

PERSONAL PROTECTIVE EQUIPMENT (PPE) DURING THE COVID-19 PANDEMIC-AUBMC EXPERIENCE

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Abstract

Worldwide healthcare systems have been under very stressful conditions since the novel coronavirus 2019 (COVID-19) outbreak. Rapid response services to this pandemic by healthcare providers (HCP) have been very challenging. The high infectivity rate of COVID-19 urged the presence of high level protection to control the transmission of the virus. The American University of Beirut Medical Center (AUBMC) has been at the front line of defense in overcoming and mitigating the severity of this pandemic both at the physical and mental levels. In this review, we present the different strategies and principles developed for the proper use of personal protective equipment (PPE) by HCPs globally in responding to the COVID-19 crisis. We summarize the worldwide recommendations and we highlight the protocols and policies adopted by the department of anesthesiology at AUBMC.

keywords: Coronavirus, Pandemics, Personal Protective Equipment, Healthcare Providers.

In December 2019, a new strain of corona virus was detected in Wuhan, China. The virus with its high infectivity rate, invaded the world within weeks, prompting the WHO to declare a Global Health Emergency on January 31st 2020. Data about the transmission of COVID-19, infectivity and effect on the human body is still obscure, presenting intensified physical and mental pressure on healthcare systems and healthcare providers (HCP). Protection against contracting the infection is a key element in decreasing the burden of the disease on HCPs and is also a stress alleviating strategy. The guiding principles for the adequate use of personal protective equipment (PPE) are based on the various theories regarding covid-19 transmission modes. Preliminary guidelines became immediately available and remain largely dynamic as the situation evolves. Vaccination for possible prevention against COVID-19 is under way, until then, extreme safety measures through regular PPE application and social distancing are being embedded into our practices, as well as in our standard lifestyle routines.

Healthcare providers are the front liners in response to health crises. They are at increased risk of infection because of their close and prolonged contact with infected and severely ill patients. The corona virus continues to burden the health care workforce. By the end of June 2020, the Centers of Disease Control and Prevention (CDC) in the US reported a total of 83365 cases among HCP and 463 deaths.¹ As a consequence, HCPs, physicians and nurses, are under great mental and physical stress. In addition to the impact of the pandemic on physical health, multiple studies have expressed

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the negative impact on the mental health of HCPs caring for COVID-19 positive patients. Symptoms such as anxiety, stress, insomnia and depression were reported and are the result of having to cope with the new work environments and the responsibility carried upon them to prevent further spread.² Moreover, feeling overwhelmed by the new standards of personal protection, witnessing patient suffering and constantly fearing infection or infecting others are challenges that should be appreciated and addressed in these dire times.²

COVID-19 has alarmed medical and public health professionals around the world, due to its high infectivity rate through the virus' transmission via respiratory droplets and contact routes. Being a primary respiratory infection, COVID-19 is transmitted through respiratory secretions generated while speaking, coughing, sneezing or in the presence of aerosol generating medical procedures (AGMPs), where infectivity relies on the amount of viral droplets in the secretions, and the total volumes of the secretions.³ Transmission of COVID-19 occurs either by direct contact or by droplet transmission within 1m proximity with someone who has respiratory symptoms (e.g. coughing or sneezing). Indirect contact with surfaces in the immediate environment or with objects used on the infected person (e.g. stethoscope or thermometer), where the virus can remain for days is also a known mode of transmission.⁴ Recent experimental work by Van Doremalen et al. demonstrated that aerosolized SARS-CoV-2 remains viable in the air with a half-life of 1 hour; they concluded that both aerosol and fomite transmission of SARS-CoV-2 is plausible, since the virus can remain viable and infectious in aerosols for hours and on surfaces up to days.⁵

