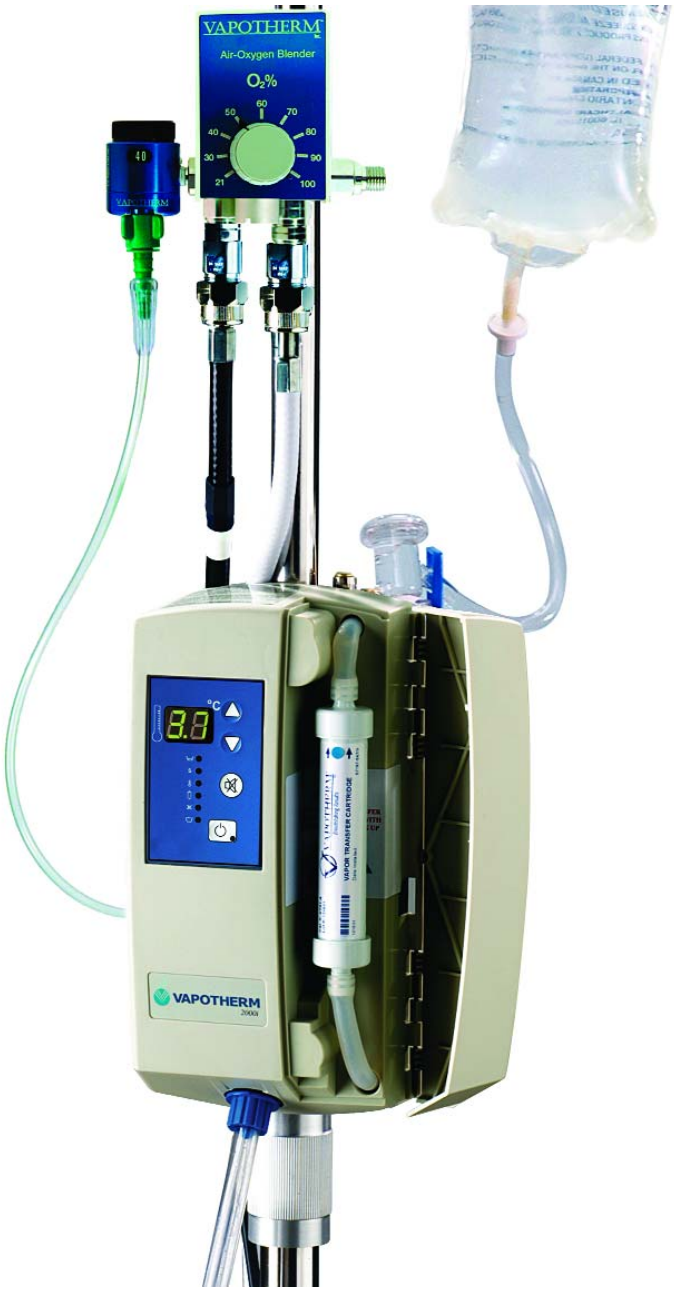
High-flow humidified oxygen therapy for neonates requiring respiratory support



Vapotherm vapour transfer technology provides optimal conditioning of breathing gases at body temperature and at 95% or greater relative humidity. This allows for the delivery of flows in the neonatal application of between 1 and 8 litres per minute via nasal cannula – higher flows are possible for paediatrics and adults.

Vapotherm therapy is simple to use and offers a high degree of patient comfort and compliance, with babies noticeably more settled when using Vapotherm. There is no rain out throughout the whole system due to the unique triple lumen delivery tube that keeps the gas warm right up to the cannula.

Inspiration Healthcare Limited, 14 Barshaw Park, Beaumont Leys, Leicester LE4 1ET. Tel: +44 116 2351010. Fax: +44 116 235 0150
info@inspiration-healthcare.co.uk/johnnash@vtherm.com www.inspiration-healthcare.co.uk/www.vtherm.com

High-flow humidified oxygen therapy for neonates requiring respiratory support

The Vapotherm2000i™ device provides warm humidified gas via standard nasal cannulae at flows of up to 8 L/min with approximately 95% relative humidity at body temperature[1]. This article reviews early clinical experience with this device in a UK tertiary neonatal service.

