

# Vancouver Coastal Health Guidelines for the use of Respiratory Equipment for Patients on Airborne or Enhanced Droplet Precautions in Acute Care Facilities

## Goals

1. To meet respiratory care needs in patients who are on airborne or enhanced droplet precautions.
2. To provide respiratory care clinicians with equipment options to minimize exposure to potentially infectious airborne or droplet particles.
3. To recommend equipment and techniques to provide maximal exhalate filtration of airborne particles.

## Important Notes

1. Use of this respiratory equipment **DOES NOT** preclude the use of Personal Protective Equipment (PPE). See [VCH Regional Infection Control Manual](#) for appropriate use of PPE and donning/doffing procedures.
2. Recommendations for the use of specific respiratory equipment are meant to be **guidelines** and should be discussed by the health care team as to the appropriateness of use in each patient.
3. As with any emerging disease, information and guidelines pertaining to patients with severe respiratory illnesses with unknown diagnosis are in evolution. Information presented here is based on evidence and equipment available at the time of publishing and is subject to change. Images are for illustration purposes only—Vancouver Coastal Health does not endorse specific manufacturers or products.
4. Equipment and language used in this document is indicated for use by Respiratory Therapists and clinicians who have experience in using the equipment described. All clinicians using these guidelines must individually confirm their equipment for applicability and patient safety and monitor carefully. Consult your Respiratory Therapy Department for specific questions on the use of recommended equipment.
5. These guidelines are not intended to provide guidance for the clinical management of patients.
6. This document frequently refers to use of an ‘appropriately rated expiratory filter’. In all cases, this refers to any filter that can demonstrate meeting HEPA filtration criteria (>99.97% filtration of MPPS using NaCl test).
7. For more information and recommendations, please refer to the following resources:

[VCH Regional Infection Control Manual](#)

[Guidelines for the Acute Management of the Patient with SARS in the Hospital Setting](#)

[Pandemic Planning - Clinical Management and Health Care Facilities](#)

[VCH Worksafe and Wellness Respiratory Protection Program](#)

[How to Use PPE Safely and Effectively](#)

[Public Health Agency of Canada: Interim Guidance: Infection Prevention and Control Measures](#)

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## Definitions

**Aerosol-generating Medical Procedures (AGMPs):** any procedure carried out on a patient that can induce the production of aerosols of various sizes, including droplet nuclei. Examples include: non-invasive positive pressure ventilation (BIPAP, CPAP); endotracheal intubation; respiratory/airway suctioning; high-frequency oscillatory ventilation; tracheostomy care; chest physiotherapy; aerosolized or nebulized medication administration; diagnostic sputum induction; bronchoscopy procedure; autopsy of lung tissue.

## Section A. Oxygen Therapy Systems and Humidification

For patients with low oxygen requirements ( $FiO_2 \leq 0.40$ ), a simple oxygen face mask, Oxymask™ or nasal prongs will be adequate to meet oxygen demands. When patients are outside the room, a surgical mask can be worn by the patient overtop their nasal prongs to protect staff from expired droplets (e.g. cough or sneeze). Generally, low flow oxygen systems do not need to be humidified. Bubble-through humidifiers are largely ineffective in delivering humidity and should be avoided as they may increase the risk of infectious airborne particles. Large volume nebulizers also generate aerosols and should be avoided if at all possible on patients who have low oxygen requirements.

For patients with high oxygen requirements ( $FiO_2 > 0.40$ ), a HiOx® mask (see figure 1) with a good seal around the face and appropriately rated expiratory filter attached is ideal for oxygen delivery. It does not require nebulized gas, protects staff from expired droplets (e.g. cough or sneeze), and filters most of the exhalate if the mask fits well. Blended gas can be used for patients with specific  $FiO_2$  requirements. However, this may not be ideal for long-term use as many of these patients require humidification. This mask may also be used for patient transport outside room (i.e. a patient would not require an additional surgical mask overtop).



Figure 1 HiOx® mask with added expiratory filter

The Oxymask™ (see figure 2) can also be considered for use with high oxygen requirements as it does not use nebulization. However, this mask has large ports and does not provide a baffle for expired droplets (e.g. cough or sneeze) or filter patient exhalate. It is therefore not recommended for use in transport for these patients. It does utilize atmospheric air entrainment, therefore may provide some ambient humidity for patients.