Regardless of the vague set of data concerning COVID-19 transmission, strategies of infection control, particularly COVID-19, are adapted from the previous guidelines devised to combat the Middle East respiratory syndrome coronavirus (MERS) and the severe acute respiratory syndrome (SARS). Based on previous experiences, guidance strategies for suspected or confirmed COVID-19 cases were continuously updated as the pandemic progressed and published by the WHO, CDC and others. For instance, as per the WHO recommendations, the resulting droplets produced can differ in size depending on the

procedure. Droplet and contact isolation is requested when in contact with an infected individual presenting with coughing or sneezing, and airborne precautions are highly recommended in case of AGMPs such as ventilation and endotracheal intubation, extubation, bronchoscopy, suctioning, nebulizer treatments and others requiring close proximity to the patient.⁴ Therefore, HCPs are required to wear an N95 mask only when exposed to AGMPs, as droplet nuclei of $<5\mu\text{m}$ in size are produced, lasting in the air for lengthy periods of time and infecting people even at distances of more than 1 m.⁴

Endotracheal intubation remains one of the most performed AGMP, which identifies anesthesiologists, emergency medicine physicians and intensivists as a high-risk group.³ Moreover, because of the high incidence of asymptomatic patients who test positive for COVID-19, the American Society of Anesthesiology mandated the use of airborne precautions in the operating rooms and in the endoscopy/bronchoscopy suites during AGMPs on all patients. Anesthesia departments across the world had to educate their HCPs on the latest guidelines for the use of PPEs during the pandemic, as well as the appropriate donning and doffing. Lockert et al recommended 3 tiers of precautions when it comes to protection against COVID-19, including.³

1- *Droplet and contact precautions in routine patient care and absence of AGMPs*

Involving surgical mask, eye protection, gown and gloves overlapping the sleeves.

2- *Airborne, droplet, and contact precautions in low risk AGMPs*

Including head cover, eye protection, N95 respirator, gown, a single pair of gloves overlapping the sleeve.

3- *Airborne, droplet, and contact precautions for high-risk AGMPs*

Including head cover, eye protection, neck cover, N95 respirator, gown, double gloves overlapping the sleeve.

The reason behind the additional recommendation of double gloves and neck cover is that the wrist and the neck have been expressed as high zones of contamination, while using double gloves has been

proven to provide less contamination than single gloves, especially when doffing the soiled pair of gloves while keeping the PPE integrity intact. Moreover, donning coveralls may either simplify the doffing process as it includes head cover, neck cover and gown or complicate it depending on how well HCPs are trained.

The risk of SARS-CoV transmission to HCPs is known to be associated with high risk AGMPs that includes by decreasing order of odds ratios, tracheal intubation, manipulation of BiPAP mask, manipulation of oxygen mask, tracheotomy, bag-mask manual ventilation before tracheal intubation.³ Placement of supraglottic airway (SGA), as well as tracheal extubation and SGA removal are also assumed to carry a high risk of transmission.³ In addition to the risk of transmission related to the various procedures, the severity of the illness seems to be dependent on the droplet size transmitted during exposure and the repetition of the exposures.⁶

As an immediate consequence of the first wave of the pandemic and similar to many other institutions worldwide, elective cases were almost completely stopped at the American University of Beirut Medical center (AUBMC). Only emergency and time-sensitive cases were allowed to be performed. Based on various recommendations, the department of Anesthesiology at AUBMC has implemented airborne, droplet and contact precautions during any routine AGMP, such as intubation, ventilation and extubation. Later during the pandemic, PCR testing was required for all cases scheduled for surgery. Despite the worldwide shortage, the institution's leadership made PPEs and PCR testing available. This strategy led to a more lenient approach to surgical cases where more elective cases were performed during the later stages of the pandemic. This strategy achieved a three-fold set of benefits. It protected HCPs and alleviated their anxiety, it allowed a timely response of the medical teams to surgical conditions while avoiding long waiting times and postponement of surgeries, and it mitigated the profound economic impact and loss of revenue that impacted health facilities across the globe.

