High Flow (using the Vapotherm Precision Flow)

Background:

Nasal High Flow (HF) refers to the delivery of humidified heated and blended oxygen/air at flow rates greater than 2L/min via nasal cannula.
HF can be used for

- Non-invasive ventilation of extremely preterm / preterm infants
- Primary treatment for RDS
- Non-invasive ventilation for infants with ongoing parenchymal lung disease (HMD/pneumonia/CLD/ MAS/ pulmonary hypoplasia/ bronchiolitis)
- Treatment/prevention of apnoea of prematurity

Use of the Vapotherm Precision with a low flow cartridge installed (range 1-8 L/min) to deliver non-invasive ventilation (NIV) is our routine first line modality. 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 may be less 'successful', but we can't accurately 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. Our evidence shows that babies transferred from labour ward on nHF are more likely to have a more stable respiratory course

How does HF work?

The mechanisms of how nHF 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, dummies 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
- HF provides some PEEP – the evidence is that HF gives about up to 4-5 cm H2O (pharyngeal pressure) up to 8 L/min, and intratracheal pressures may be closer to 2cm H2O. HF is not a CPAP device, and we are not controlling nor weaning PEEP.

Work of breathing may also be reduced by humidification of gases, a particular feature of nHF delivery. There is no difference in the work of breathing between CPAP and nHF

Benefits include

- Babies on nHF 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:

Study data (Manley/Collins/Yoder etc.) show that HF and CPAP have very similar overall outcomes. Therefore any baby can be considered suitable for HF treatment, at any age/gestation, provided they are breathing, do not have congenital abnormalities that make HF impossible to administer and are not likely to require imminent mechanical ventilation.

We no longer withhold HF if a baby is from another NICU/SCBU that does not have HF 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 HF is increasing all the time – all Surrey and Sussex SCBU now have at least one HF unit. There is no good evidence that one manufacturer is better than another.

We have also observed that babies treated with nCPAP (e.g. transferred in from other units) seem to tolerate HF less, and may be more likely to need to go back onto CPAP especially where they have been on CPAP for a prolonged period.

Setting up the Vapotherm for HF:

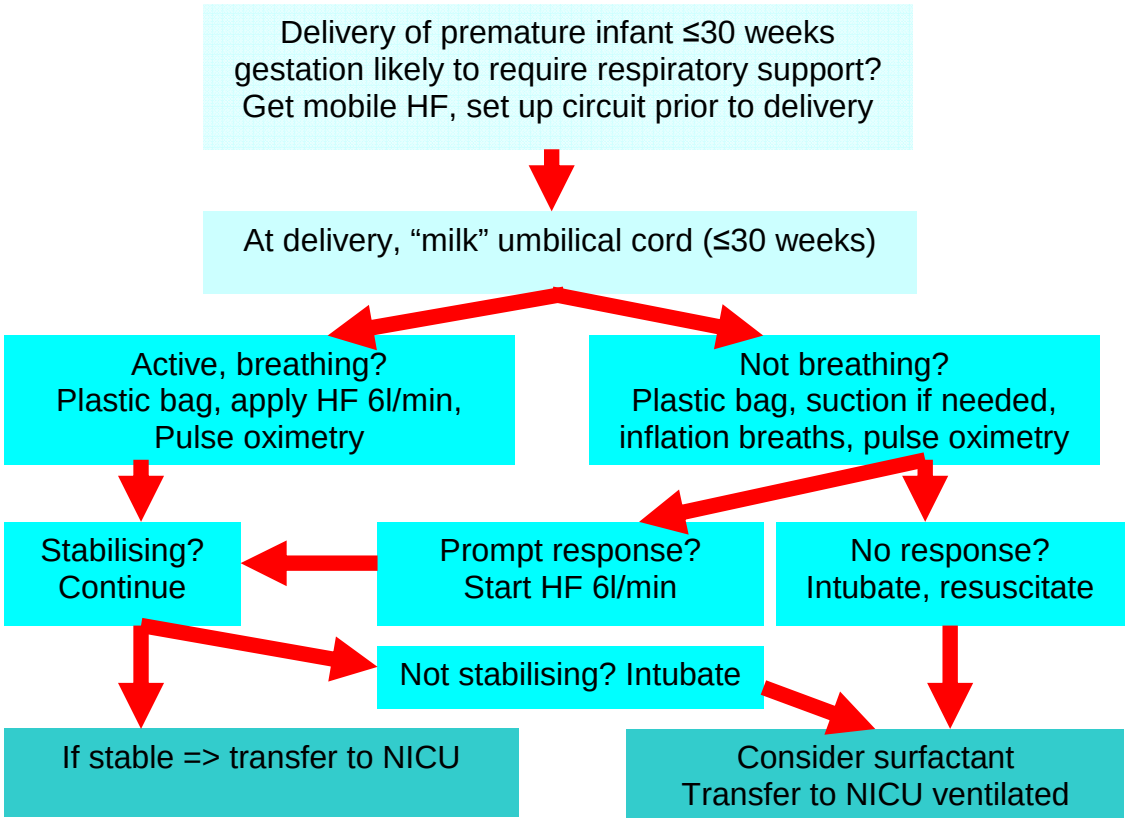
- Wait for desired operating temperature to be reached before placing the cannula on the end of the patient delivery system: Set at 37^{o}C for all flows unless in an open cot, where nasal cannula condensation may become an issue at flows <4l/min.
- Attach appropriate sized nasal cannula. The cannula must not obstruct the nostrils fully, and should generally allow for half of each nostril to be unobstructed.

