

# DETERMINATION OF WATER VAPOR DELIVERY FOR INTUBATED PATIENTS

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## INTRODUCTION

Humidification devices are used in intubated patients to prevent the complications that may result from drying of the respiratory mucosa. Many studies have assessed these devices based on conditions at the Y-piece, which often conclude that devices provide similar levels of heat and humidity to condition inspired gas. However, this fact has not been confirmed by measurement of actual water vapor delivered to a patient.

## OBJECTIVE

To measure the water vapor delivered to an intubated patient with different forms of humidification and ventilation.

## METHODS

In a bench model of a humidified ventilator circuit (Figure 1), water vapor delivery was measured using a condenser and hygrometer. Some of the water provided by a humidification device was condensed and measured. The water vapor which escaped the condenser was calculated based on hygrometric measurements used to determine the absolute humidity (AH) of the gas which exited the condenser. This allowed us to recover the total amount of water vapor which was supplied to the system.

First, the system was calibrated with a point source humidifier and water pump. Then, devices providing non-heated wire (NHW), and heated wire humidification (HWH) were tested for water vapor delivery using three different ventilators (Drager 4 NeoFlow, Puritan Bennett 7200, T-Bird AVS III) and two patterns of ventilation ( $V_t=750$ ,  $RR=15$  and  $V_t=400$ ,  $RR=15$ ). Temperatures and relative humidity (RH) were measured throughout the ventilator circuit using a thermocouple and hygrometer (Fisher Scientific, Pittsburgh, PA).

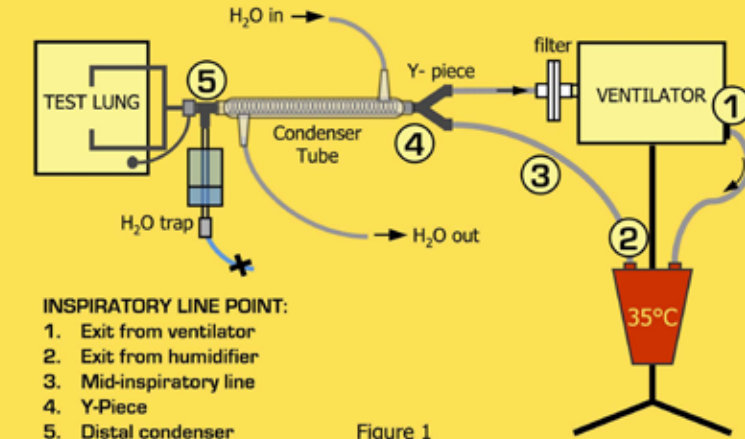


Figure 1

## RESULTS

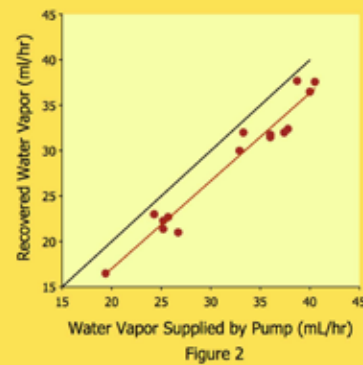


Figure 2

Using linear regression, our method for determining water vapor delivery was validated (Figure 2). Temperature at the Y-piece was similar using both devices, but the overall inspiratory line temperature was higher using NHWH (Figures 3-6). RH was 100% throughout the inspiratory line in each experiment. NHWH delivered significantly more water vapor than HWH for the greater minute ventilation (MV) ( $26.4 \pm 0.83$  mL/hr vs  $21.2 \pm 1.00$  mL/hr,  $p < 0.0001$ ), and similar amounts for the lower MV ( $13.7 \pm 0.81$  mL/hr vs  $12.3 \pm 1.8$  mL/hr,  $p = 0.064$ ) (Figure 7). The Drager and PB7200 ventilators performed similarly, whereas the T-Bird ventilator had lower inspiratory line temperatures and lower water vapor delivery.