Non-invasive ventilatory support in neonates has traditionally been restricted to nasal continuous positive airway pressure (nCPAP), nasal cannula oxygen or head box oxygen.

The use of nCPAP in infants is not without its problems. All nCPAP devices are fitted to an infant's face using bulky fixation systems. Consequently, infants are often restless when on nCPAP, which can make it difficult to maintain the device in a proper position. When dislodged it is less effective as it will not deliver the required positive end expiratory pressure (PEEP). Bulky fixation devices also place an obstruction in an infant's visual field, which may affect visual maturation.

Complications of nCPAP include:

- trauma to the nasal septum
- airway obstruction from secretions requiring regular nasal pharyngeal suctioning
- abdominal distension and feed intolerance
- risk of pneumothorax

Nasal cannula oxygen therapy use is limited by inadequate humidification and the consequent drying effect on the nasal mucosa resulting in nasal obstruction from secretions[2]. This means that flow rates are restricted to 0.5-2 L/min[3].

Warm humidified head box oxygen is still used in some units but is technically difficult and access to infants, especially larger ones, is limited.

VAPOTHERM2000I™

The Vapotherm2000i™ (VT) device (*FIGURE 1*) delivers around 95% humidified air or blended oxygen through ordinary nasal cannulae, without rainout, with flows of up to 8 L/min[1]. The VT humidifies and warms flows of air; blended air and oxygen; or pure oxygen; for delivery to infants via nasal cannulae. Warming and humidification occurs in a special cartridge inside the body of the machine. Within the cartridge is a membrane separating the air and the water, which is permeable to water vapour and excludes bacteria from crossing from the water to the gas[1]. The warmed humidified gas stream passes from the cartridge down a special triple lumen tube. Humidified gas travels in the middle lumen, the outer lumens contain warmed water. The nasal cannula is attached to the triple lumen tube close to the infant to prevent heat loss.

VT has been shown to be effective in reducing hypoxaemia in adult patients with chronic obstructive airways disease and asthma since the late 1990s[4]. In 2004 and 2005 early data obtained in a small numbers of infants showed VT to be a safe and successful alternative to nCPAP[5,6]. VT performed better than standard high flow nasal cannula oxygen in a small randomised trial in 30 newly extubated preterm infants. VT was better than nasal cannula oxygen at 1-2 L/min in avoiding reintubation, reducing respiratory effort score and reducing nasal mucosal abnormalities on blinded examinations[7].

A retrospective study of infants of all gestational ages comparing a cohort of infants who received VT compared to historical controls who received nCPAP, showed no difference in deaths, ventilator days, BPD, blood infections or other outcomes[8].

CLINICAL CONCERNS

There are two main concerns regarding VT use:

Written by
Cassie Lawn MBBS, DRCOG, MRCGP, MRCPCH,
Consultant Neonatologist, Trevor Mann Baby Unit, Brighton cassie.lawn@bsuh.nhs.uk

infant
Volume 3 Issue 3 2007, Pages 105-108

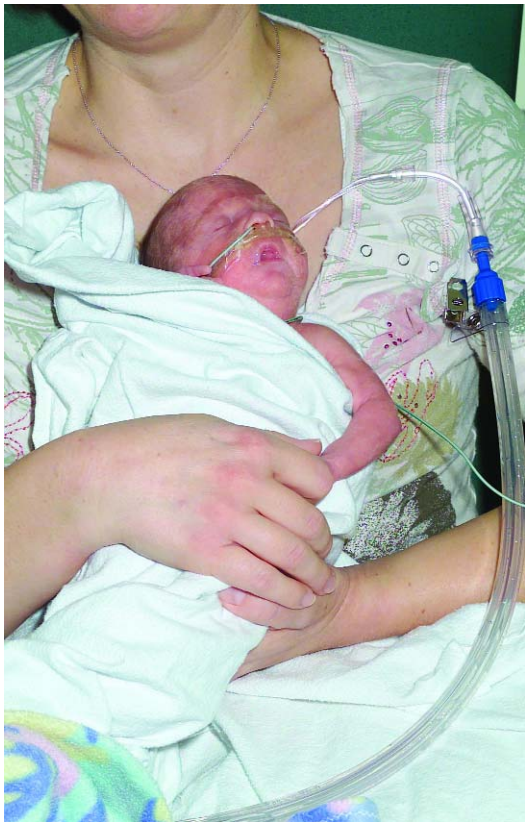


FIGURE 2 Preterm infant on VT.

