

# ICU and Aerosol-Generating Procedures in COVID Patients

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**Abstract:** Some of the COVID-19 patients required an intensive care unit admission, additionally an aerosol delivery is an important treatment method in this type of patient. The present mini-review describes the best aerosol delivery method in this type of patients. Additionally, the different delivery methods of aerosol, and the best placement of the aerosol which allows the best delivery was discussed in this paper.

**Keywords:** COVID-19; ICU; Mutation; Aerosol

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## 1. Introduction

The last attack of coronavirus was in the year 2003, and the disease caused by the coronavirus was severe acute respiratory distress (SARS), which provide researchers and healthcare with an important note about aerosol generation, and their role in disease spread <sup>[1]</sup>. In addition, studies that are conducted to compare the rate of infection among the healthcare providers, showed a higher rate of infection among those who performed an endotracheal intubation, noninvasive ventilation (NIV), and other aerosol-generating procedures <sup>[1]</sup>.

The COVID-19 pandemic transmission primarily occurs through the spread of droplet or fomites that have been contaminated by infected subjects through touching or emitted droplets. The new coronavirus could be survived in the droplets in the air or deposited on fomites for hours or days <sup>[2,3]</sup>. In additional, the aerosol-generating procedures like endotracheal intubation, manual ventilation before intubation, high-flow nasal cannula (HFNC), NIV, nebulization, tracheal suction, open suctioning of the respiratory tract, and tracheal intubation may contribute to the spreading of the virus to the surrounding area, and infecting the healthcare workers <sup>[1,4]</sup>. Aerosol is composed of fine droplets that could be suspended in the air, and could travel for a distance away from the patient after exhaled from the patient's lungs. Based on these findings, it is recommended for healthcare workers to have protective measures by wearing protective covers like fit-tested N95 masks that protect against inhalation of exhaled contaminated aerosol or touching by contaminated hands, mouth, or nose when dealing with COVID-19 suspected or confirmed cases. Additionally, other preventive measures, such as gloves, eye protectors, and gowns should also be used by healthcare workers when faced with COVID-19 suspected or confirmed cases <sup>[4,5]</sup>.

Aerosol therapy using nebulizers during mechanical ventilation could be the source for spreading COVID-19 infection <sup>[6]</sup>, hence it is recommended to use a pressurized metered-dose inhaler (pMDI) and spacers, rather than using nebulizers if possible, and if it is necessary to use nebulizers, extra protective measures should be taken <sup>[7,8]</sup>. The ability of the nebulizer to spread the infection to the healthcare team or

other close contact of the patient is based on the aerosol particles that are produced by the nebulizers, which have a particle size ranging from 1 to 5  $\mu\text{m}$ , and these fine particles is sufficient to carry the microorganism from the infected patient's lungs through the exhalation [9].

## 2. Safety of intensive care providers; personal protective equipment

All healthcare providers, who are in close contact with COVID-19 patients are at high risk of contracting the infection [10,11]. Therefore, all the healthcare workers in the intensive care unit (ICU) should follow the preventive measures, such as using a medical protective N95 mask, gown, disposable surgical cap, gloves, and full-face respirator protective device when dealing with COVID-19 patients [4]. In the case of insufficient of N95 masks, the FFP2/FFP3 masks are the second choice, and the recommended type [12]. In additional, 2 randomized clinical trials comparing the protective effect of N95 mask with other medical mask against the spreading of infection to the healthcare workers were conducted, and the results indicated that there is a no significant difference in the effects of using different types of in preventing the spreading of the infection, however the usage of surgical mask is not recommended when dealing with the patients [13,14]. Other precautions that should be taken by the healthcare workers are; Avoiding from touching the face mask after contact with the patient; Making sure that there is no gap between the mask and skin; and Replacing the mask with new one if accidentally touching [15]. Additionally, the mask should be removed from behind and avoid touching the mask from the front, followed by washing hands after removing the mask with soap or sanitizer. Other preventive strategies that should also be followed like routine are the hand hygiene through washing with the running water and soap [16], using sanitizers that contain alcohol which could be beneficial, however it is not superior to washing hands with running water [17], and healthcare providers should wear double gloves when handling patient blood, urine, or airways [15].

There are different types of gowns available, such as surgical, non-surgical, and overall gowns. For healthcare providers who deals with COVID-19 cases, it is recommended to use the overall gown for the maximum benefits and protection [15].

During the surgical procedures for COVID-19 patients, special precautions should be considered to prevent the spreading of the infection to the responsible medical staff as shown in **Table 1**.

