Clinical Guideline: Heated Humidified High Flow Nasal Cannula (HHHFNC) Guideline

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For use in: EoE Neonatal Units
Guidance specific to the care of neonatal patients.

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Approved by:

Neonatal Clinical Oversight Group	
Clinical Lead Mark Dyke	Matthew James

Audit Standards:

1. **Documentation of indication of HHHFNC**
2. **Record of clinical assessment after commencing HHHFNC**
3. **Blood gas analysis within 2 hours of starting HHHFNC**
4. **Documentation of decision to discontinue HHHFNC**

Heated Humidified High Flow Nasal Cannula (HHHFNC) Guideline

This guideline outlines the use of humidified high flow nasal cannula (HHHFNC) for non-invasive ventilation support in infants on the neonatal unit.
There are various manufacturers of HHHFNC devices including Vapotherm (Vapotherm Inc) Optiflow (Fisher-Paykel) and Fabian Therapy evolution. Setting up HHHFNC will depend on which device is used in each neonatal unit and relies on the correct choice of nasal cannula size.
There is considerable difference in experience in the use of this relatively new modality of non-invasive respiratory support in neonates.
Some neonatal units in the region have used this modality of non-invasive ventilation since 2008 and it is often their routine first-line tool for non-invasive support. Others have just started using it bigger babies while they continue to gain confidence.
The aim should be to use the least invasive respiratory support possible that permits stabilisation and minimises adverse outcomes.

Introduction:

- Humidified high flow nasal cannula (HHHFNC) delivers non-invasive respiratory support in neonates in the form of oxygen or a mixture of oxygen and air at flow rates ≥ 1L/min. Delivery of high flow rates via standard nasal cannula is not possible due to the negative impact on the respiratory mucosa with delivery of cold and dry gases. For this reason nasal cannula are only used at low flow-rates (generally <0.5L/min) to deliver supplemental oxygen and maintain saturations.

- HHHFNC offers an alternative option to low-flow nasal cannula, head box oxygen and nasal continuous positive airway pressure (nCPAP).

- It may be used as primary therapy or as step down care from mechanical ventilation. Early initiation of non-invasive ventilation is advocated to prevent prolonged use of endotracheal ventilation, which increases the risk of bronchopulmonary dysplasia (BPD), air leak and lung injury (Lee et al., 2020).

- HHHFNC can be used for non-invasive ventilation support in both term and premature infants.

Background & Rationale:

- HHHFNC allows the delivery of oxygen or a mixture of oxygen and air at flow rates greater than the inspiratory flow rate possible for a neonate to achieve (Kugelman et al 2014)

- Entrainment of room air is reduced as the flow-rate increases and hence HHHFNC therapy can deliver oxygen at higher concentrations than is possible by low flow therapy or head box oxygen.

- This can be achieved by flows greater than 2L/min; however, the American Academy of Respiratory Clinicians advocates a flow of at least 3L/min to define high flow therapy.

Non-invasive delivery of gases by other modes has different benefits and complications.

- Face masks / standard low flow intranasal cannula are uncomfortable and can cause irritation due to the use of dry, cold gases. Infants treated with low flow nasal cannula oxygen, require more suctioning, which can lead to mucosal damage, bleeding and infection.

- Head box oxygen can generate significant noise and can lead to substantial fluctuations in the delivered FiO_2 during cares, examinations and incubator entry.

- Nasal CPAP (nCPAP) delivered via nasal prongs or nasal mask has been shown to cause barotrauma as well as trauma to the nose and head. Abdominal distension is often seen and can at times lead to avoidable discontinuation of feeds, completion of septic screens and abdominal X-rays (Armfield and West, 2009).
- Bubble humidifiers do not significantly increase humidity and temperature and have been associated with mucosal trauma, infection and nasal bleeding.

The use of HHHFNC may minimise or avoid the problems noted above and has gained popularity due to it's ease of use, increased comfort and benefits with mother – infant bonding (Lee et al., 2020).
There is evidence that HHHFNC provides some PEEP, approximately 3-5 cm H_2O when flow rates up to 8 L/min are used (Collins et al 2013). However, HHHFNC is not a CPAP device and the PEEP is neither controlled nor monitored.

Mechanisms of Action:

The mechanisms of action of HHHFNC are multiple and probably have different contributions dependent on the gestation of the infant and disease cycle.