Figure 2 Oxymask™

Non-ventilated patients with tracheostomy or endotracheal tubes frequently require humidified oxygen or air. Generally, this is delivered with a large-volume nebulizer system, which could increase the risk of creating infectious airborne particles. Tracheostomy masks or T-pieces with large volume nebulizers for humidity should be avoided. Instead, use a heat moisture exchanger with appropriately rated incorporated filter (HMEF) to filter

the expired air (see figure 3). By using an HMEF, much of the patient's expired moisture is retained, and the need for humidified gas is reduced, therefore a dry nebulizer can be used to provide oxygen (see figure 3). HMEF's must be changed frequently and these patients need to be watched closely to ensure that the filters do not become plugged with secretions.



Figure 3 Dry Nebulizer with T-piece, HMEF, flextube and inline suction catheter

High flow humidified oxygen should not be delivered via large-volume nebulizer and open aerosol face mask, as the nebulized gas can carry bacteria and viruses in expired aerosolized particles. A better alternative would be to deliver humidity and oxygen with a heated humidifier system (e.g. Fisher-Paykel Optiflow System, see figure 4). The heated humidifier systems provide humidity with vapour, which do not easily carry bacteria and viruses. The circuit used would ideally be a disposable single limb with internal heater wire, to prevent condensate from forming in the circuit (which could lead to infectious droplets). It is important to ensure humidifier settings and room temperature settings are set optimally so as not to lead to condensate within the circuit. Consultation with the clinical product specialist for these systems may be helpful. Patient interfaces used with these systems could include nasal prongs, nasal pillows, or face masks. Patients could wear a surgical mask if they are using nasal interfaces to protect staff against expired droplets (e.g. cough or sneeze). **NOTE:** The heated humidifier systems have high gas flows, and therefore could lead to propelling of expired gases with high velocity into the room.



Figure 4 Optiflow heated humidity blended gas system

**Summary: Oxygen Therapy Delivery Systems and Humidification**

	<b>Recommended</b>	<b>Not Recommended</b>
<b>Spontaneously breathing patient, no artificial airway, FiO<sub>2</sub> requirements &lt;0.40</b>	A. Simple oxygen face mask B. <a href="#">Oxymask™</a> C. Nasal prongs, no bubble humidifier	Large volume nebulizer with sterile water
<b>Spontaneously breathing patient, no artificial airway, FiO<sub>2</sub> requirements &gt;0.40</b>	A. <a href="#">HiOx® mask with expiratory filter</a> B. <a href="#">Optiflow humidification system with blender or entrainment device</a> C. <a href="#">Oxymask™</a>	Large volume nebulizer with sterile water
<b>Spontaneously breathing patient, tracheostomy or endotracheal tube, FiO<sub>2</sub> requirements 0.21-1.00</b>	A. <a href="#">HMEF with inline suction catheter, T-piece and dry large volume nebulizer</a>	Large volume nebulizer with sterile water

## Section B. Respiratory Medication Delivery Systems

Avoid the use of small-volume nebulizers for medication administration whenever possible to avoid generating aerosolized particles. If bronchodilators are required, metered dose inhalers (MDI) (see [figure 5](#), [figure 6](#)) are preferable.

### Examples of Metered Dose Inhaler Delivery Systems



Figure 5 MDI with spacer and mouthpiece



Figure 6 MDI with spacer and mask

If this mode of delivery is not feasible for the patient and nebulization must be used (e.g. decreased level of consciousness or if the patient has difficulty coordinating the optimal breathing pattern), then a breath-actuated nebulizer (see [figure 8](#)) with minimal emissions or a closed aerosol delivery system with a reservoir and appropriate filter (see [figure 7](#), [figure 9](#)) should be used. Non-vented masks are preferable.

