The Performance of a Novel Humidification Device for Mechanical Ventilation

N.H. Tiffin[1], L.A. Weinstein[1], D.E. Sunstein[2], T.Q. Tran[1] and J.B. Taylor[3]
[1]Pari Respiratory Equipment, Midlothian, VA, United States
[2]Sunrise Labs, Auburn, NH, United States
[3]Farm Design, Hollis, NH, United States

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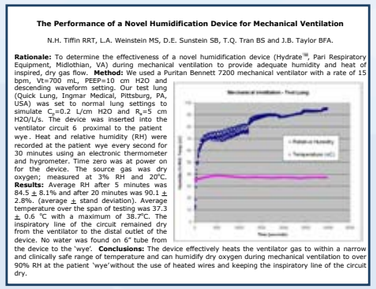

The Performance of a Novel Humidification Device for Mechanical Ventilation

N.H. Tiffin RRT, L.A. Weinstein MS, D.E. Sunstein SB, T.Q. Tran BS and J.B. Taylor BFA.

Rationale: To determine the effectiveness of a novel humidification device (Hydrate™, Pari Respiratory Equipment, Midlothian, VA) during mechanical ventilation to provide adequate humidity and heat of inspired, dry gas flow. **Method:** We used a Puritan Bennett 7200 mechanical ventilator with a rate of 15 bpm, Vt=700 mL, PEEP=10 cm H2O and descending waveform setting. Our test lung (Quick Lung, Ingmar Medical, Pittsburg, PA, USA) was set to normal lung settings to simulate C_p=0.2 L/cm H2O and R_a=5 cm H2O/L/s. The device was inserted into the ventilator circuit 6 proximal to the patient 'wye'. Heat and relative humidity (RH) were recorded at the patient 'wye' every second for 30 minutes using an electronic thermometer and hygrometer. Time zero was at power on for the device. The source gas was dry oxygen; measured at 3% RH and 20°C. **Results:** Average RH after 5 minutes was 84.5 ± 8.1% and after 20 minutes was 90.1 ± 2.8%. (average ± stand deviation). Average temperature over the span of testing was 37.3 ± 0.6 °C with a maximum of 38.7°C. The inspiratory line of the circuit remained dry from the ventilator to the distal outlet of the device. No water was found on 6" tube from the device to the 'wye'. **Conclusions:** The device effectively heats the ventilator gas to within a narrow and clinically safe range of temperature and can humidify dry oxygen during mechanical ventilation to over 90% RH at the patient 'wye'without the use of heated wires and keeping the inspiratory line of the circuit dry.

Introduction

- A novel humidification technology (Hydrate™; Pari Respiratory Equipment, Midlothian, Virginia) is capable of vaporizing water to heat and humidify therapeutic gases. (Figure 1) This technology is based on a porous, multi-layered ceramic disk that draws water in through the bottom and, using a heating element on the top surface, vaporizes the water; ejecting it out of the top of the disk. It has the potential to be used as a humidifier in mechanical ventilator circuits.

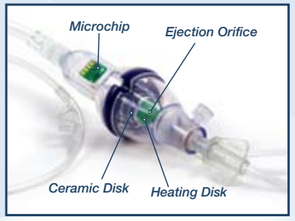

Figure 1. The C-Force™ housing containing the disk which is the vaporizer. The housing is placed in-line and the vapor jet is directed toward the incoming gas flow for better mixing. A microchip is contained in the C-Force™ housing to measure and control temperature of heating element and gas.

Objective

- To determine the effectiveness of a novel humidification device (Hydrate™, Pari Respiratory Equipment, Midlothian, VA) during mechanical ventilation using standard ventilatory settings to provide adequate humidity and heat of inspired, dry gas flow.

Technology

- The C-Force™ (Figure 1) houses the ceramic disk which is fed water by a peristaltic pump and is electronically controlled by the Pari Hydrate (Figure 2). Water is drawn into the disk by capillary forces, is vaporized, then ejected out the top due to pressure from expansion from the phase transition to a gas. (Figure 3) A heating element on the top of the disk, which is controlled by the Hydrate™, creates the heat to provide vaporization. There is a thermal balance between the top of the disk and the cooling water entering the bottom. (Figure 3) Because the water (via the peristaltic pump) and the heat (via the heating element) are controlled separately by the Hydrate™ there can be independent variations in the temperature and humidity of the gas within a range of operating temperatures.

