High flow nasal cannula (HFNC) for respiratory support (Vapotherm Precision Flow)

Background:
High flow nasal cannula (HFNC) refers to the delivery of humidified heated and blended oxygen/air at flow rates greater than 1L/min via nasal cannula.
HFNC can be used for
- Non-invasive ventilation of extremely preterm / preterm infants
- Non-invasive ventilation for infants with parenchymal lung disease (HMD/pneumonia/CLD/ MAS/ pulmonary hypoplasia/ bronchiolitis)
- Treatment/prevention of apnoea of prematurity

This guideline describes our experience and use of the Vapotherm Precision with a low flow cartridge installed (range 1-8 L/min) to deliver non-invasive ventilation (NIV) from extremely preterm to term infants. We have used this for the past 4 years, and it is our routine first line tool for non-invasive ventilation. Our standard policy is to extubate most preterm babies within an hour or two of birth if possible, regardless of gestational age depending on condition. Below 600g however NIV is frequently unsuccessful and it can be difficult to predict which babies can avoid prolonged invasive ventilation. Our aim, as always, is to use the least invasive support possible to achieve stabilisation and minimise adverse outcomes.

How does HF work?
The mechanisms of how High Flow works are multiple and probably have differential contributions at different gestations and disease cycles.
- Flush is an important and novel concept, and flush is improved by having small nasal prongs to allow leak. This also means that we never use chin-straps etc as flush relies on the flow of gas escaping!
- Gas conditioning – the evidence is that unconditioned (i.e. gas that is not fully humidified or at 37 degrees) causes adverse compliance changes in lung tissue
- HFNC provides some PEEP – the evidence is about 4 cm H2O up to 8 litres/min. However this is not a CPAP device, and we are not controlling nor weaning PEEP.

How does CPAP compare?
- Reduced work of breathing through chest wall stabilisation, preservation of surfactant, reduction of atelectasis etc
- Some babies seem to be more stable at high mean airway pressures (8-10cm H2O measured at the nares), although there is limited evidence that this is transmitted at alveolar level.
- Stabilisation / opening at a larger airway level.
- PEEP may improve gas exchange at alveolar level
- Head’s (pharyngeal dilatation) reflex was thought to be an important mechanism in CPAP, however the contribution of this remains unclear.
- Other mechanisms may involve e.g. stimulation of nasal mucosa.

Work of breathing may also be reduced by humidification of gases, a particular feature of HFNC delivery. There is no difference in the work of breathing between CPAP and HFNC (Saslow)
There is some evidence that synchronised BiPAP (SnIPPV) use in infants at greatest risk of BPD or death (500-750 g) was associated with decreased BPD, BPD/death, neurodevelopmental impairment and death when compared with infants managed with NCPAP (Bhandari). To date we have seen no clear differences between the use of CPAP (and variants) and HFNC in terms of successful and unsuccessful non-invasive ventilation; however this has not been set in the context of a trial. Our experience of successful use of Vapotherm in extremely preterm babies is growing and we routinely manage babies of 500-600 grams upwards using high flow.

Finally there may be emerging evidence that Vapotherm is superior for this purpose than Optiflow (Woodhead et al). If true, this is likely to be for the flush effect around loose fitting nostril prongs. This is a guideline, not a discussion paper however.

Benefits include

- Babies on HFNC appear to be well settled and more comfortable than babies on CPAP.
- Less abdominal gaseous distension than CPAP
- Babies do not require “time off” for nose breaks or changes between nasal prongs / masks, reducing the amount of handling.
- Some evidence for better weight gain and improved feed tolerance.
- Parents have reported preferring being able to see more of their babies face.
- Easier access for cranial ultrasound scans and head circumference measurements.

When to use Vapotherm for non-invasive ventilation:

There is, at the moment, no outcome data to suggest that any one non-invasive respiratory support mode is significantly better than the other, and anecdotal reports may be the strongest deciding factor, which is acceptable whilst equipoise exists.

Therefore any baby can be considered suitable for HFNC treatment, at any age/gestation, provided they are breathing, do not have congenital abnormalities that make HFNC impossible to administer and are not likely to require imminent mechanical ventilation.

We no longer withhold HFNC if a baby is from another NICU/SCBU that does not have HFNC on the basis that we wish to offer the best treatment, in the judgement of the clinician, to all babies regardless and also that the number of units using HFNC is increasing all the time – all Surrey and Sussex SCBU now have at least one HFNC unit.

When to decide Vapotherm is not providing sufficient support:

- Recurrent / persistent apnoeas
- Increasing FiO2
- Increasing work of breathing
- Increasing pCO2 / TcCO2 causing acidosis

may indicate that the baby is not responding well to Vapotherm treatment.

Unless intubation and ventilation is required, it is suggested that sNIPPV (BiPAP with trigger) is used as a more aggressive technique of non-invasive ventilation. However babies who are becoming apnoeic due to sepsis etc, will require ventilation and the clinician should not automatically elevate to sNIPPV as intubation may be more appropriate.

