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[COVID-19] Use of One Ventilator to Mechanically Ventilate Two or More Patients Simultaneously Presents Risks [ECRI Exclusive Hazard Report]

Summary

On April 13, 2020, this Alert was updated to include some additional information.

Problem

1. The use of one ventilator to treat two or more patients via adapters has been proposed as one way to address ventilator shortages related to a surge of COVID-19 patients.
2. While this may be technically feasible, there are numerous risks and complications involved in the process, many of which could lead to inadequate ventilation or increased risk of volutrauma for patients ventilated using this arrangement.

ECRI Recommendations:

1. If clinicians consider using one ventilator for two or more patients, they should do so only as a last resort, and the hospital should have a plan to manage the associated risks before doing so.
2. Refer to the Greater New York Hospital Association (GNYHA) [working protocol](#) for guidance. However, note that according to recent media reports, two New York hospitals that attempted the practice abandoned it quickly because of patient complications.
3. As explained in the GNYHA protocol, pressure control is more advisable than volume control in this arrangement. While ventilating in this mode, there will still be variations in tidal volume between patients, but some other risks are mitigated (e.g., an obstruction for one patient will not lead to dangerously large tidal volumes being delivered to other patients, as could happen in volume control).
4. Use bacterial/viral filters with >99% efficiency on both breathing circuits to reduce the risk of cross contamination between connected patients.

Background:

1. The Society of Critical Care Medicine (SCCM), American Association for Respiratory Care (AARC), American Society of Anesthesiologists (ASA), Anesthesia Patient Safety Foundation (APSF), American Association of Critical-Care Nurses (AACN), and American College of Chest Physicians (CHEST) released a consensus statement that ventilator sharing should not be attempted because it cannot be safely done with current equipment.
2. FDA's [Emergency Use Authorization](#) issued on March 24, 2020, includes a section on Continuous Ventilator Splitters. The Labeling Considerations section highlights many of the risks of this strategy.
3. One piece of evidence that has been cited in favor of this approach states that it was used successfully in the 2016 Las Vegas mass shooting. However, reports from the incident suggest that this approach was used one time, and only for a few minutes until another ventilator was acquired. COVID-19 related shortages are expected to last for an extended period of time, and many of these patients will require ventilator support for a week or longer, which introduces many additional complications that the doctors in Las Vegas did not face.
4. Several groups have published detailed ventilator sharing protocols:
 1. Greater New York Hospital Association
 2. U.S. Public Health Service Commissioned Corps
 3. Solis-Lemus, et al.

Manufacturer's Perspectives or Comments:

1. Ventilating more than one patient with one ventilator would be considered off-label use.
2. This is a sample of manufacturer comments that ECRI has seen.

1. Draeger: See [Alert A34797](#).
2. Hamilton Medical: See the [website](#).
3. Medtronic: See [Alert A34790](#).
4. Getinge/Maquet: See the [website](#).

Discussion:

1. The following risks and complications are associated with the use of one ventilator on two or more patients:
 1. Inability to deliver a known tidal volume:
 1. In a vent splitting arrangement, every patient will be receiving the same pressure, but delivered volumes will be unpredictable and highly variable between patients because of differing lung compliance.
 2. When ventilating with volume control mode, the total tidal volume delivered to **all** connected patients will be equivalent to the set tidal volume.
 3. In pressure control mode, the total tidal volume delivered to **all** connected patient will be based on the average compliance of all of the patients connected to the ventilator.
 4. In either mode, the tidal volume delivered to **each** patient will be dependent on each patient's lung size and compliance relative to the average. Patients with higher compliance will receive larger tidal volumes and vice versa.
 5. Measuring the tidal volume delivered to each patient will require independent monitors for each patient separate from the ventilator's internal monitoring.
 1. The ventilator will only be able to, in the best case scenario, measure the total flow and volume delivered to the sum of all patients.
 2. Some facilities may have handheld respirometers (e.g., a Wright respirometer) that could be used to spot-check tidal volumes; however, this would involve disconnecting part of the breathing circuit, which increases the risk of spreading the virus through aerosols and loss of lung recruitment in these hypoxemia patients.
 6. This is a serious complication because COVID-19 patients may present with acute respiratory distress syndrome (ARDS), and lung-protective strategies with relatively low tidal volumes are advised.
 7. In addition, the tidal volume each patient receives will be dynamic. A change in compliance for any patient will affect the tidal volumes of all patients connected to a single ventilator. Because it is not uncommon for a patient's condition to change rapidly, the subsequent change in distribution of gas could lead to a cascading effect on the other patients.
 8. Theoretically, matching patients by size and disease progress can mitigate some differences in lung size; however, in practice, such matching may be hard to achieve. In addition, matching by size does not necessarily mean patients will have similar compliance.
 2. Inability to set positive end-expiratory pressure (PEEP) and FiO₂ independently:
 1. In a vent splitting arrangement, every patient will be receiving the same pressure and FiO₂. However, even though the patients will be receiving the same PEEP, the actual end-expiratory volume will vary based on each patient's compliance.
 2. While COVID-19 patients typically present with ARDS and treatment protocols emphasize higher than average PEEP and high FiO₂, the exact PEEP and FiO₂ necessary for each patient is not possible to know ahead of time.
 3. Currently, PEEP and FiO₂ are titrated to effect; however, this is not possible when more than one patient is connected to the same ventilator, because clinicians cannot independently control these parameters for each patient and cannot readily assess the effectiveness of changes.
 3. Prevention of spontaneous breathing:
 1. Allowing spontaneous breath triggering could lead to chaotic ventilation because the device would try to respond to efforts from every patient.
 2. To prevent this, ventilators would have to be configured to ignore spontaneous efforts.
 1. Modern ventilators do not typically have modes that ignore spontaneous efforts, but some older devices might.
 2. For modern devices, the flow or pressure trigger sensitivity would need to be set as high as possible (i.e., least sensitive value).
 3. In addition, patients should be heavily sedated and given neuromuscular blocking agents to prevent the distress that might arise from spontaneous efforts that are ignored. Such paralysis is generally avoided when possible since it is associated with poorer outcomes.

