax et al. [30] reported that some disposable shoe covers may increase the risk of self-contamination during removal. In contrast, the Joint Task Force of the Chinese Society for Anesthesiology and the Chinese Association of Anesthesiologists recommends the use of shoe covers [14]. A recent article showed that half of the soles of medical staff working in ICUs housing COVID-19 patients have been reported to have tested positive for the virus, [3] which may happen even in the OR. At this stage, the use of shoe covers with the caution regarding self-contamination would be reasonable.

For suspected or confirmed COVID-19 patients, many guidelines/recommendations call for the use of a negative pressure room [14, 30]; however, for facilities that do not have such a room [31], the best practice should be discussed with the institutional infection control department. For example, if the airflow is designed to flow from the supply hall through the OR into the corridor, a portable HEPA filter [30] could be placed near the exit to the corridor. The effects of such measures even in COVID-19 patients should be studied in the future.

### Social distancing in the OR

Social distancing is defined as keeping a physical space between people to avoid spreading illness. The Centers for Disease Control and Prevention [32] recommends staying at 6 feet from other people to reduce the spread of COVID-19. Assuming that SARS-CoV-2 is also present in aerosols smaller than the size of pores on masks, as is the case for influenza virus, the possibility of transmission even between people with masks theoretically exists [33]. Health care providers may be asymptomatic carriers, so ensuring social distancing may be beneficial even when wearing a mask. Prin et al. [34] proposed several strategies in their review article, which included limiting speaking, volume of voices, and the proximity of staff to one another. However, in the OR, social distancing can be challenging because communication is extremely important for successful operative outcomes. Therefore, the review study authors also stated that proactive, intuitive communication—that is characterized by broad shared goals and mutual respect—is desired as ideal team management, such as using a text message thread for sharing essential information or a positive hand gesture versus speaking.

### Scheduling of the OR

Many guidelines/recommendations address the OR scheduling for suspected or confirmed COVID-19 patients, for example, planning their surgeries at the end of the day in each OR, and ensuring that appropriate cleaning and ventilation in the OR are performed afterward. Meanwhile, during the first several months of the COVID-19 pandemic, a

considerable number of elective procedures have been postponed, especially for those patients with the risk of viral spread. Therefore, these essential but nonurgent surgeries must be performed after the acute crisis period. Optimization of OR scheduling is a particularly important topic in this context. Dexter et al. [4] proposed adapting the typical long workdays ( $\geq 10$  h) for surgical suites as a way to reduce the number of late hours that the surgical staff works while also increasing operating room occupancy.

## Conclusion

It is expected that more experiences and study results on infection transmission associated with the use of anesthesia machines and ORs will be published in the future. Meanwhile, in this current environment of pandemic, anesthesiologists must become aware of and accept new standard practices focusing on the prevention of COVID-19 infection.

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