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The "masks for the ventilator" in the COVID-19 era

To the Editor

With the COVID-19 pandemic underway, health-care workers (HCW) are the most valuable yet highly vulnerable resource for any community [1]. Despite adequate provision of personal protective equipment, it is important that all other measures are taken to prevent transmission of the virus to healthcare workers. The intensive care setting presents a specific challenge; while dealing with severe cases requiring ventilator support and performing procedures that generate aerosols, the HCW are frequently exposed to an environment with high likelihood of viral contamination for prolonged periods of time.

The use of filters in the ventilator circuit has been suggested as a means of minimizing the chances of transmission of virus [2]. These breathing system filters are usually of two types; the electrostatic and pleated. The terms "electrostatic" and "pleated" are not ideal, as both types rely to some extent on electrostatic charge to hold particles within the filter material and both types of material could be pleated. The main difference between the two types is the density of the fibres. For electrostatic filter material, the density of fibres is comparatively low and the electrostatic charge on the fibres is high. For pleated filters, the density of the fibres is high: this causes an increase in the resistance to gas flow; pleating the material increases the surface area and thus reduces resistance. This type of filter is also termed "hydrophobic" (as the surface of the filter material repels water) or "mechanical filter" [3]. In general, pleated hydrophobic filters reduce gas-borne transmission of bacteria and viruses more effectively than electrostatic filters [4]. Devices that contain both a filter and a heat and moisture exchanger (HME) are termed heat and moisture exchanging filters (HMEFs).

The breathing system filters can be placed in several possible positions in the respiratory circuit: at the gas intake, at the patient end and at the expiratory circuit (Figure 1). When the filter is placed at air inlet (position 1) or the inspiratory limb (position 2); it filters the compresses ambient air and prevents bacterial and particulate contamination of the air being delivered to the patient [5]. It is unclear how much this contributes to the prevention of hospital-acquired infection. Its use may be considered when the ambient air is contaminated. Another possible site of placement would be at the patient end (position 3). When used here, it is often a HMEF rather than a simple filter; and keeps the breathing system dry.

When placed at the expiratory side (position 4 and 5), it filters the expired gas thereby preventing the contamination of the ventilator and the ambient atmosphere and protecting healthcare workers and other patients. This is a specific need when ventilating patients with COVID-19 pneumonia. The exhaled air from the patient may also contain the clouds of nebulised medications. Using expiratory filters decreases risk of second hand exposure to aerosol released to the atmosphere during mechanical ventilation [6]. The expiratory filter also protects the expiratory sensors of the ventilator from moisture and degradation when placed proximal to the sensors (position 4).

The expired air from ventilated patients may be loaded with pathogens. It has been seen that patients exhaled up to 2520 particle per breath, of which 80% were in the 0.3–1.0 μm range. The

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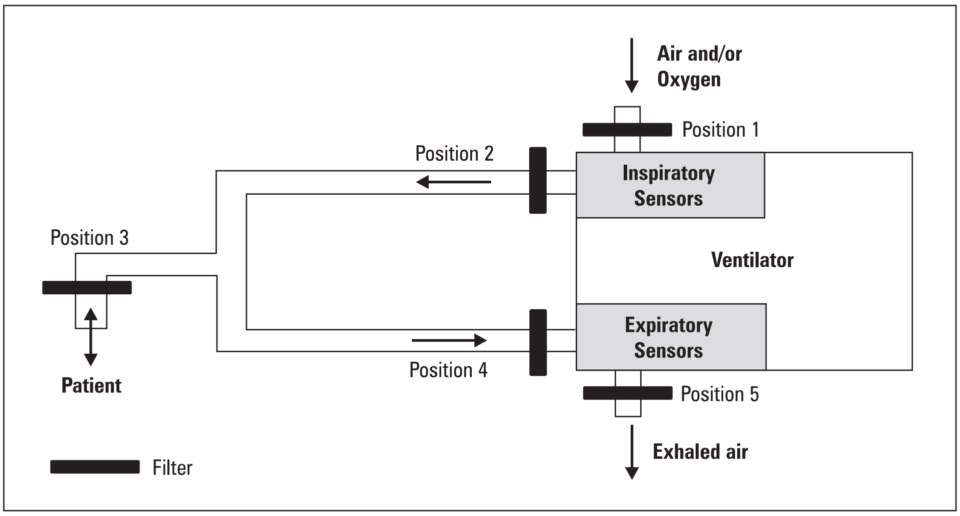

Figure 1. Possible sites where the filter may be placed in the breathing circuit

main determinant of particle numbers is the positive end-expiratory pressure (PEEP) — the higher the PEEP, the more exhaled particles are generated [7]. The breathing system filters are believed to protect the intensivist and their co-workers from exhaled pathogens. In a bench study to assess the utility of such filters, a monodispersed aerosol of human influenza A (H1N1) virus in an air stream model was used and the virus particles quantified; it was seen that viral filtration efficiency of these filters was ≥ 99.9995% indicating that their use in the breathing systems of intubated and mechanically ventilated patients can reduce the risk of spreading the virus to the breathing system and the ambient air [8]. In a study to evaluate the transmission risk of bacteria and also viruses via breathing circuits after extended use of 7 days, it was seen that endoluminal contamination of breathing circuits with bacteria did not increase and no viruses were detected in the breathing circuits using filters [9] suggesting that prolonged use of such filters may be possible.

However, another study showed that viable microorganisms may pass through anaesthetic breathing system filters when they are wet [10]. The assumption that breathing systems remain free of microbes when a filter is used might not be always appropriate. Hence, clinicians should never let their guard down and always continue to use PPE even when using breathing system filters. Also, clinicians should be aware that condensation can occur over these filters and viscous sputum and nebulised drugs can block these filters. Such blocked filters in the breathing systems may increase the resistance to gas flow and hence the work of breathing [11]. The blockage of these filters from liquids may further increase the resistance and prevent adequate ventilation [12].

An expert consensus has advised for the use of a dual limb ventilator with filters placed at the ventilator outlets [13]. They also recommend that when using NIV, use a heat-moisture exchanger (HME) instead of heated humidification. If using a single limb ventilator the HME should be placed between exhalation port and mask; its best to avoid using mask with exhalation port on the mask [13]. Similar considerations are warranted for the use of such breathing system filters while delivering anaesthesia to the patient especially patients suspected of COVID-19 [14, 15]. All efforts have to be made to ensure a safe working environment to prevent COVID-19 from becoming an occupational hazard, especially for the intensivists.

Conflict of interest

None declared.

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