### Examples of Closed Aerosol or Breath Actuated Delivery Systems



Figure 7 HiOx® with VixOne™ nebulizer and expiratory filter



Figure 8 AeroEclipse® II breath-actuated nebulizer



Figure 9 Circulaire® with VixOne™ nebulizer and expiratory filter

**Summary: Respiratory Medication Delivery Systems**

	<b>Recommended</b>	<b>Not Recommended</b>
<b>Respiratory medication required</b>	A. MDI with <a href="#">spacer and mouthpiece</a> or <a href="#">mask</a> B. <a href="#">Closed, filtered aerosol delivery system</a> C. <a href="#">Breath-actuated nebulizer</a>	A. Small volume nebulizer

## Section C. Noninvasive Ventilation

On single limb noninvasive ventilation circuits using typical machines, all exhaled gases and corresponding droplet nuclei are vented out a small orifice either on the breathing circuit or on the mask itself. Caution must be taken due to the risk of propelling infectious airborne particles at high velocities. Options for filtration are available, such as the Philips Respironics™ circuit with expiratory port filter (see figure 10), which would need to be used with a closed (non-ported) face mask.



Figure 10 **Philips Respironics™ circuit with expiratory port filter**  
\*photo used with permission

An alternative would be to use a closed (non-ported) face mask and a mechanical ventilator (see figure 11) with an appropriate expiratory filter capable of delivering a non-invasive mode of ventilation with adequate leak compensation settings. A disposable dual-limb circuit would be used so that all expiratory gases can be filtered through the expiratory limb and filter of the ventilator.

In both options, there is always risk of exposure from leaks around the sides of the face mask, therefore these options do not preclude the use of personal protective equipment.



Figure 11 **Ventilator with nonvented Bipap mask and heated humidified circuit on NIV mode**

**Summary: Noninvasive Ventilation**

	<b>Recommended</b>	<b>Not Recommended</b>
<b>Noninvasive Ventilation required</b>	<p>A. Mechanical ventilator in noninvasive mode with non-ported mask, disposable circuit and heated expiratory filter</p> <p>B. Philips Respironics™ noninvasive patient circuit with expiratory port filter</p> <p>B. Early intubation as applicable</p>	<p>A. Bipap or CPAP without filtration</p>

## Section D. Invasive Ventilation

Patients who are invasively ventilated (i.e. with tracheostomy or endotracheal tube) should ideally have a disposable dual-limb circuit with heated humidifier, heater wires within both the inspiratory/expiratory lines to prevent condensate, and an appropriately rated heated expiratory filter. Mechanical ventilation creates high gas flows, therefore use of a cuffed tracheostomy or endotracheal tube is optimal to prevent expired gases from being propelled into the room. Uncuffed tubes or Laryngeal Mask Airways are less optimal for this reason. Tracheal cuff pressures should be checked frequently and kept inflated at pressures of 25-30 cmH<sub>2</sub>O to create a good seal against the tracheal wall. Mechanical ventilators that have an internal, appropriately rated heated expiratory filter are ideal (see [figure 13](#)). Others can have an external heated appropriately rated expiratory filter added to the circuit (e.g. VADI®, see [figure 12](#)).



Figure 12 Ventilator with VADI® external heated expiratory filter



Figure 13 Ventilator with internal heated expiratory filter

Another option to provide expiratory filtration and humidification is to use a Heat Moisture Exchanger with Filter (HMEF, see [figure 14](#)). Care should be taken to ensure the product you are using has the filter included (some products are HME only). However, these filters need to be changed frequently as they become saturated with moisture or secretions and create resistance to flow. It is important for staff to note that each HMEF change results in a patient circuit disconnection and a short period of time when expired airborne particles are not filtered.



Figure 14 Heat Moisture Exchange Filter

Disposable ventilator circuits should be used whenever possible. Circuit changes should be avoided and changed only when clinically indicated; most manufacturers recommend changing the circuits once every 7 days, and some circuits are safe to use for a longer period of time.