4. Inability to monitor many respiratory parameters:
 1. Many parameters (e.g., tidal volumes, minute volumes, airway resistance, lung compliance) measured by the ventilator will be meaningless in a splitting arrangement.
 2. Some ventilators have integrated end-tidal CO₂ monitors, but the sensor connects to the patient wye, so only one patient could be monitored at a time.
 3. Tools such as waveforms and trending, which can be very helpful in treating patients requiring extended ventilator support, do not provide meaningful information in a splitting arrangement.
5. Difficulty of weaning patients:
 1. Weaning patients off of ventilators as quickly as possible is critical in a shortage situation.
 2. However, weaning requires many capabilities that will not be available in a vent splitting arrangement, such as spontaneous breathing, frequent titration of ventilator settings, respiratory monitoring, and tools like trending and spirometry. Therefore, weaning will require the use of a dedicated ventilator.
 3. A delay in weaning could mean that vent splitting may actually exacerbate ventilator shortages.
6. Difficulty of setting appropriate alarm limits:
 1. Volume alarms would be meaningless in such an arrangement and should either be disabled or set so they will not activate.
 2. Pressure alarms are critical, but the appropriate limits may be difficult to determine.
 3. A disconnect for one patient would mean every connected patient would also stop receiving ventilator support, so disconnect/low pressure alarms are critical.
7. Risk of cross-contamination between patients:
 1. All patients connected to one ventilator will likely be sharing gas, so the potential for cross-contamination is very high.
 2. Heat and moisture exchanging filters at each patient wye might help mitigate some of this risk, assuming there are sufficient filters; however, this will also increase the resistance, which could lower tidal volumes and prolong exhalation times.
 3. Even though all patients will have COVID-19, some patients could have other communicable diseases.
8. Inconvenient room layout:
 1. It is likely that patients will have to be arranged side by side in a space large enough to accommodate them and other necessary equipment. The ventilator would need to be positioned at the head of the beds.
 2. This would complicate the placement of other devices such as infusion pumps and physiologic monitors.
 3. It would also make access to the patients for assessment, lab samples, etc. very difficult.
 4. Current clinical evidence suggests that prone positioning can be very effective in treating COVID-19 patients. Keep this in mind when arranging patients in this configuration, since you may need multiple staff members around the bed to change the patient's position periodically.
2. Technical limitations to consider when using one ventilator on two or more patients:
 1. Ventilators with external expiratory valves, such as most portable ventilators, cannot be used in such an arrangement. External exhalation valves are incorporated in the breathing circuit, and the ventilator can control only one such valve at a time.
 2. Ventilators with flow sensors that are placed at the patient wye will either be very difficult or impossible to use in such an arrangement, because the ventilator can only accept input from one sensor.
 3. A ventilator used in such an arrangement should be able to provide a sufficient tidal volume, with the demand proportional to the number of patients connected. For example, a ventilator connected to four patients would need to be able to provide at least 2 L tidal volumes at a very high flow rate.
 4. For COVID-19 patients specifically, the ventilator should be able to provide high levels of PEEP (e.g., a minimum of 10 cm H₂O).
3. Patient care and staffing considerations when using one ventilator on two or more patients:
 1. Supervision by a respiratory therapist must be much more frequent than typical. Since staffing levels are also likely to be affected during the COVID-19 pandemic, this is not a trivial consideration.
 2. The lack of reliable respiratory monitoring from the ventilator may necessitate more frequent blood gas analysis, if possible.
 3. Additional stand-alone monitors, such as end-tidal CO₂, would be useful.
 4. Everything connected to the patients should be labeled and/or color coded to minimize the risk of a mix-up. This includes infusion pumps and administration sets, breathing circuits, drains, chest tubes, etc.

5. Determining how to adjust therapy based on any given patient's trajectory would be complicated because parameters cannot be independently set.
6. Some have suggested arranging patients by acuity, configuring ventilator settings appropriately, and then moving patients between ventilators as their conditions change. This might work in theory, but the logistical challenges in practice are immense. For example, if one patient gets worse and needs to be moved to a ventilator with more aggressive settings, that can be done only if a spot opens up on such a ventilator (i.e., another patient has improved enough to move down).

References & Source Documents:

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11. <https://www.nytimes.com/2020/04/10/nyregion/coronavirus-new-york-update.html>

UMDNS Term(s)

Ventilators, Intensive Care [17429]
 Ventilators, Portable/Home Care [17423]
 Ventilators, Transport [18098]

Geographic Region(s)

Worldwide

Suggested Distribution

Clinical/Biomedical Engineering, Critical Care, Emergency/Outpatient Services, Pulmonology/Respiratory Therapy, Risk Management/Continuous Quality Improvement, Internal Medicine

Comment

- This alert is a living document and may be updated when ECRI receives additional information.