Humidification and Noninvasive Ventilation

The present use of high-flow dry gases during noninvasive positive-pressure ventilation (NPPV) raises interesting clinical questions regarding maintenance of the airway environment. In the normal airway, inspired air is heated and humidified by the respiratory mucosa until it reaches core body temperature and 100% saturation with water vapor at the "isothermic saturation boundary," which is usually found at the fourth or fifth generation of subsegmental bronchi.[1] The gas at that point should be under alveolar conditions, with a temperature of 37°C and relative humidity of 100%. Over a 24-hour cycle, the respiratory tract loses approximately 1,470 J of heat and 250 mL of water.[1] In patients breathing dry gases (such as during NPPV) from an oxygen tank or compressed air, the upper airways' ability to heat and humidify inspired gases can be overwhelmed, leading to increased heat and water losses from the respiratory mucosa and eventual respiratory tract dysfunction.

The consequences of inadequate humidification can be serious. Inadequate humidification increases mucus viscosity and retained secretions, resulting in increased airway resistance, diminished pulmonary compliance, and atelectasis.[1] Adding a humidifier to an NPPV circuit increases the humidity of the inspired air.[2] Clinical studies that have evaluated humidification with continuous positive airway pressure in patients with sleep apnea have had mixed results,[3–4] and warm, humid air may have a bronchodilatory effect on patients with abnormal airways.[5]

The paper by Holland et al[6] in this issue of RESPIRATORY CARE represents an in vitro attempt to evaluate the interaction between inspiratory positive airway pressure (IPAP) and humidity. Holland et al found that increasing IPAP increases gas temperature (probably because of the action of the compressor) and decreases the relative humidity of the gas, unless additional water vapor is added to the respiratory circuit.

The decrease in relative humidity was expected, as there is always a relationship between absolute humidity and relative humidity: the higher the temperature, the higher the absolute humidity at saturation, which defines the maximum water vapor capacity of the gas at a given temperature (eg, at 37°C, the absolute humidity at saturation is 44 mg H_2O/L). The relative humidity is defined as the ratio of the absolute humidity (ie, the absolute amount of water in each liter of air) to the absolute humidity at saturation. Holland et al found that with increasing pressure there was an increase in gas temperature. The temperature increase raised the absolute humidity at saturation, and when combined with a lack of added water vapor to the circuit, it reduced the relative humidity of the gas.

Holland et al also evaluated the effect of humidity on IPAP by adding a humidification device downstream of the bi-level positive airway pressure machine. They found a minimal reduction in IPAP with the addition of humidification to the inspiratory circuit, which indicates that humidifying NPPV gas would not substantially affect inspiratory pressure clinically. The humidification device added water vapor distal to the bi-level positive airway pressure machine, but there was some loss of pressure as the inspiratory gas passed through the humidifier. The decrease in IPAP may have occurred because the inspiratory gas had to traverse the humidifier chamber, which added additional space to the respiratory circuit.

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In theory it seems logical to humidify NPPV gas. However, NPPV has traditionally been used without humidification, and questions remain as to who will benefit from NPPV humidification. Typically, NPPV is used in patients with hypoxia, hypercarbia, and sleep apnea, and they rely on their upper airways for humidification. It is unclear which, if any, of those clinical entities would benefit from humidified gas during NPPV. Potential clinical end points include changes in P_{aO_2}, intubation rate among those who fail NPPV, and subjective improvement in patient symptoms while using humidified, versus nonhumidified, NPPV. Finally, it is possible that humidified NPPV may simply be better tolerated, as the face and upper airways receive humidified gas.

Clinical studies are needed to determine the benefits of humidifying NPPV gas. In addition, the same arguments and need for data apply to nasal-prong devices that use heated, humidified gas at high flow.[7] The findings from the in vitro study by Holland et al[6] should be assessed in vivo to determine if the bench results can be extrapolated to the clinical setting.

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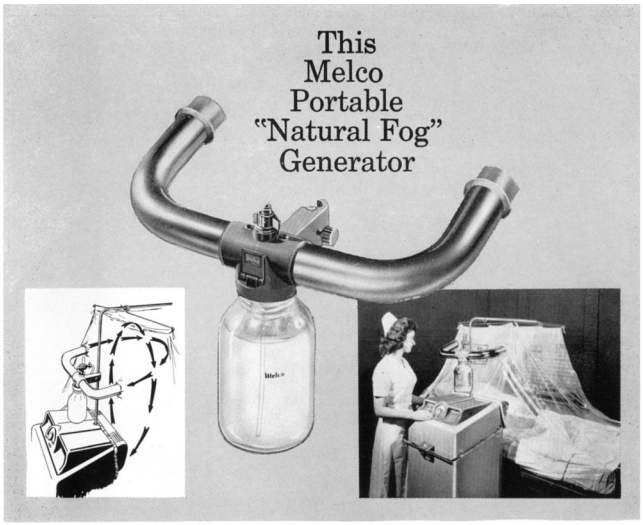

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