### Summary: Invasive Ventilation

Item	Recommended (best option)	Acceptable	Not Recommended
<b>Artificial airway</b>	A. Cuffed tracheostomy tube or endotracheal tube with subglottic suction port B. Cuff pressures maintained 25-30 cmH20	A. Cuffed tracheostomy or endotracheal tube without subglottic suction port B. Cuff pressures inflated to minimal occluding volume	A. Cuffless tracheostomy or endotracheal tubes B. Laryngeal mask
<b>Ventilator circuit</b>	A. Disposable, dual-limb circuit with heated humidifier and insp/exp limb heater wires B. Circuit changes > 7 days	A. Circuit changes at 7 days	A. Nondisposable circuits, nonheated expiratory limb B. Circuit changes < 7 days
<b>Filtration</b>	A. <a href="#">Heated internal expiratory filter</a>	A. Externally applied heated expiratory filter (e.g. <a href="#">VADI®</a> ) B. Heat moisture exchange filter ( <a href="#">HMEF</a> )	A. No filtration

## Section E. High Frequency Oscillatory Ventilation

High frequency oscillators should be used with extreme caution due to the risk of propelling infectious airborne particles at high velocity, caused by the rapidly moving piston. Newer circuits for the SensorMedics 3100B oscillator include expiratory filters; however, these are not heated and would need to be changed frequently, necessitating frequent circuit disconnection (resulting in an increased risk of Ventilator Associated Pneumonia), would result in lung de-recruitment (lung recruitment maneuvers must be performed after each disconnect), and increase the number of staff exposures to airborne gases.

Modifications to the oscillator circuit are possible to incorporate the use of an added external heated expiratory (VADI®) filter (see [figure 15](#)). A heated filter results in less water saturation and therefore does not need to be changed periodically. This circuit modification requires some further manipulations to support the use of this filter (regarding bracket support, tube kinking, etc) and these specific instructions are included as an addendum to this document.



Figure 15 HFOV adapted circuit for external heated expiratory filter

**NOTE:** Contact VGH Respiratory Services for recommendations on circuit modifications for use of a high frequency oscillator with external heated expiratory filter.

### Summary: High Frequency Oscillatory Ventilation

	<b>Recommended (best option)</b>	<b>Acceptable</b>	<b>Not Recommended</b>
<b>HFO circuit</b>	A. <a href="#">Heated external expiratory filter with circuit modifications</a> (e.g. VADI®)	A. Nonheated expiratory filters	A. Standard circuit without filtration

## Section F. Manual Ventilation Units

Manual Ventilation Units (MVUs) should ideally be disposable and have an appropriately rated HMEF attached (see [figure 16](#)). An added feature of the MVU shown is the multi-directional exhaust port, which may be adjusted to direct exhaust away from the care provider.



Figure 16 **MVU with HMEF**

### **Summary: Manual Ventilation Units**

	<b>Recommended</b>	<b>Not Recommended</b>
<b>MVU</b>	A. <a href="#">MVU with HMEF</a>	A. MVU without HMEF

## Section G. Tracheal Suctioning

Inline (closed) tracheal suction systems (see [figure 17](#)) should be used whenever possible to avoid disconnecting the ventilator circuit during the suctioning procedure. They should be changed only when clinically indicated to avoid repeated disconnection of the ventilator circuit. These systems can also be used with non-ventilated patients (i.e. endotracheal tubes or tracheostomy tubes), but should be changed Q24 hours if they are used in an open circuit to prevent colonization (see [figure 3](#)).



Figure 17 Closed inline suction catheter

### **Summary: Tracheal Suctioning**

	<b>Recommended</b>	<b>Not Recommended</b>
<b>Tracheal Suction Catheters</b>	A. <a href="#">Closed (inline) suction catheters</a>	A. Circuit disconnection and manual tracheal suction procedure with disposable suction catheters

## Section H. Patient Transport

Transporting patients on airborne precautions presents an added risk to staff, visitors and patients. The HiOx® mask (see [figure 1](#)) with appropriately rated expiratory filter can be used for spontaneously breathing patients requiring oxygen. Humidity is not generally necessary for short transports, and these masks can be disposed of after use. Patients with tracheostomy or endotracheal tubes can be attached to an MVU with HMEF (see [figure 16](#)), even if they require no ventilatory support. Transport ventilators should also be used with an HMEF. Infants should be transported in closed incubator systems.