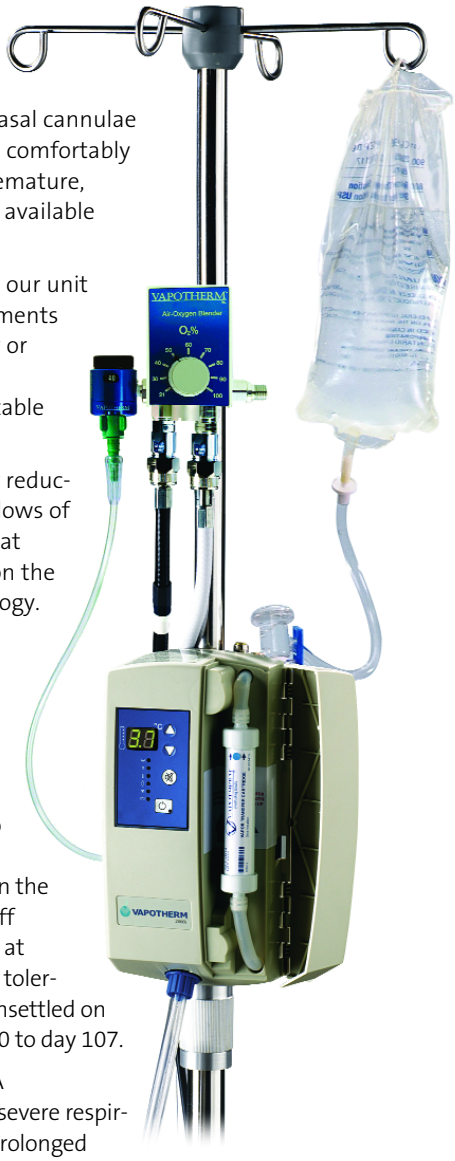
1. Possible CPAP effects

Oesophageal pressure measurements (to estimate airway end distending pressures) in a small study of 18 preterm infants weighing less than 2kg showed an increase in pressure at VT flows of 3, 4 or 5 L/min – although the mean increase was <2cm H_2O[9]. By comparison, high flow nasal cannula oxygen at 1-2.5 L/min has been shown to deliver pressure equivalent to nCPAP at 6cm H_2O in infants <2kg[10]. Thus it is likely that there are small CPAP effects from VT, but further work is needed to support or refute the equivalence of VT with nCPAP[11].

2. Potential for infection

Ralstonia species were isolated from VT devices and from clinical specimens from 18 paediatric patients in five hospitals in the USA in 2005. Ralstonia species are gram-negative bacilli that grow well in moist environments and are an infrequent cause of colonisation and infection in humans. Following notification to the Centre for Disease Control (CDC) and Food and Drug Administration (FDA) in the USA, Vapotherm Inc recalled the device. In response to the investigation, Vapotherm has developed a new spike adaptor to enable single use, sealed bags of sterile water to be used in the delivery circuit, rather than refillable bags. In addition their cleaning guidelines emphasise that devices must be disinfected thoroughly between patients or every 30 days. The Vapotherm-2000i™ device was reintroduced following clearance from the CDC and FDA in January 2007 with no restriction. Concerns regarding risk of infection in infants receiving VT must be viewed in context – three Ralstonia infections were confirmed by CDC between January and December 2005. This represents 1 per 0.000025 patient VT episodes (0.0025%) based on 11,000 uses per month (estimated from sales figures). This must be compared to a risk of ventilator acquired pneumonia in ventilated paediatric patients of 0.47% per ventilator day (data from CDC).

FIGURE 1 Vapotherm2000i™ device mounted for clinical use.



Set up and settings

The VT is straightforward to set up. Nasal cannulae should be selected in the size that fits comfortably into the nares. There are neonatal, premature, infant or intermediate sized cannulae available (*FIGURE 2*).

