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LETTERS TO THE EDITOR

Home PAP devices in patients infected with COVID-19

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Given that the COVID-19 pandemic is affecting millions of people, many patients on PAP therapy are affected. As current PAP systems are open and do not filter expired air, there is a theoretical concern, supported by experimental data of plausibility, that viruses can be shed from patients into the local environment. This shedding may endanger those around the patients in homes or health care facilities. However, both in countries where ventilator devices have been traditionally readily available and in resource-poor conditions, demands can exceed supply, such that clinicians need to consider using positive pressure devices at least as a bridging therapy to formal invasive ventilation. The U.S. Food and Drug Administration recently allowed such use during the COVID-19 crisis (https://www.fda.gov/medical-devices/letters-health-care-providers/ventilator-supply-mitigation-strategies-letter-health-care-providers).

Humans produce exhaled breath particles during various breath activities, such as normal breathing, coughing, talking, and sneezing.[1] Exhaled breath particle concentrations do not differ significantly between the volume control and pressure control modes of the ventilation settings in mechanically ventilated patients.[1] Exhaled breath particle concentrations in patients with high positive end-expiratory pressure (> 5 cm H_2O) are higher than those in patients with low positive end-expiratory pressure (< 5 cm H_2O).[1] Thus, the risk of environmental contamination from droplet-based mechanisms seems real and relevant to viral and bacterial infections.

Bacterial/viral filters are designed to trap more than 99.99% of relevant particles.[2] They typically consist of a housing that incorporates a hydrophobic glass fiber filter and a media made of corrugated hygroscopic paper. An example of specifications is tidal volume: 150–500 mL; flow rate resistance: 5, 13, and 28 mm H_2O at 30, 60, and 90 L/minute; bacterial filtration: > 99.9999%; viral filtration: 99.999% (https://www.accessdata.fda.gov/cdrh_docs/pdf10/K102483.pdf). The maximum duration of use is usually 24 hours, but filters could be replaced more frequently if necessary.

We designed elements of a circuit that we believe will be helpful in reducing viral shedding in patients infected with COVID-19 who are on PAP devices. The elements of the circuit were described in earlier research as Enhanced Expiratory Rebreathing Space, used to stabilize CO_2 fluctuations and thus to aid in the management of central and complex sleep apnea.[3] The fundamental idea is to vent exhaled air away from the patient and impose a filter before the air can exit the system. The air going to the patient passes through a filter, but more important, the air leaving the system passes through the same viral and bacterial filter. We believe that versions of this design can also be used in hospital settings in patients requiring respiratory support when volume ventilators are not available. However, home bilevel and CPAP systems differ by model and manufacturer and are not designed to be used as life-support ventilators. Repurposing home units for this use may be problematic, especially if high flow oxygen is added to the circuit of some devices (David Rapoport, personal communication).

The circuit consists of:

(1) Nonventing full-face mask (to reduce leaks at the face). Most vented masks can be easily modified to become nonvented by blocking the holes in the mask with a putty-like product, such as Mack's Silicone Putty Ear Plugs. There are also some native nonventing masks (available from major PAP manufacturers): Philips (https://www.usa.philips.com/healthcare/solutions/hospital-respiratory-care/hospital-respiratory-patient-interface-masks), Fisher & Paykel (https://www.fphcare.com/us/products/nivairo-rt045/), and ResMed (https://www.resmed.com/us/en/healthcare-professional/products/masks.html).

(2) Safety valve (this is integrated in some masks, allowing the patient to breathe in case of a power failure). Integrated safety valve examples include those from Fisher & Paykel: https://www.fphcare.com/us/products/nivairo-rt045/; they are also available to add to the circuit.

(3) In-line heat moisture exchanger (would need to be replaced daily) or viral filter (eg, https://www.4mdmedical.com/main-flow-bacterial-viral-filter.html).

(4) Tubing connected to a Whisper Swivel–type valve; also called leak valve by some manufacturers (eg, https://www.vitalitymedical.com/respironics-whisper-swivel-ii-exhalation-valve.html).

(5) Tubing connected to the PAP device.

An alternative approach is to use a nonrebreathing valve following the filter. A nonrebreathing valve prevents any CO_2 retention,[4] which can occur even in some conventional PAP setups, although less so when exhalation ports are in the mask

Figure 1—An example of a circuit that might be used with off-the-shelf components (with manufacturers' names and part numbers) in patients with OSA infected with COVID-19 and on CPAP.

design specifically at the nose/mouth. The main difference of such a configuration compared with what we propose is that the exhalation port of the valve is a large leak port, which could compromise pressure ventilation at low settings and reduce the effective pressure at the mask or interfere with the sensing by the device that drives switching between inspiratory and expiratory support. Data that such undesirable effects are small exist,[4] but direct comparisons with our proposed configuration are not available.

If necessary, standard adaptors can be added that will allow oxygen or metered dose inhalers to be added to the circuit. Close collaboration with experienced respiratory therapists is recommended to source the components mentioned above. The main manufacturers of PAP units and/or supplies are ResMed, Philips, Fisher & Paykel, Becton Dickinson, Invacare, DeVilbiss-Drive, and Hans Rudolph. When components are not available from usual channels, online retailers may have components in stock.

Figure 1 shows an example of such a circuit with off-the-shelf components that could be used. Other manufacturers' components with similar functions could also be used. One of the authors has used this type of circuit for more than 15 years, and in his experience there is not more than a 1 to 2 mm Hg increase in measured mainstream end-tidal CO_2.[3]

There is obviously still a danger that virus will be shed if there is any leak at the patient/mask interface, or when the patient is repositioned, the mask is changed, or the patient eats or drinks. It is strongly recommended that in the hospital setting anyone attending the patient wear full personal protective equipment, that if possible the patient be in a negative-pressure room, and that staff consider adding a high-efficiency particulate air filter system in the room. The patient will breathe through the inline filter and thus may reinhale pathogens. The only way to reduce this possibility is to change filters more frequently.

Additional measures such as full head masks and bed tents may be considered for the safety of the health care professionals in contact with patients infected with COVID-19. Further, these measures may be considered in the future for other infectious agents (eg, influenza, measles, herpes zoster).

In the home setting, it may be difficult to protect family members and other domestic contacts. It may be most prudent for a patient with severe OSA and COVID-19 infection to be monitored and treated in a health care facility, where personal protective equipment and adequate precautions may be more readily available. Patients with persistent cough and dyspnea may have difficulty tolerating PAP. Milder disease may be conservatively managed, perhaps by short-term supplemental oxygen or simply with positional therapy.

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