### Summary: Patient Transport

	<b>Recommended</b>	<b>Not Recommended</b>
<b>Patient transport</b>	A. Manual ventilation unit or transport ventilator with <a href="#">Heat Moisture Exchange Filter</a> B. <a href="#">HiOx® mask</a> with expiratory filter C. ISO-O2 oxygen mask	A. Open oxygen systems without filtration or large volume nebulizers

## Section I. Therapy and Diagnostic Procedures

Percussive therapy and assist cough procedures should be avoided unless patient is ventilated with closed filtered circuit. Patients without artificial airways should wear a surgical mask to protect staff from high velocity expired droplets during procedure. **NOTE:** Accidental ventilator circuit disconnections are common during chest physiotherapy procedures. All clinicians involved should be wearing appropriate PPE and N95 masks.

Sputum induction procedures involving aerosolized saline should be avoided as a means of obtaining respiratory samples for culture and sensitivity. Nasopharyngeal swabs for influenza should be performed with the patient wearing a mask over their mouth during the procedure, and paired with a tracheal aspirate if patient has one insitu. Specimen containers should be wiped down with a virucidal agent prior to placement in a biohazard bag or container for transport.

Bronchoscopy should be performed in a negative pressure room using appropriate PPE. If bronchoscopy is performed away from the bedside (e.g. procedure room), adequate time for air recirculation must occur prior to the start of the next case (9 air exchanges/hr – wait 30 minutes; 12-15 air exchanges/hour – wait 20 minutes) per Health Canada Guidelines.

Complete pulmonary function testing should not be performed. However, routine spirometry may be performed using an appropriate viral filter. For patients who need peak expiratory flowrates only, a disposable peak flowmeter (see [figure 17](#)) should be used.



Figure 18 Disposable peak flowmeter

### Summary: Therapy and Diagnostic Procedures

	<b>Recommended</b>	<b>Not Recommended</b>
<b>Chest physiotherapy (i.e. Assist Cough using manual technique or assistive devices, percussive techniques or devices)</b>	A. Therapy utilized with closed filtered ventilator circuit or patient wearing surgical mask if no artificial airway	A. No filtration during procedure
<b>Sputum Collection</b>	A. For influenza: nasopharyngeal swab performed with patient surgical mask overtop, paired with a tracheal aspirate through an artificial airway	A. Sputum induction with use of aerosolized saline nebulizer
<b>Bronchoscopy</b>	A. Use with caution in negative pressure room	
<b>Pulmonary Function testing</b>	A. Routine spirometry with appropriate filter B. <a href="#">Disposable peak flowmeter</a>	A. Complete pulmonary function testing or use of equipment without adequate filtration