Flow rates are started at 5-6 L/min on our unit and then adjusted in increasing increments of 0.5 L/min if the saturations are low or there is respiratory distress, until the saturations and respiratory rate are stable up to a maximum flow of 8 L/min.

Weaning stable infants is achieved by reducing the VT flow by 0.5-1 L/min until flows of 1-3 L/min are achieved. The flow rate at which to end VT treatment depends on the severity of the underlying lung pathology.

CLINICAL USES IN OUR CENTRE

• Infants who were unsettled on CPAP

The first was an ex 24 +2 gestational age (GA), birthweight (B Wt) 660g, who had CLDP and prolonged ventilation. Initially VT was cycled with nCPAP when the infant was able to tolerate two hours off nCPAP on day 98 of life. The VT was set at 6 L/min in 30-35% oxygen. VT was well tolerated and as the infant appeared very unsettled on nCPAP, VT was used solely from day 100 to day 107.

The second infant was born at 28+2 GA (B Wt 850g). This infant had unusually severe respiratory distress syndrome and required prolonged ventilation with conventional mechanical ventilation, high frequency oscillatory ventilation and nitric oxide and was finally extubated to nCPAP after a very stormy course on day 77. When nCPAP in 50-70% oxygen was able to be cycled with nasal cannula oxygen at 1.5 L/min on day 90, VT was started at 7 L/min in 60-70% oxygen. This infant was more settled on VT. To wean VT, flows were gradually reduced to 5 L/min and as the oxygen requirement gradually fell VT was changed to nasal cannula

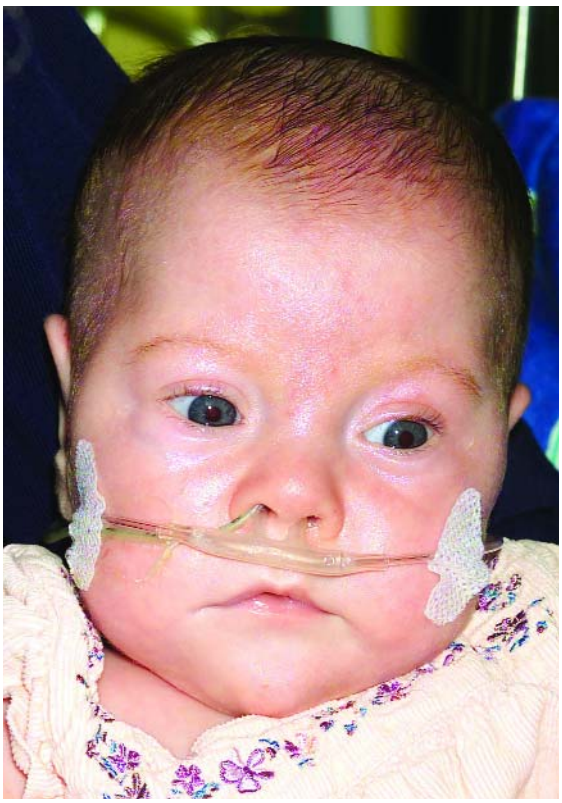


FIGURE 3 Post term corrected GA infant on VT.

oxygen on day 148 at 0.6 L/min. This infant was discharged home in oxygen at 0.6 L/min on day 173.

VT was used in two triplets, the donor and recipient of twin to twin transfusion syndrome, born at 25 weeks and 6 days GA (B Wt 700g and 550 g). These two infants had extremely complex problems including severe CLDP and hypertrophic cardiomyopathy. VT was used in these infants as an alternative to nCPAP after term corrected gestational age as it was felt to be better tolerated by both infants.

VT was commenced on day 106 of life in an ex 28+1 week GA donor, in twin to twin transfusion syndrome (B Wt 950g), who had extremely severe CLDP. This infant was finally successfully extubated to nCPAP on dexamethasone on day 87 of life. VT was commenced at 7 L/min in 50 -70% oxygen following a period of stability on nCPAP. Initially VT was cycled with nCPAP but as VT was better tolerated with no increase in inspired oxygen concentration it was used as the sole respiratory support from day 108 of life.