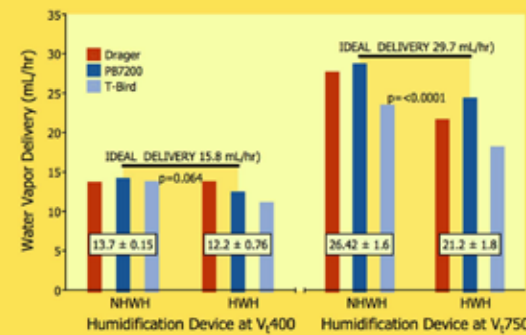


Figure 7

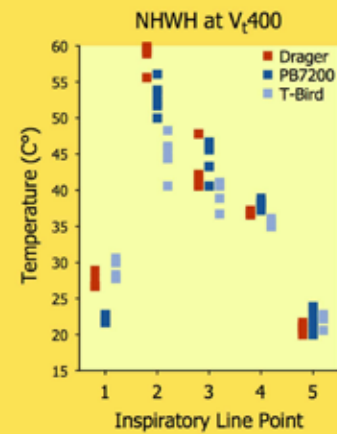


Figure 3

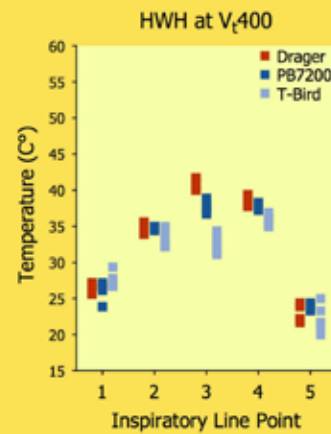


Figure 4

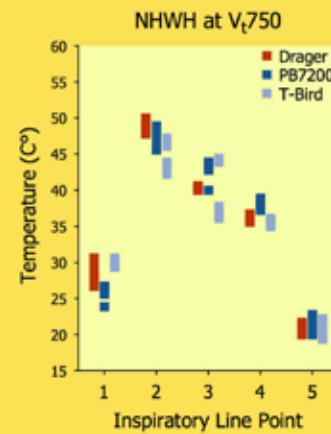


Figure 5

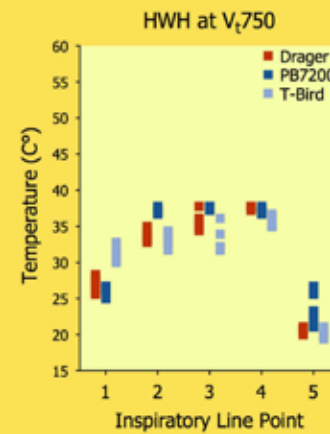


Figure 6

## CONCLUSIONS

- NHWH delivered more water vapor than HWH, approaching ideal physiologic levels.
- Inspiratory line temperatures were highest with NHWH.
- Temperature at the Y-piece is not predictive of water vapor delivery.
- Ventilators using bias flow (T-Bird) impair humidification device performance by adding additional gas volume that absorbs heat and moisture.

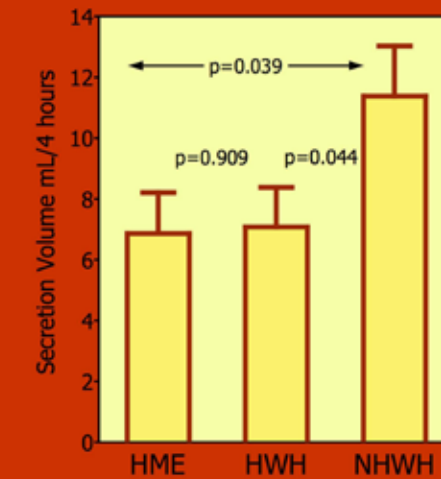


Figure 8

<sup>1</sup>Am J Respir Crit Care Med 169:7, A348, 2004

- In vitro / in vivo correlation: In a separate study (1), patients ventilated with NHWH had significantly greater secretion volumes than patients ventilated with HWH, or a heat and moisture exchanger (HME) (Figure 8).
- Greater water vapor delivery leads to greater secretion volume, which may prevent the complications associated with drying of the respiratory mucosa.