Taking into account a 30% incidence of false negative PCR tests in asymptomatic patients, airborne, droplet and contact isolation precautions is our

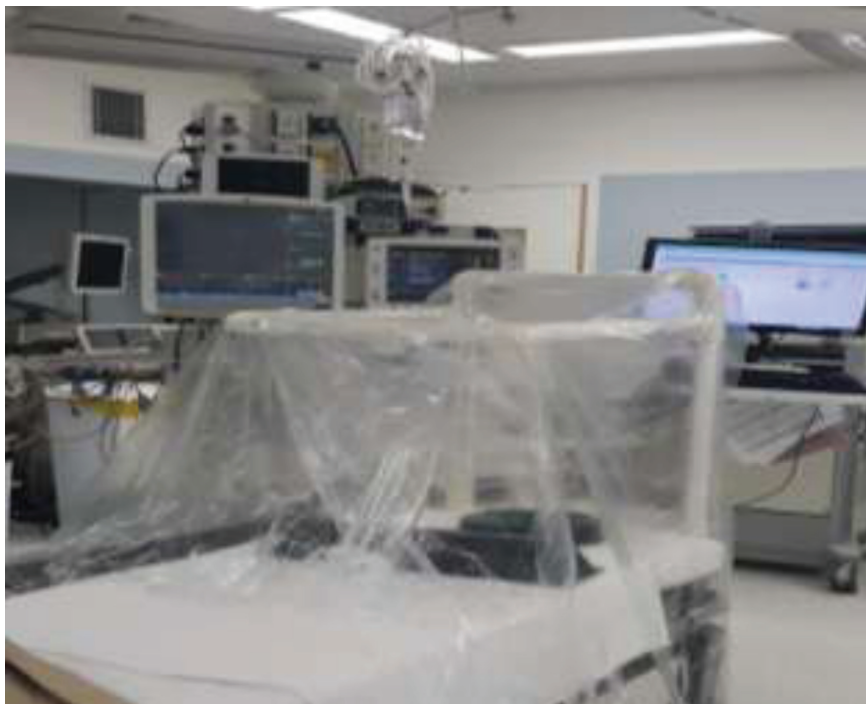
universal strategy in the presence of an AGMPs, such as tracheal intubation and extubation. Patients arrive to the operating room wearing a face mask. All non-anesthesia staff are asked to leave the room during induction and emergence from general anesthesia. Providers would don their PPE in induction rooms which are equipped with mirrors to observe and correct the process of donning and doffing. The set of PPE includes a head cover an N95 mask, goggles or face shield, a nylon gown and double gloves. Due to the universal shortage in N95 masks, it is covered by a surgical facemask. The latter is changed between cases, while the N95 mask is ideally used for as long as 4 consecutive hours or up to 8 hours of intermittent use.

For those cases with positive PCR test, a Tyvek suit or coverall is used in addition to protect from droplet deposition. Moreover, all equipment is protected with nylon, anesthesia trolley is kept in the anteroom, and only needed medications and equipment is brought inside the room. In all cases, when doffing the PPE, gloves, protective gown, surgical mask and goggles are discarded in the operating room, while the Tyvek suit and N95 respirator are doffed and discarded in the induction room.

Protection against COVID-19 during AGMPs such as intubation and extubation is further reinforced through the utilization of a video laryngoscope to ensure farther distance from the patient's airway. Also, a negative pressure hood equipped with a HME filter and covered with a plastic sheet to prevent dispersion of droplets on the surfaces could be used (figure 1). Other precautions are done through pausing gas flow when the patients are disconnected from the ventilator, and avoiding ventilation during induction unless needed. One of our operating rooms was transformed into a negative pressure room to accommodate surgical patient's positive for COVID-19.

Variable evidence is found concerning the donning and doffing of PPE when encountering an infected patient. Donning of PPE is rarely associated with contamination; nevertheless, the proper order of donning the PPE affects the efficacy of infection risk aversion during doffing. Multiple methods and steps could be available concerning the application of PPE. We adopted the following steps for donning of the PPE

Fig. 1
Negative pressure hood



during the COVID-19 pandemic that are in accordance with the CDC guidelines.⁷

1- Gather the needed PPE with the appropriate gown size.

2- Carry out hand hygiene using hand sanitizer.

3- Don the isolation gown while tying all its ties.

4- Put on the N95 mask or use a regular one if not available. Adjust to the nose ridge with both hands and extend the mask under the chin. Don't keep the mask in pockets or under the chin between patients.

5- Wear the face shield or goggles.

6- Wash hands thoroughly before putting on the gloves while covering the cuff of the gown

7- HCP could now enter the patient's room.