Weight	Cannula type
<1.0 kg	Premature
1.0 - 2.0	Neonatal (or Premature if small nostrils)
>2.0 kg	Infant

Primary use of HF (from birth using mobile unit)

This is a new development we have pioneered in the use of High Flow. Supervision by an experienced registrar or consultant is important for those learning how to do it.

- Set up the mobile HF unit as normal, with air / oxygen flowing from cylinder / wall supplies depending on availability. Once the machine is set, minimise the flow to 1 l/min to conserve cylinder gas until the delivery of the baby takes place, it can be quickly turned up.
- Use an initial flow of 6 l/min
- All babies should be stabilised in air initially according to the flow chart (below). There should be no need for inflation breaths or suction in babies who are active and breathing



- Pull right forearm gently through small hole in plastic bag and apply saturation probe with cosy wrap
- Be patient and do not overuse oxygen. Provided the pulse is normal (generally >120/min), wait for saturations to rise steadily over the first few minutes.
- No unnecessary touching or handling. Do not "pull down" plastic bag to auscultate chest. Thermal stability is really important.
- **All babies should have a size 6 orogastric tube placed as soon as stable on open drainage**

LISA (Less Invasive Surfactant Administration) can be carried out with a baby on HF with ease

Post-extubation use of HF

- Adjust the flow to the desired rate and place the cannula on the patient. Clinical flow rates range from 2-8 L/min
- **Start at flow rate of 7L/min in most preterm babies <1000g, lower flows 5-6 L/min may be sufficient for babies ≥1000g**
- 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 FiO_2 >60%, or has significant persisting respiratory acidosis (pH<7.2) or apnoea s/he is likely to need alternative support.
- Nursing:
    - **Loose fitting nasal prongs to allow leak**
    - Place a size 6 orogastric tube, and leave the tube on free drainage to allow the escape of any gas from the stomach.
    - If the baby is large enough for a nasogastric tube (generally if >1kg) the nurse should ensure that the nostril not occluded and the tube does not 'pull' nares towards cheek.
    - Placement of OGT/NGT in stomach must be confirmed clinically (and radiologically if uncertain)
    - Minimal handling, quiet and dark appropriately humidified (see guideline) environment
    - Monitoring of heart rate, respiratory rate and SaO_2 as a minimum
    - Transcutaneous pCO2 monitoring is very useful and is strongly recommended
    - Blood pressure monitoring intermittently unless UAC/arterial line in place
    - Prone position, tilted head up to minimise work of breathing
    - No pacifier/dummy. No neck rolls or chin straps – the gas must escape through an open mouth.

- 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. Weaning can begin when the baby is stable, which may take hours or days.

Term Babies and ex-preterms >1.0kg – weaning

- More regular weaning should be attempted, aiming to see if the baby will tolerate a reduction towards about 3 L/min which would permit discontinuation or switch to low-flow/ambient support. The table below provides a guide to weaning thresholds. Do not be over-constrained by time, some babies can be weaned even more than twice a day.

Weaning strategy for Term babies / Ex-preterms >1.0kg		
FiO2< 0.25	**FiO2 0.25 – 0.30**	**FiO2 > 0.30**
Reduce by 1 L/min 12-24 hourly	Reduce by 0.5L – 1 L/min 24 hourly depending on stability	Weaning <4L/min usually not indicated

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 higher risk of pneumothorax, RDS and IVH in the first few days postnatally, and stability during that time is particularly crucial
- For 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 may not aggressively wean the respiratory support further, unless the baby is in air. Instead, we concentrate on achieving growth and stability, using the High Flow to minimise energy expenditure on breathing. Opportunistic weaning may be possible, and babies should have this discussed and documented regularly

Weaning strategy for Preterm babies (<1kg, flow >4-6L/min)		
FiO2< 0.25	**FiO2 0.25 – 0.30**	**FiO2 > 0.30**
Reduce by 0.5 L/min 12-24 hourly if stable	Reduce by 0.5L/min 24-48 hourly, sometimes 24 hourly if stable	Weaning <6L/min usually not indicated but may be possible

At lower flows (less than about 4 L/min), babies being nursed in open-cots may experience "spitting" of water from the nasal prongs due to condensation of the humidified gas. Turning the temperature down to 36 degrees C is usually sufficient to solve this. Don't reduce the temperature routinely as there is not always this problem.