**Table 1.** Preventive strategies for healthcare providers before, during, and after surgical procedures of COVID-19 patients [12,18]

Time	Action
Before surgery	All contributing staff should wear personal protective equipment, also they should be trained on how to wear and remove the equipment properly without contamination.  <b>Personal protective equipment:</b> Waterproof apron, Mask (N95 or FFp2/FFP3), Full face transparent protective, Latex gloves (double gloves with a disinfectant in-between could also be used), Shoes with no holes or overshoes could be used, Standard steel surgical apron.
During surgery	All invasive operations should be carried out in an isolated area. During laparoscopic procedures, it is recommended to use CO <sub>2</sub> filters for trapping the contaminated emitted aerosol [19]. Preoperative enterotomy is the recommended method in lower digestive system surgery [20].

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Time	Action
After surgery	<p data-bbox="392 277 895 304"><b>(1) Disinfection of floor, surfaces, and walls</b></p> <p data-bbox="440 320 1469 506">Visible contamination should be removed firstly before starting the disinfection of the floor or surfaces. Disinfection should be conducted by using 1 g/L chlorine for at least 30 minutes, three times per day. Surfaces of objects should be rinsed with water after 30 minutes. For object surface disinfection, wiping should be initiated from the area of the surface which is less frequently touched, then move to an area with more frequently touches.</p> <p data-bbox="392 521 619 548"><b>(2) Air disinfection</b></p> <p data-bbox="440 564 1469 667">It is recommended to use a plasma air sterilizer for the disinfection of air inside the room and it is recommended to run continuously. The ultraviolet lamp could be used for 1 hr, three times daily in case a plasma sterilizer is not available.</p> <p data-bbox="392 683 1150 710"><b>(3) Disinfection in case of biological fluids spilled from the patient.</b></p> <p data-bbox="440 725 1469 1016">If the volume of blood or fluid is less than 10 ml, the spills should be covered with wipes containing chlorine (5 g/L) and cleaned, than the area of the spills should be disinfected with chlorine (0.5g/L). If the spilled volume is more than 10 ml, used a clean and absorbent towel containing peroxyacetic acid for 30 minutes, then clean the contaminated area. Disinfecting powder that contains absorbent material could also be used. After cleaning the area, a disinfecting solution containing 10 g/L chlorine should be poured into the water- absorbing material. For disinfection of vomiting, fecal matters, and other secretions should be placed in a container and disinfected with chlorine 20 g/L for 2 hrs.</p>

### 3. Patient transfer

The COVID-19 case condition could be mild or severe, however, this does not mean that the case with mild condition will not deteriorate, and some COVID-19 cases with mild condition may need to transfer to the ICU, therefore, advanced facilities should be available for the patient transfer process. Hence, patients can be transferred to intra- or inter-hospital, and specific precautions should also be considered during the transfer to avoid the spreading of the infection <sup>[21]</sup>.

The patient transport recommendations according to Liew et al., <sup>[21]</sup> are based on five principles: (1) Safety of the patient; (2) Healthcare provider and transporters safety; (3) Bystander safety; (4) Contain rescue plans; and (5) Decontamination process after patient transfer.

To optimize the patient safety, the transfer of deteriorated cases should be done as fast as possible, in terms of patient transfer both intra- and inter-hospital. Before patient were transferred, a well-trained medical team consisting of physician and nurse should be available to provide emergency interventions if anything happens during the transfers, and they should have a defibrillator with them. If the patient initially is not intubated, the intubation process should be performed before the transfer process is initiated, and also monitoring of patient parameters like oxygen saturation, pulse rate, and blood pressure, is essential during the transfer.

Based on the second principle, to avoids the spreading of the infection during the transfer, the healthcare providers or other members involved in the transportation process should take preventative measurements. Where, they should wear all the personal protective equipment including N95 mask, and the patient should wear a surgical mask, and if possible, the patient should be transferred using a negative pressure vehicle <sup>[22]</sup>. In additional, aerosol delivery procedures should be avoided during the patient transfer process, and a high-efficiency particulate air filters should be added to the expiratory limb of the ventilator circuit, and to the endotracheal tube in case of using the Ambu bag. Regarding the transfer of the patient to another hospital, additional precautions should be taken, like winding down the ambulance window, and all

the transporting teams should wear powered air purifier respirators (PAPRs), at the same time bring additional batteries with them for Personal Protective Equipment (PAPRs).

Regarding the third principle, the safety of bystanders, it is important to make sure there are no bystanders during the entrance and exit of the ambulance, where a security team could help to ensure this, however the security team should also wear a surgical mask when on duty.

Emergency medications and equipment should be available in the ambulance or during the transfer process for dealing with emergency conditions, like hypotension and cardiovascular collapse. To reduce the emitting of aerosol, gentle bags with valves could be used, in contrast endotracheal intubation is not recommended to be performed outside the ICU by a trained physician and nurse.

After completing the patient transfer, the route and equipment used during the transfer process should be cleaned, and personal protective equipment should be removed. In addition, to the disinfection of the transfer route and team, the ambulance also should be cleaned and disinfected [23].

### Disclosure statement

The authors declare no conflict of interest.

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