# Sensormedics 3100B with modified circuit and heated expiratory VADI® filter

For use with patients on airborne or enhanced droplet respiratory precautions

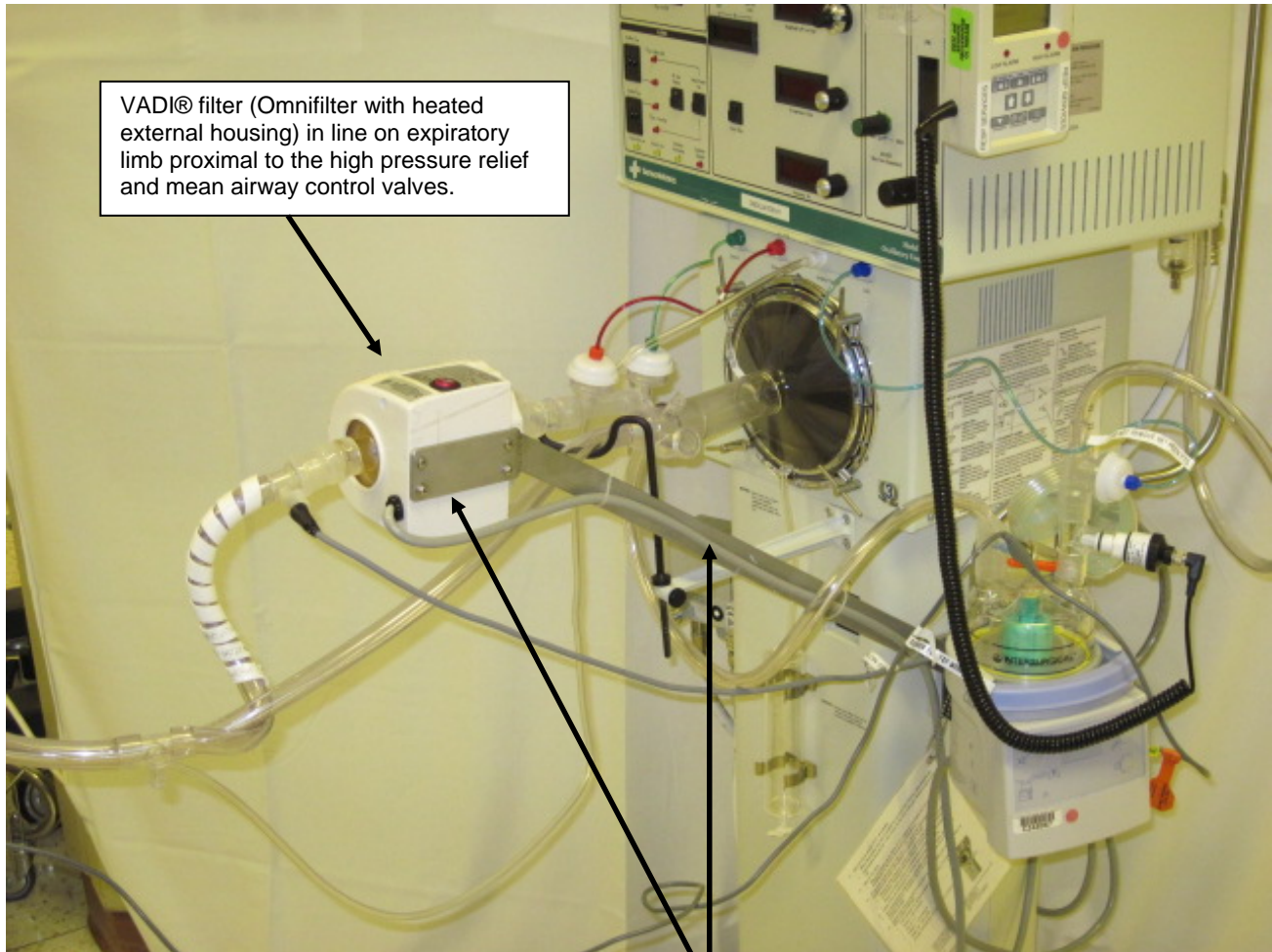


Figure 1

Support bracket built to hold weight of VADI® filter housing (fig 1)

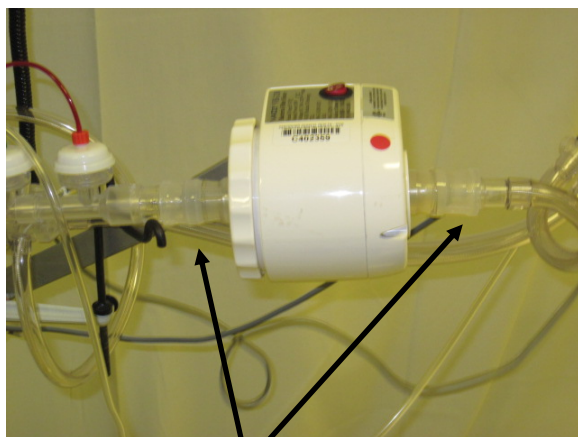


Figure 2

Silastic connectors pre and post filter ensure tight connections (fig 2)



Figure 3

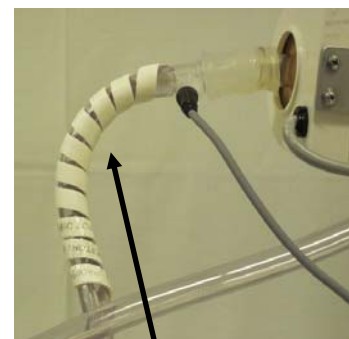


Figure 4

Tubing kinks proximal to expiratory (fig 3) prevented with hard plastic coil wrap (fig 4).

