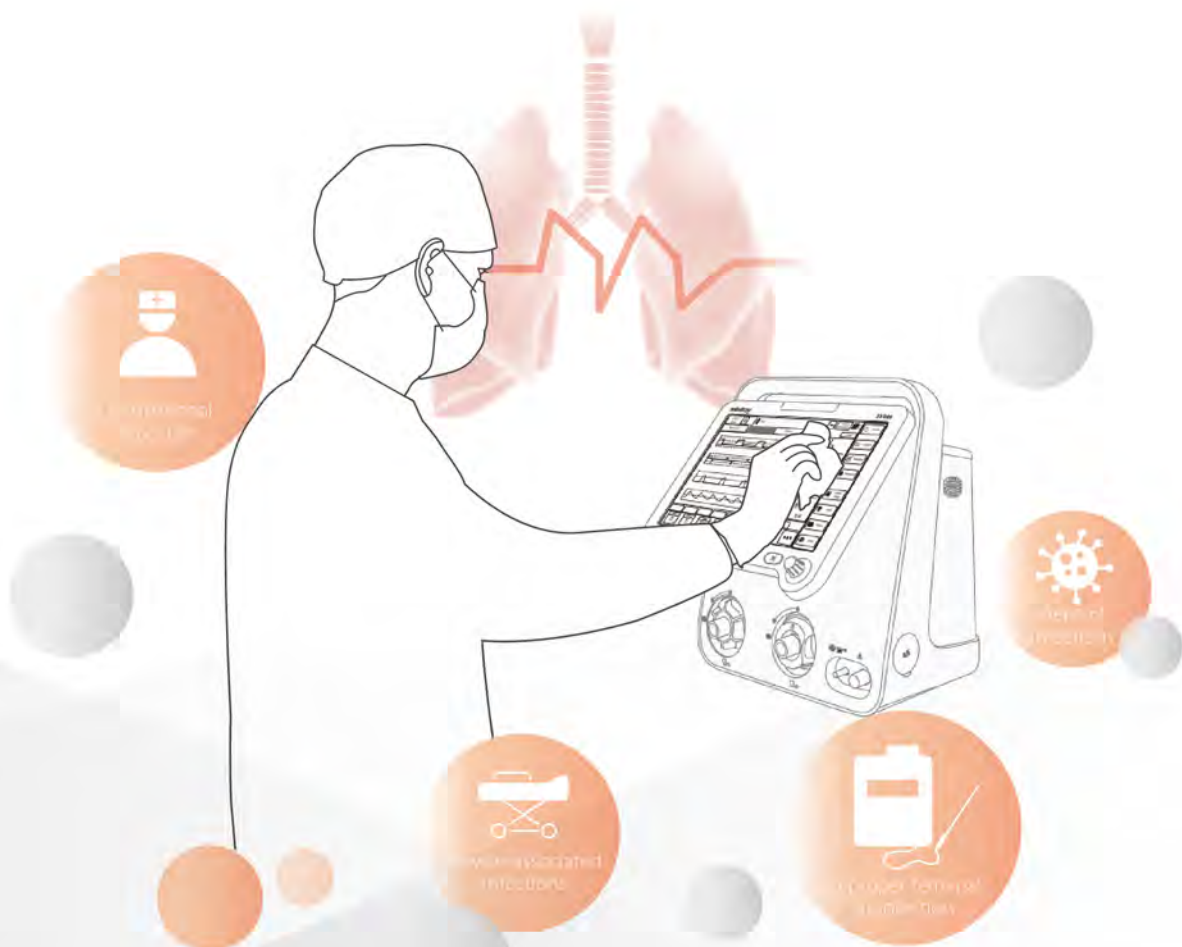
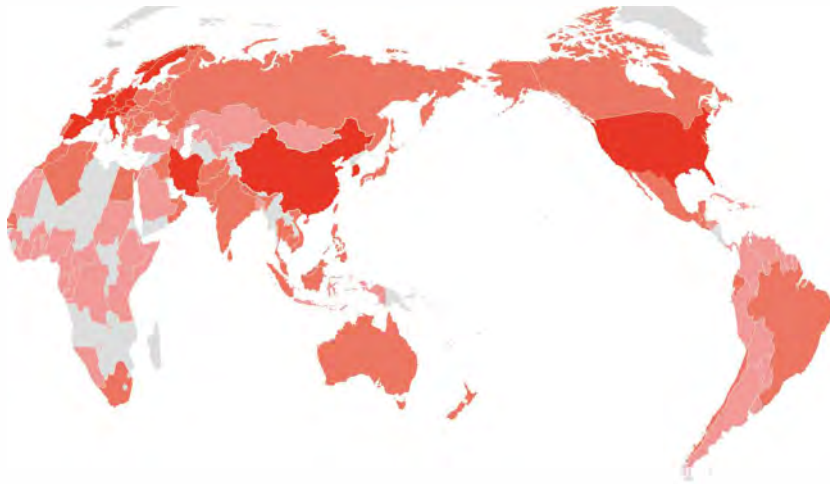