• Infants with nasal injury from nCPAP

Two infants suffered nasal injury on nCPAP, a twin to twin transfusion syndrome recipient born at 28+1GA (B Wt 1175g) and a 25 +4 GA infant (B Wt 790g). Both received VT from day 16 and day 37 postnatal age respectively following n CPAP. Both were initially treated with alternating VT and nCPAP followed by sole VT as it was better tolerated. Both infants' nasal injuries healed on VT.

• As an alternative to nCPAP following extubation

Three infants (27 weeks GA, B Wt 1196g; triplet 26 weeks GA, B Wt 930g; 30+6 weeks GA, B Wt 1695g) were treated using VT as an alternative to nCPAP on day 9, day 33 and day 3 of life respectively. All infants received nCPAP prior to VT following extu-bation, all infants received initial flows on VT of 6 litres/ minute, and all tolerated VT well.

SUMMARY

VT was introduced on our unit for infants who were stable but had difficulty tolerating either Fisher and Paykel bubble CPAP or EME Infant Flow™ continuous flow driver CPAP. This use progressed to smaller infants who had nasal injuries from nCPAP and VT is now considered as an alternative to nCPAP following extubation in some circumstances.

The feedback from nursing staff and parents has been very positive. All infants on VT were felt by their carers to be more comfortable when on VT than when on nCPAP. Nurses reported fewer secretions on VT and less desaturations as infants are more settled. Setting up the system requires training, but once this is achieved the system is not difficult to use. Infants on VT are cared for in the special care room on our unit rather than the intensive care or high dependency areas. This has been advantageous as it allows greater flexibility in cot management, however these infants continue to be monitored as if they were receiving nCPAP.

The use of relatively untested devices is not new in neonatology. Despite the fact that this device is well tolerated and easy to use, it must still be introduced cautiously until further trials are available to delineate optimal timing, safety and efficacy of its use in the neonatal population.

REFERENCES

1 **Company literature: Vapotherm Inc website http//:www.vtherm.com**

2 **Kopelman A., Holbert D.** Use of oxygen cannulas in extremely low birthweight infants is associated with mucosal trauma and bleeding, and possibly with coagulate-negative staphylococcal sepsis. *J Perinatol* 2003; **23**(2): 94-97.

3 **Finer N.N., Bates R., Tomat P.** Low flow oxygen delivery via nasal cannula to neonates. *Pediatr Pulmonol* 1996; **21**(1): 48-51.

4 **Nammour H. et al.** High flow humidified nasal room air improves hypercapnia during wakefulness and sleep in severe COPD patients. *Am J Resp Crit Care Med* 1999; **159**.

5 **Bukush M., Clarke D., Klukow M.** Initial clinical experience with Vapotherm™ – a new high humidification device. Newborn Care Centre, Royal North Shore Hospital, St Leonards and University of Sydney NSW. Perinatal Society of Australia & New Zealand. April 2005.

6 **Nair G., Karna, P.** Comparison of the effects of Vapotherm and Nasal CPAP in Respiratory Distress in Preterm Infants. Pediatric Academic Societies' Annual Meeting. 2005.

7 **Woodhead D.D. et al.** Comparing two methods of delivering high-flow gas therapy by nasal cannula following endotracheal extubation: A prospective, randomized, masked, crossover trial. *J Perinatol* 2006; **26**(8): 481-85.

8 **Shoemaker M.T., Pierce M.R., Yoder B.A., DiGeronimo R.J.** High flow nasal cannula versus nasal CPAP for neonatal respiratory disease: A retrospective study. *J Perinatol* 2007; **27**(2): 85-91.

9 **Saslow J.G. et al.** Work of breathing using high-flow nasal cannula in preterm infants. *J Perinatol* 2006; **26**(8): 476-80. Epub 2006 May 11.

10 **Sreenan C. et al.** High-flow nasal cannulae in the management of apnea of prematurity: A comparison with conventional nasal continuous positive airway pressure. *Pediatrics* 2001; **107**(5): 1081-83.

11 **Gilmore M.M.** Preterm VLBW infants: Post-extubation respiratory support. *J Perinatol* 2006; **26**(8): 449-51.