Figure 2. The PARI Hydrate™ controls the function of the C-Force™ (tempurature and vapor) and contains the peristatic pump for precise water flow to the C-Force™.

**Results reported are for early software versions of the Hydrate™.*

Method

- We used a Puritan Bennett 7200 mechanical ventilator with a rate of 15 bpm, Vt=700 mL, PEEP=10 cm H2O and descending waveform setting.
- Our test lung (Quick Lung, Ingmar Medical, Pittsburg, PA, USA) was set to normal lung settings to simulate Cp=0.2 L/cm H2O and Ra=5 cm H2O/L/s.
- The C-Force™ was inserted into the ventilator circuit 6" proximal to the patient 'wye'.(Figure 4) Heat and relative humidity were recorded at the patient 'wye' every second for 30 minutes using an electronic thermometer and hygrometer (Rotronic Instrument Corp, Huntington, NY) which was calibrated to manufacturer's specifications.
- Time zero was at power on for the device.
- The source gas was compressed air.

Results

- Source gas was measured at 3% relative humidity and 20°C. The average relative humidity after 5 minutes was 84.5 + 8.1% and after 20 minutes was 90.1 + 2.8%. (mean + SD).
- Average temperature over the span of testing was 37.3 + 0.6°C with a maximum of 38.7°C.
- The inspiratory line of the circuit remained dry from the ventilator to the distal outlet of the C-Force™.
- No water was found in 6" tube from the device to the 'wye'.

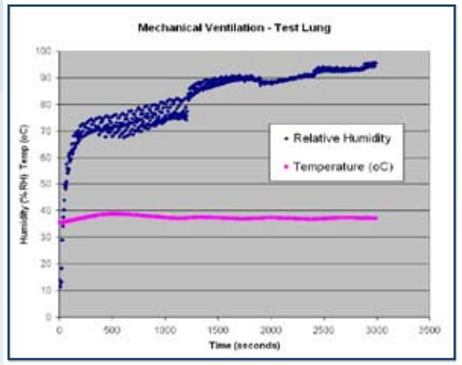

Table 1. Temperature and relative humidity measured at the outflow in C-Force™ during mechanical ventilation of a test lung.

Conclusion

- Minimum recommended absolute humidity for mechanical ventilation is 30 mg H2O/L at 30°C[1] and recommended levels of absolute humidity between 36 mg/L to 40 mg/L.[2]
- The Pari Hydrate™ at an average temperature of 37.3°C and 90.1% relative humidity delivers is capable of heating and humidifying dry oxygen flow up to 40 L/min to over 35°C and over 90% relative humidity. Application to mechanical ventilation is possible.

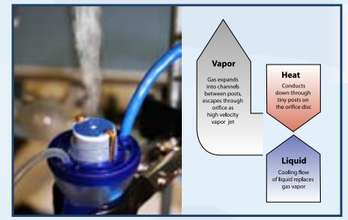

Figure 3. Heat generated by the heating element and the cooling influx of water allow thermal equilibration.

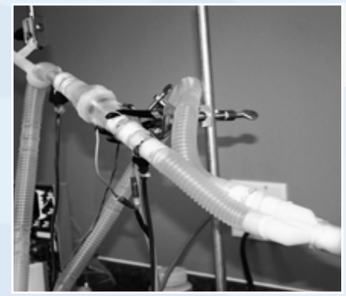

Figure 4. Setup of C-Force™ [proto-type model in ventilator circuit proximal to the 'wye'.

Summary

- The device effectively heats the ventilator gas to within a narrow and clinically safe range of temperature and can humidify dry oxygen during mechanical ventilation to recommended levels at the patient 'wye' without the use of heated wires and keeping the inspiratory line of the circuit dry.

References

1. AARC Clinical Practice Guideline: Humidification during Mechanical Ventilation Respir Care 1992;37:887-890
2. Respiratory Care: Principles & Practice. Dean R. Hess et al. W.B. Saunders Company, Philadelphia, PA 2002, pp 635

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