Infection Control for Ventilators in the battle against COVID-19



The Challenge of COVID-19



No doubt that mechanical ventilation is one of the most effective therapy strategies for those patients that develop severe respiratory failure. However, if handling and disinfection are not done properly, the ventilators and the associated accessories will be act as a major source of contamination.

Statistics from the China Centers for Disease Control and Prevention (China CDC) and other media sources indicate that thousands of medical staff worldwide who work with COVID-19 have got infected. Reports from many countries revealed that the number of infected medical staff outside China has reached over a few thousand. The four main contributors to infections are: occupational exposure, device-associated infections, improper terminal infection and aerosol infections.

Main factors

of caregiver's infection



Occupational exposure

Device-associated infections

Improper terminal disinfection

Aerosol infections

Consensus of Infection Control for Ventilators

As mentioned previously, one of the major sources of potential infection is from secretions and aerosol dispersion from the patient. Therefore, it is vital to handle the ventilator properly before, during and after the ventilation procedures.

As suggested in *Expert Consensus of Mechanical Ventilation Infection Control for Novel Coronavirus* from China ^[1] and the Clinical management of severe acute respiratory infection when novel coronavirus (COVID-19) infection by WHO ^[2], the following preventive measures should be taken:

1. Infection control during ventilation

- Recommend using single-patient use circuits (water-trap with one-way valve mechanism). Patients with COVID-19 are not advised to routinely change circuits unless damaged or soiled. Changing circuits leads to the dispersion of contaminated droplets and aerosols, as well as increased use of medical resources (workload and consumables).
- Ventilator circuits have high concentration of pathogens, which may induce VAP. Therefore, condensate should be

removed regularly. When disconnecting the ventilator or condensate, avoid accidental splashing of condensate or allowing condensate to go into the patient's airway. Suggest placing the ventilator on stand-by to suspend the ventilator from operating prior disconnecting the circuits to prevent this.

- Closed-suction is preferred, use suction tube as alternative, and avoid disconnecting the ventilator circuits.
- Place filter in both inspiratory and expiratory end of the ventilator. When using a disposable filter, the exhalation filter requires to be replaced when resistance is increased due to the accumulated condensate increases due to active humidification.
- For invasive ventilation, a heated humidifier (active humidification) with dual heating wires should be used to reduce the formation of condensate in the circuit; or a humidified heat exchanger (passive humidification) with a bacterial filtration function. It is not recommended to add a filter at the Y-tube during active humidification, as it will increase the filter's water content and increase respiratory resistance.
- When using a single-limb non-invasive ventilator, the non-invasive ventilator should use a disposable exhalation valve as much as possible instead of using vented masks. A filter should be added between the mask and the exhalation valve.

2. Post Ventilator Disinfection

COVID-19 is sensitive to ultraviolet light and heat. 56 °C for 30 minutes, ether, 75% ethanol, chlorine-containing disinfectant, and lipid solvents such as peracetic acid and chloroform can effectively inactivate the virus.

- **Ventilator surface disinfection:** 75% ethanol or hydrogen peroxide to wipe external surfaces (including monitors)
- **Handling of breathing circuits:** After disposable ventilator circuit is used, it shall be disposed as medical waste. For reusable circuits, disinfection measures should be taken. For the circuits contaminated with COVID-19, it is recommended to use 1:25~1:50 chlorine preparation soak disinfectant (circuits) and high temperature and high pressure (filter) for sterilization.
- **Ensuring gas sources are clean:** Filters are usually installed in central air supply systems. For ventilators that use compressors or turbines to provide high-pressure gas, avoid dust and pathogens in the environment. The ventilator should be equipped with air filters or high-efficiency filters at gas inlet.
- **Disinfect inspiratory and expiratory valves:** The components of the ventilator that need to be cleaned or disinfected are mainly the flow sensors located in the exhalation valve and in the expiratory side of the ventilator. If a reusable external pressure-differential flow sensor is connected, external sensor should be disinfected together with the exhalation valve. Dispose single-patient use external pressure-differential flow sensors as medical waste.