Doffing on the other hand is associated with a higher risk of self-contamination and possible infection transmission due to the contamination of the outer surface of the PPE with the micro-organism.⁹ The risk of self-contamination, about 13%, is higher when there are breaches in the recommended order of removing the PPE.⁹ During this pandemic, shortage of PPE, unclear transmission modalities of the infection, and the resultant uncertain guidelines, added to the inadequate doffing of the PPE. N95 masks and the

coveralls are reported to be the most difficult PPE to don and doff.⁹

The CDC recommended the following order for PPE doffing.⁷

1- Remove the contaminated gloves through an adequate technique.

2- Remove the gown and dispose in the trash bin.

3- Exit the patient's room.

4- Wash hands thoroughly.

5- Take off face shield or goggles while avoiding touching the face by removing the straps and pulling upwards.

6- Take off the mask or respirator and discard while avoiding touching the front surface of the PPE.

7- Perform hand hygiene after removing the mask or respirator, and before reuse of the mask or respirator.

The sequence of donning and doffing the PPE by HCPs for AGMPs at the AUBMC are presented, by steps, in figure 2. While factors that affect the N95 respirator's effectiveness are listed in figure 3.

1- Extended use up to 8 hours according to the CDC.¹⁰

Fig. 2

The sequence of donning and doffing the personal protective equipments by health care providers for aerosol geenrating medical procedures at the American University of Beirut Medical Center

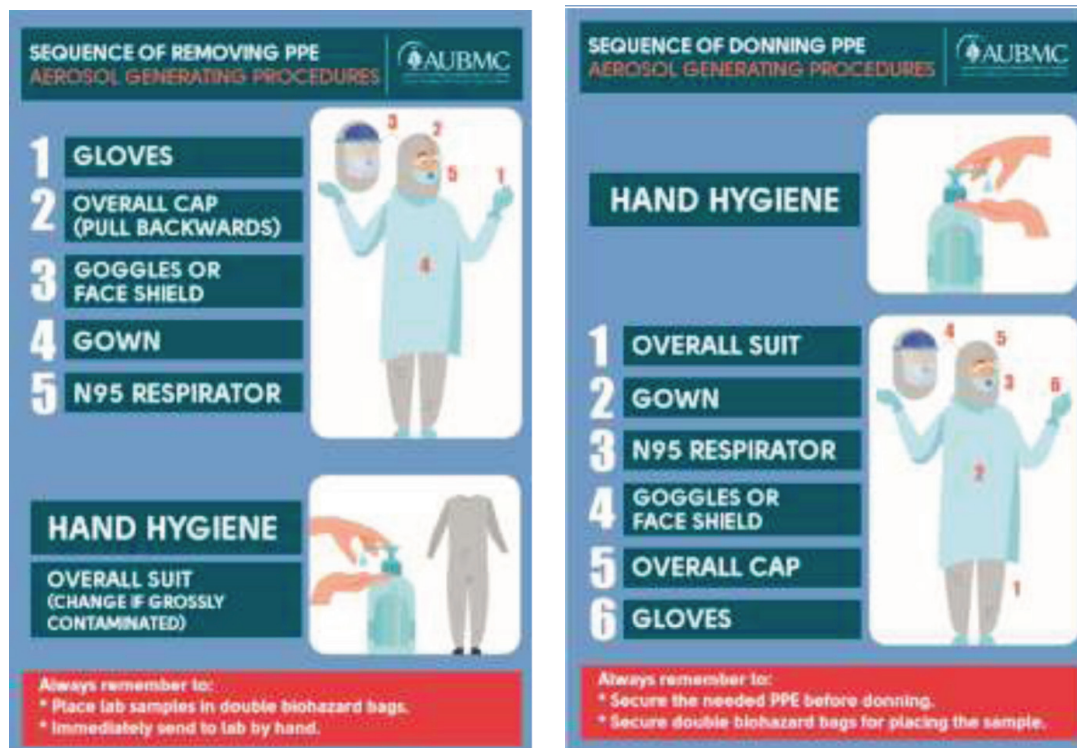
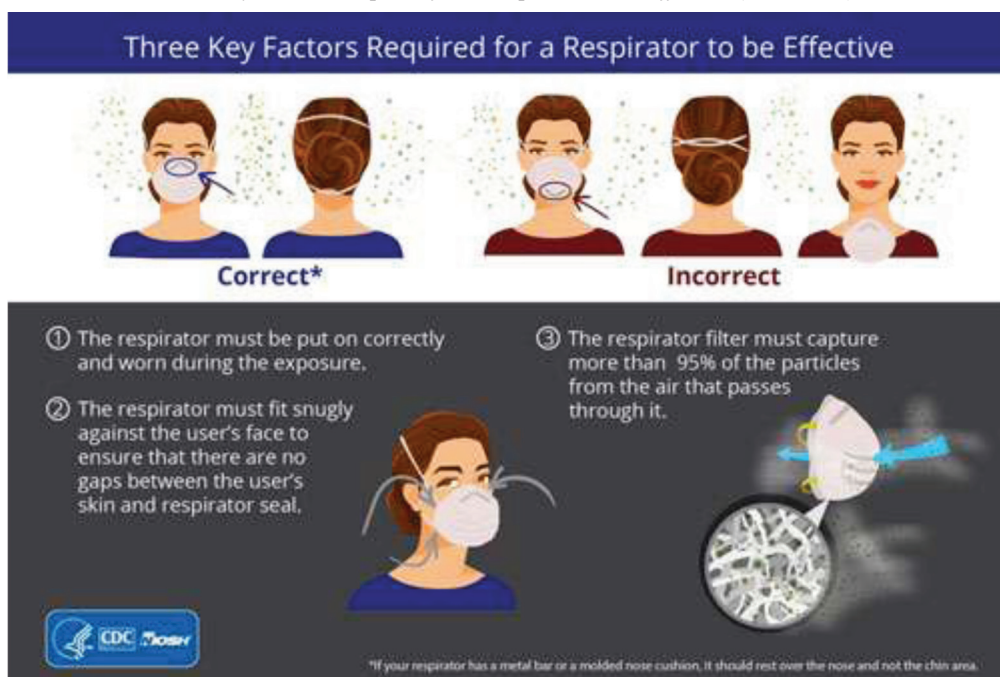