For any baby being weaned on High 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 (2.5-3 L/min) and clinically stable, then extubation to ambient oxygen/air should be attempted. Sometimes babies can be taken off higher flows (e.g. 3.5 - 4 L/min).
- Attempt to stop if in air and requiring 3 L/min (or less)
- Attempt switch to Low Flow Oxygen if requiring oxygen and requiring 2.0L/min. Some babies may rarely need to be weaned to1 L/min before switching to low flow oxygen.
- Low flow nasal prongs should only be used if there is a persisting oxygen requirement.

Contraindications:

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

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High Flow "Dysventilation" (i.e. either hypo- or hyper-ventilation)

Routine HF (Vapotherm) management is flow up to 8 L/min. Minimal handling and prone position, ensuring shoulders are <u>above</u> baby's bottom when prone. Sometimes "dysventilation" will occur, which means that ventilation is not optimal:

HF hypoventilation

1. FiO2 >0.5 and rising
2. Persistent respiratory acidosis <pH7.20 (in conjunction with TcCO2 monitoring)
3. Recurrent significant apnoea and/or bradycardia despite caffeine load /maintenance 10-15mg/kg
4. Increasing WOB

and the following have been excluded

1. RDS responsive to surfactant
2. Pneumothorax
3. Oropharyngeal secretions causing airway obstruction
4. Congenital malformation
5. Equipment failure

Cold light examination of the chest, radiography of chest and/or abdomen, culture and antibiotic treatment should all be considered and performed if clinically indicated.

Consider if non-invasive ventilation (NIV) is still appropriate in the presence of
1. Significant sepsis
2. IVH
3. Pulmonary haemorrhage
4. GI perforation/NEC
5. Significant neuromuscular compromise
6. Circulatory compromise (e.g. myocardial dysfunction or cardiac failure)

Consider supportive measures
1. Antibiotics
2. Increased dose of caffeine
3. Blood transfusion

Next step options for managing hypoventilation are
(1) nBiPAP / nCPAP – aim MAP 6-8cm H2O
or
(2) mechanical ventilation

Escalation to BiPAP / nCPAP is the preferred option for high flow hypoventilation. Often intubation and ventilation is required in babies who are becoming apnoeic due to sepsis etc, and the clinician should not automatically elevate to BiPAP / nCPAP as intubation may be more appropriate. It is suggested that sNIPPV (BiPAP with trigger) is used as a more aggressive technique of non-invasive ventilation in cases where insufficient support appears to be mechanical. The failure rate is no worse with HF than with nCPAP.

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HF hyperventilation

1. pCO2 / TcCO2 less than 4.5 kPa
2. Persistent respiratory alkalosis >pH7.45

Next step options for managing hyperventilation are
1. Reduce flow by 1 L/min
2. Ensure continuous TcCO2 monitoring if possible

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Air Leak

The rate of any air leak in the SUPPORT trial of early CPAP was about 7-8%.This might include pneumothorax, pneumomediastinum or gastric perforation. The risks can be reduced by using the minimum flow needed for stability, and by ensuring nostril and mouth leak, and placement of a large bore orogastric feeding tube.

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About The Precision Flow – Troubleshooting/Common problems

Machine on, no alarms but no/reduced flow or baby oxygen requirement higher than expected?

1. Check the patient circuit is fully pushed into the Vapour transfer block (side connection)
2. Remove the vapour transfer block from the unit and check there is no liquid in the metal "bowl" at the bottom of the unit
3. Ensure that there is oxygen and air connected – if using the mobile unit ensure the gas manifold is correctly set to wall or cylinder (and if cylinder that the cylinder is switched on and contains gas (see dial)).

Oxygen Valve Accuracy

Please note that the Precision Flow cannot give 22% and 23% oxygen – the oxygen valve does not "open" until 24%, so readings of 22% and 23% will be air (21%).

Cleaning and Circuits:

- 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 manufacturer's guidelines

Guideline Details
Written by Dr. Peter Reynolds, Neonatal Consultant
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Updated and Section on dysventilation troubleshooting added/discussed August 2017

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