Infection Control Management for Mechanical Ventilators

Safeguard for Medical Personnel and Patients

3-in-1 device

The SV series ventilator integrates with high-flow oxygen therapy, non-invasive ventilation and invasive ventilation into one device, making it perfectly reliable for satisfying the changing needs of patients in different acuity levels. It also eliminates frequent disconnection of tubing, which is suspected to be the major potential source of contamination. The clinicians can use one ventilator with the same tubing throughout different acuity stages for one patient, hence reducing the chance of cross-infections.



Avoid aerosol infection

WHO believes that the use of non-invasive positive pressure ventilation (NPPV) with vented mask may be one of the main sources for aerosol transmission in the hospital. The vented mask does not have dedicated filters to process the contaminated gas, so that the gas is directly released to the environment.

Mindray SV ventilators use dual-limb circuit design and non-vented mask for non-invasive ventilation that can highly reduce the amount of aerosol released to the environment during ventilation.



Reliable hardware design: detachable and autoclavable ins-/expiratory valves

The SV Series ventilators are designed according to the latest CE guideline, allowing detachability and autoclavability for both inspiratory and expiratory valves. The valves can go through steam autoclave at a temperature of up to 134 °C. This makes it easier for sterilization and thus prevent the risk of cross-infections. Also, the built-in flow sensor of the expiratory valve can work under high condensation environment and will not be affected by nebulization drugs, making it more stable and reliable. The flow sensor can last for the whole ventilation period without the need of change and hence further the chance of disconnection.



Intergrated with the HEPA Filter

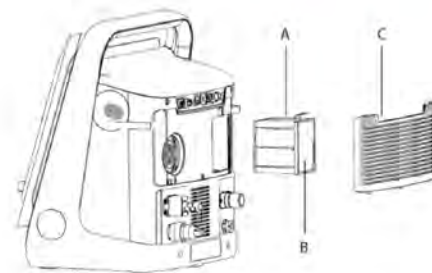
The large and fast-growing number of COVID-19 patients means an urgent demand for a respiratory support equipment with strong functions and reliable designs. Mindray's SV Series ventilators (SV300/SV600/SV800) have proven its capability of providing complete and reliable support for patients with severe respiratory failure.

With built-in turbine and backup battery that mean even under the most stringent environment, you patient can still receive ventilation treatment. All the Mindray turbine driven unit come with Level H-14 HEPA filter, this makes it a reliable guardian for both patients and medical personnel.



Turbine

HEPA Level	Filtering Efficiency	Corresponds to NIOSH mask filtering level
E10	>85%	—
E11	95%	N95
E12	99.5%	N99
H13	99.95%	N100
H14	99.995%	—



A. HEPA filter B. Air inlet dust filter C. Main unit air inlet grille

Methods for Cleaning and Disinfection

SV300, SV600, SV800

Parts	Recommended frequency Interval	Cleaning	Disinfection
Ventilator Housing			
External ventilator surface (including housing, plug-in module housing, backup air supply module housing, power cord and gas supply hose).	Each patient		or
Trolley and support arm	Each patient		or
Touch screen	Each patient		or
Fan dust filter	Every four weeks/as necessary*		
Main Unit Air Outlet Dust Filter	Every four weeks/as necessary*		
Air intake dust filter	Every four weeks/as necessary*		
Ventilator inspiration safety valve assembly			
Inspiration safety valve assembly	as necessary*		or
Ventilator expiration valve assembly			
Expiration valve membrane (silicone)	Each patient/weekly		or
Expiration valve assembly (except membrane)	Each patient/weekly		or

Cleaning Methods

Wipe: wipe with a damp cloth immersed in alkaline detergent (soapy water, etc.) or alcohol solution, and then wipe off the remaining detergent with a dry lint-free cloth.

Immersion: flush with water first and then immerse it in alkaline detergent (soapy water, etc., water temperature of 40 °C recommended) for approximately three minutes. Finally, clean with water and dry completely.

Methods for Disinfection

Wipe: wipe with a damp cloth immersed in medium- or high-efficiency detergent and then wipe off the remaining detergent with a dry lint free cloth.

Immersion: immerse it in medium- or high-efficiency detergent for more than 30 minutes (recommended time). Then clean with water and dry completely.

Autoclaving: steam autoclave at 134 °C for 10 to 20 minutes (recommended time).

Ultraviolet radiation: ultraviolet radiation for 30 to 60 minutes (recommended time).

Reference:

[1] Expert Consensus of Mechanical Ventilation Infection Control for Novel Coronavirus, Chinese Journal of Respiratory and Critical Care Medicine, Mar. 2020, Vol. 19, No. 2.

[2] WHO: Clinical management of severe acute respiratory infection when Novel coronavirus (2019-nCoV) infection is suspected: Interim Guidance.

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