Our experience is that many babies escalated to BiPAP progress to full ventilation. The failure rate is no worse with Vapotherm than with CPAP and may be better.
Setting up the Vapotherm:

- Wait for desired operating temperature to be reached before placing the cannula on the end of the patient delivery system: Set at 37°C for all flows unless in an open cot, where condensation may become an issue at flows <4l/min.
- Attach appropriate sized nasal cannula. Cannula should not obstruct or be larger than ½ the diameter of the nares.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Cannula type</th>
<th>Outer diameter at tip</th>
<th>Outer diameter at base</th>
<th>Inter prong distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.0 kg</td>
<td>Premature</td>
<td>0.152 cm</td>
<td>0.254 cm</td>
<td>0.559 cm</td>
</tr>
<tr>
<td>1.0 - 2.0 kg</td>
<td>Neonatal</td>
<td>0.152 cm</td>
<td>0.254 cm</td>
<td>0.660 cm</td>
</tr>
<tr>
<td>&gt;2.0 kg</td>
<td>Infant</td>
<td>0.185 cm</td>
<td>0.227 cm</td>
<td>0.762 cm</td>
</tr>
</tbody>
</table>

- Adjust the flow to the desired rate and place the cannula on the patient. Operational flow rates range from 1-8 L/min
- Start at flow rate of 7 L/min
- Increasing flow (maximum 8L/min): flow can be increased in increments of 0.5-1 L/min to try to treat increasing oxygen requirements or apnoea of prematurity. However other causes (sepsis, worsening RDS, pneumothorax, exhaustion etc should be considered)
- If the baby is requiring FiO₂ >60%, or has significant persisting respiratory acidosis (pH<7.2) or apnoea s/he is likely to need alternative support.
- Nursing:
  - Minimal handling, quiet and dark appropriately humidified environment
  - Monitoring of heart rate, respiratory rate and SaO₂ as a minimum
  - Blood pressure monitoring intermittently unless UAC/arterial line in place
  - Prone position, tilted head up to minimise work of breathing
  - Nasogastric tube should ensure that nostril not occluded and than tube does not ‘pull’ nares towards cheek.
- Medical checks:
  - Blood gases are indicated if on supplemental oxygen or on clinical grounds. A stable baby in air does not require blood gases to be checked from a respiratory perspective
  - Coordinate examinations, blood tests and procedures with nursing care to minimise handling
Weaning a baby on Vapotherm:
The purpose of weaning is to find the **minimum required level of support** and this process should begin once the baby is stable. This is a clinical decision.

**Term Babies and ex-preterms >1.0kg – weaning**
- More proactive weaning should be attempted, aiming to see if the baby will tolerate a reduction towards 2 – 2.5L/min which would permit switching off or to low-flow/ambient support. The table below provides a guide to weaning thresholds.

<table>
<thead>
<tr>
<th>FiO2&lt; 0.25</th>
<th>FiO2 0.25 – 0.30</th>
<th>FiO2 &gt; 0.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce by 1 L/min 24-48 hourly</td>
<td>Reduce by 0.5L – 1.0L/min 24 hourly depending on stability</td>
<td>Weaning &lt;4L/min usually not indicated</td>
</tr>
</tbody>
</table>

**Preterm Babies – weaning**

*For babies <1.0 kg*
- Babies on flow rates > 6L/min should have these re-evaluated regularly (minimum daily). Preterm infants are at high risk of pneumothorax, RDS and IVH in the first few days postnatally, and stability during that time is particularly crucial.
- For a stable babies, it is suggested that clinicians attempt to wean according to the criteria below until the flow rate is about 4-5 L/min.
- Once the baby is settled in the target range of 4-5L/min we do not aggressively wean the respiratory support further, unless the baby is in air. Instead, we concentrate on achieving growth and stability, using the Vapotherm to minimise energy expenditure on breathing. Opportunistic weaning may be possible, and babies should have this discussed and documented regularly.

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<th>FiO2 &gt; 0.30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce by 0.5 L/min 24 hourly if stable</td>
<td>Reduce by 0.5L/min 48 hourly, sometimes 24 hourly if stable</td>
<td>Weaning &lt;6L/min usually not indicated but may be possible</td>
</tr>
</tbody>
</table>
For any baby being weaned on Vapotherm Flow

- If a significant and sustained increase in
  - Respiratory rate
  - Oxygen requirement
  - Work of breathing
  is seen in the 24 hours after weaning, then it is a clinical decision whether to revert back to the previous flow rate, or to continue at the new flow rate with close observation.

- If weaning has been halted, then it should be recommenced after 24-48 hours if there is no other clinical reason to delay.

- Once a baby is on minimal flow (2 - 2.5 L/min) and clinically stable, then extubation to ambient oxygen/air should be attempted.
  - Attempt to stop if in air and requiring 2.5L/min or less
  - Attempt switch to Low Flow Oxygen if in oxygen and requiring 2.0L/min

- Low flow nasal prongs should only be used if there is a persisting oxygen requirement.

- Vapotherm should be disinfected according to guidelines
  - The nasal prong circuit is changed weekly
  - The disposable patient flow circuit which includes the low-flow cartridge is changed monthly.
  - The machine is disinfected after every patient use according to manufacturers guidelines

Contraindications:

- Upper airways abnormalities precluding the placement of prongs
- Need for intubation: ventilatory failure, severe cardiovascular instability, unstable respiratory drive with frequent apnoeas

Guideline Details
Written by Dr. Peter Reynolds, Neonatal Consultant
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Review June 2014

References:

4. personal communication (Dr. K Ives, Neonatal Consultant, Oxford John Radcliffe)
5. Spence KL et al. High flow nasal cannula as a device to provide continuous positive airway pressure in infants. J Perinatol 2007;27(12):772-775
6. Armfield M Use of Vapotherm for respiratory support with neonates