Humidification for the Home Ventilated Patient
A Case Study

Introduction

Tracheostomy bypasses the upper respiratory, tract and compromises the humidifying, filtering and warming function of the nose, nasopharynx, oropharynx, laryngopharynx and larynx. The isothermic saturation boundarv (ISB) describes, at any one point in time, that place within the bronchial tree at which inhaled gas reaches full saturation and body temperature. The ISB is a moving target, residing anywhere between the 2nd and 10th generation bronchi. Variables influencing the ISB include gas flow, gas volume, initial gas inhalation temperature and relative humidity.[1]

Bypassing the upper airway, moves the ISB down the respiratory tract and places the burden for gas conditioning upon the lower respiratory, tract structures not evolved to tolerate this stress. The effects of moisture and heat loss on the respiratory tract are well documented. Inadequate gas conditioning alters tracheobronchial mucosa, impairs mucociliary clearance, increases mucus viscosity, increases the chance of atelectasis and retained secretions, and adversely affects airway resistance and pulmonary compliance. [2] Studies suggest that return of normal gas flow conditioning allows relatively rapid recovery of functional damage (2 -3 days), however structural damage may take 3 -6 weeks to fully recover. [3]

Heated humidifiers and heat and moisture exchangers are the two means of conditioning gas delivered by ventilation therapy. [3]
Our literature review identified a number of studies comparing these devices, especially in the acute care environment. A smaller volume of work relied on bench test measurements and evaluation. There is little published information studying the effect of various humidification devices on patients with chronic illness, ventilated at home.

Case Study -S

This case study reports our experience with one patient on home ventilation. The effect of a change in humidification technique was monitored, evaluated and is reported.

S is a 23 year old man with Duchenne muscular dystrophy on home ventilator therapy. (P1X 100. Respironics. Pittsburgh. PA, US), since March 1999. His parents are his primary, care providers. He has a tracheostomy with an un-cuffed tracheostomy tube (no 6 Shiley, Boston. MA, US) bypassing his upper respiratory tract. A controlled leak past the tube allows speech. To maintain respiratory muscle strength S is encouraged to breathe without ventilatory support for 4-6 hours per day. Whilst on positive pressure ventilation his ventilator operates in SIMV mode with a tidal volume of 660 ml (day) and 900 ml (night). His minimum respiratory rate is 15 bpm.

When originally discharged from hospital, S relied on the Thermovent HEPA (SIMS Portex Ltd, Hythe, Kent, UK) HME filters as humidification for positive pressure and spontaneous ventilation during the day. Overnight a passover humidifier (HC100. Fisher & Paykel, Auckland, New Zealand) was connected into the circuit.

During his first year of home ventilation, S required 2 courses of antibiotics for chest infections and his parents found he required suctioning 3 to 12 times per day depending on S's general health and the local weather conditions. Dry weather tended to increase the suctioning requirements.

Adequate systemic hydration is mandatory to ensure effective intrinsic gas conditioning. S feeds

through a gastric feeding tube. A minimum of 2 L fluid per day is passed through this tube and S is able to take extra fluid orally as he wishes. Urine output and colour are monitored. For the first 6 months of this feeding regime. 2 weekly blood tests measured kidney function. electrolyte. haemoglobin and albumin levels. From these results dietetic and medical staff are satisfied that S is maintaining adequate systemic hydration.

From February to April 2000. S trialed an alternative ventilator (LTV900. Pulmonetic Systems, Colton. CA) before settling on the current device (PLV 100, Respironics. Pittsburgh. PA, US). Following this trial period S began to produce more sputum, required suctioning frequently and found he was not settling at night. He would wake with a choking sensation and to find the ventilator alarming due to high airway pressure. Suctioning would alleviate these symptoms. 2 to 3 months subsequent to this ventilator trial S's situation deteriorated.
The ventilator continued to alarm with high airway pressures at night and S would require suctioning up to 15 times during the day and 6-8 times at night. S and his family were becoming sleep deprived, particularly Fraser his dog and S's protector.
The inner cannula of the tracheostomy tube was heavily coated with secretions when removed for cleaning each morning. 24-hour suction volumes ranged from 700 to 1000 ml (this included tube rinse water).

Sputum was generally creamy with occasional yellow return. There was no clinical evidence of a chest infection at this tirne. A sputum sample was ultimately, taken which revealed a heavy growth of coliform species and polymorphs. A two week course of doxycycline was instigated by S's GP. Concurrently. S and his family had been discussing humidification with other muscular dystrophy patients. Through the Internet S has developed a wide network of friends and the consensus was that S was-receiving sub optimal humidification with his current therapy. Independently, S made contact with a New Zealand humidifier manufacturer
(Fisher & Paykel flealthcare Ltd) and sought their advice. At S's request we agreed to trial a new respiratory humidifier, the F&P model MR850. This uint uses a heated wire in the inspiratory limb to maintain gas temperature and minimise condensation between the humidification chamber and the tracheostomy. The intentiori is to move the ISB as far as possible up the bronchial tree by delivering core temperature saturated gas to the airway.

During the trial of this new humidifier suctioning frequency, quality and amount of secretions, quality of sleep and the cleanliness of the inner cannula were recorded.

Within 2 weeks of commencing the trial suction volumes had dropped from 700 ml per day to < 100 ml per day. Suction frequency had dropped from a peak of 15 times per day to < 3 times per day. Night waking had stopped and the inner cannula of the tracheostomy was clean every day.

Recordings were continued for 3 months. After the first month, S found he was going for long periods without needing suctioning. The longest period was 5 weeks. The new humidifier was consuming a litre of water per night. This was 3 times the amount of water consumed by the HC 100 humidifier used prior to this trial. The water use reflects the increased amount of humidity being created and subsequently delivered to the airway.

In the six months since using the new humidifier S has had no chest infections. his sleeping quality has improved and he is suctioned only intermittently. He has had one viral upper respiratory tract infection. Previously, viral infections would increase sputum production and require S to be suctioned 6-8 times per day. This often persisted for 1-2 weeks. With the new humidification regime he required suctioning 4-6 times per day and returned to normal within 3 days.

Discussion

The switch to the Fisher & Paykel MR850 heated humidification system designed for use with

closed circuit ventilation has improved S's ventilation therapy and quality of life.
Initial improvements in secretion quantity, and quality sleep and suction frequency may be the result of either the antibiotic therapy or the change in humidification.

However the continued improvement in S's airway function. documented over the 3 months of the study is most likely attributable to the result of improved gas conditioning by the MR850 humidification system. We postulate that the increased level of humidity delivered to Ss airway has enhanced his mucociliary elevator and that sputum is cleared past the tracheostomy tube and swallowed.

Increased humidifier water consumption suggests that the previous humidification regime was sub-optimal. We suggest that the F&P MR850 humidifier is effectively delivering water vapour to the bronchial tree. There is no evidence of rain out or other extraneous fluid loss in the circuit and improved water vapour delivery results in increased fluid uptake by lung tissue and is responsible for the improvement in mucociliary clearance and mucous production. It appears that this benefit carries across the day when S returns to using an HME filter.

We suggest that for clients on home ventilation therapy close monitoring of humidification is important . Our experience with S suggests that providing optimal airway humidification can lead to significant improvements in the quality of ventilation therapy and the patients quality of life.

References

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