High Frequency Oscillation is safe and effective in improving oxygen in patients with acute respiratory distress syndrome (ARDS)<sup>1,2</sup>. Severe pneumonia caused by nH1N1, H5N1, or SARS may require high frequency oscillation. The rapid movement of the piston within the SensorMedics 3100B High Frequency Oscillatory Ventilator may cause aerosolization of expired droplet particles, increasing the risk of infectious disease exposure for critical care clinicians through airborne transmission. Circuits with included inspiratory/expiratory filters for the 3100B are available from the manufacturer (CareFusion) but these filters are not heated, resulting in condensation and an increase in resistance to flow. This necessitates frequent changing of the filters during oscillatory ventilation, causing loss of recruitment with the opening of the circuit and a further exposure risk to staff with each disconnection. Use of a high frequency oscillator is often not recommended for use in patients on airborne or enhanced droplet precautions for these reasons.

We modified the circuit of a Sensormedics 3100B High Frequency Oscillator (flexible patient circuit with dual heated wire, FP850) to include a Tyco OmniFilter Bacterial Filter, with filtration efficiency of >99.97% of 0.3 micron (MPPS) particles. The OmniFilter was surrounded by a heated external housing device (VADI® VH-210 Bacterial Filter Heater, 100-120V, 10W, constructed of PC plastic with aluminum sleeve), heated to 55-70 degrees Centigrade. The filter was placed inline with the expiratory limb of the oscillator circuit proximal to the high pressure relief valve and mean pressure control valve, to effectively filter all expired gases. Silastic 22mm ID connectors were used to connect the filter to the circuit without loss of circuit pressure, to avoid leaks, and to ensure a tight seal avoiding risk of accidental disconnection. This circuit modification resulted in an overall lengthening and sharper angle of the expiratory limb, resulting in an increased likelihood of expiratory tubing kinks proximal to the new filter. We added a short length of hard plastic splinting coil surrounding the tubing to mitigate this issue, effectively splinting the tubing and preventing kinks from occurring. The weight of the heated VADI housing (total weight = 1.02 kg with filter) was supported through the addition of a metal bracket manufactured by biomedical technicians within our Healthcare Technology Management team. The new circuit modification and heated filter was benchtested in our lab to ensure no increase in expiratory resistance when used at differing bias flows with heated humidity. Problems with condensation and water drainage have not been an issue. Delivered pressures including mean airway pressure and measured delta P were not affected by the use of the modified circuit. The filter is kept in line with the circuit and not changed during the course of oscillation treatment within our facility.

The modification of the Sensormedics 3100B high frequency oscillator circuit to include an effective heated expiratory filter allows us to use this device for severe ARDS patients who are on airborne or enhanced droplet precautions. Use of the modified circuit mitigates the risk of exposure to aerosolized expired gases for critical care staff, families and other patients and is useful in a pandemic containment strategy within acute care facilities.

1. Chan, K.P., Stewart, T.E., & Mehta, S. **High-Frequency Oscillatory Ventilation for Adult Patients with ARDS.** *Chest* 2007; 131:1907-1916. DOI: 10.1378/chest.06-1549
2. Derdak et al. **High Frequency Oscillatory Ventilation for Acute Respiratory Distress Syndrom in Adults – A Randomized, Controlled Trial.** *American Journal of Respiratory and Critical Care Medicine* 2002; 166:801-808. DOI: 10.1164/rccm.2108052

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**CareFusion SensorMedics 3100B Oscillator circuit specs:**

- Flex patient circuit with dual heated wire, FP850 (16390-102)
- Bellows/water trap (p/n 766897)
- Control tubes (11438)

**Tyco OmniFilter Bacteria Filter (Reusable) specs:**

- Size 8.9 cm diameter x 14.6 cm long
- Resistance to Flow: 2.5 cmH20 at 100 L/min
- Filtration Efficiency: 99.97% retention of particles 0.3 microns or larger
- Leak Tested: 3psi (211 cmH20) internal pressure

**VADI® Bacteria Filter Heater specs:**

- 100-120V, 10 watts
- Heated temp = 55-70 °C
- Physical 11.4 cm high/10.8 cm wide/11.4 cm diameter
- Weight 0.79 kg (empty) 1.02 kg (with filter)
- Construction: PC plastic with aluminum sleeve
- P/N:800-21101