Fig. 3

Three Key Factors Required for a Respirator to be Effective (CDC 2019)



Under shortage conditions of the N95 masks, some strategies to mitigate their unavailability are recommended. These include:

2- Alternative use by following the Mask Rotation strategy where at least 5 masks should be used and allowed to dry for at least 72 hours (CDC recommendations) while properly stored in a breathable bags between uses.¹⁰

3- Reprocessing/decontamination that involves using hydrogen peroxide vaporization, UV treatment, moist heat, and dry heat.¹⁰

4- Other non-surgical PPE substitutes includes: the half-mask respirator (covers the nose and mouth), the full-face respirator (covers the eyes and face), and the powered air purifying respirator (PAPR). The PAPR is a full face and head shielding and is considered to possess a high level of protection. PAPRs can be cleaned and decontaminated for re-use and are not too tight so it can be used for longer periods at work.¹¹

If by any chance the mask becomes contaminated from any AGMPs or any other source that might damage it, the N95 should be disposed as recommended by the CDC.¹⁰

It is being frequently asked by HCPs whether a fit test is necessary each time the respirator is donned. According to the Occupational Safety and

Health Administration (OSHA), an annual formal fit test is required; thereafter, a user seal check can be done each time the already fitted respirator with the proper model and size is used.¹² To keep in mind, the user seal check cannot substitute the fit testing. It is always required to do the fitting test at least once per year and when the model of the respirator is changed.¹² However, because of global challenges related to PPE supplies mainly N95 masks and in accordance with a CDC recommendation, fit testing was stopped during the peak of the pandemic and was replaced with fit checking instead.

Another layer of protection in addition to the PPE remains maintaining a social distance, washing hands frequently with soap and water or using hand sanitizer containing at least 60% alcohol, and frequently cleaning and disinfecting touched surfaces. In light of limited data on the transmission and protection against COVID-19, the maximum available protection should be used while emphasizing the importance of proper HCP training. Also, restricting the overuse of PPE and controlling its use is a very useful strategy due to the worldwide shortages.

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