- 'Flush' is an important and novel concept. Flush is improved by having small nasal (< 50 % of the diameter of the nares) prongs to allow leak. The flush of carbon dioxide during expiration from the upper airways dead space is probably the most important mechanism underlying its efficacy (de Jongh et al 2014, Dysart et al 2009).

- Gas conditioning: the evidence is that unconditioned gases (not fully humidified and not at 37°C) cause adverse compliance changes in lung tissue. Heated and humidified gases therefore;
    - Improve functional residual capacity
    - Reduce inspiratory resistance and subsequently improves work of breathing (Dysart et al 2009)
    - Improve lung compliance with increasing flow-rate (Dysart et al 2009, Saslow et al 2006)
    - Aids carbon dioxide elimination
    - Improves oxygenation (Dysart et al 2009).
    - Delivery of heated and humidified gases reduce metabolic demand of conditioning the inspiratory gases. With respiratory distress and tachypnoea, minute ventilation increases leading to larger volumes of

Inspired gases requiring warming and humidification by the nasopharynx.This leads to a considerable energy demand. By providing gases that arealready conditioned, HHHFNC aims to counteract this extensive energy expenditure (Dysart et al 2009).

- Continuous positive distending pressure (CPDP) prevents alveolar collapse. The amount of CPDP produced is directly related to the degree of flow delivered in a linear association. However, the patient's weight, the size of nasal cannula in relation to size of nares also impact upon CPDP produced, although to a lesser degree (Collins et al 2013, Dani et al 2009).

Summary of Actions:

Dead space washout	Reduce dead space making minute ventilation more efficient
Reduce inspiratory work of breathing	Exceed inspiratory flow thus eliminating nasal resistance
Improved lung Mechanics	Warmed, humidified gas has been shown to improve conductance, lung compliance and lung elasticity
Eliminates metabolic work associated with gas conditiong	Attenuates the energy and water loss associated with conditiong inspiratory gas
Provision of mild distending pressure	Provides positive distending pressure for lung recruitment. It prevents alveolar collapse
Improve secretion mobilisation	Ideal humidification of the inspired gas has been shown to restore muco-cilliary function and reduce symptoms of airway exacerbations

Table adapted from: High Flow Nasal Cannula Therapy in Neonatology (TL Miller 2013).

Choice of Nasal Cannula Size:

- Fitting nasal cannula that is narrower than the size of the nares is vital in preventing the generation of potentially harmful high pressures.

- The nasal cannula should be no larger than 50% of the diameter of the nares to ensure only safe CPDP is produced (de Jongh et al 2014, Dysart et al 2009).

- Incorrect nasal cannula fitting may lead to high distending pressures and pulmonary barotrauma, with the extremely premature infant being at greatest risk.

The choice of nasal cannula will depend on the device used

1. Vapotherm:

Weight	< 700 g	< 1100 g	>1100 g
Max flow rate	8 L / min	8 L / min	8 L / min
Outside tip diameter	1.5 mm	1.5 mm	1.9 mm

Adapted from Vapotherm: NICU pocket guide (Offers.vapotherm.com 2021).

2. Optiflow

Gestational age	< 32 weeks	27 weeks – 6 months
Weight	< 2 kg	1 – 8 kg
Max flow rate	8 L / min	8 L / min

Adapted from fphcare.co.uk (Optiflow Junior Nasal Cannula, 2021).

Operating Temperature:

Vapotherm - 35º C for flow rate < 5 L/min and 37ºC at > 5 L/min

Optiflow – humidifier set at 37◦C *(NB – use non invasive setting on the Fisher & Paykel MR850 humidifier)*

Fabian – humidifier set at 37◦C *(NB – use non invasive setting on the Fisher & Paykel MR850 humidifier)*

HHHFNC versus CPAP:

Studies have shown that HHHFNC is as effective as nCPAP when used in neonates and that there may be benefits to choosing HHHFNC over CPAP.

- In treating infants with respiratory distress, there is no difference in work of breathing of the patient when nCPAP and HHHFNC are compared (Klingenberg et al 2009, Saslow et al 2006)

- There is similar efficacy to nCPAP for support of neonates >28 weeks gestation with respiratory dysfunction; when applied post-extubation and when used as primary therapy (reducing the need for intubation and mechanical ventilation (Fleeman et al 2019). Some studies have in fact shown a greater rate of endotracheal intubation or need for re-intubation in patients treated with nCPAP. Greater caution is required when treating infants < 28 weeks gestation (Holleman-Duray et al 2007, Manleyet al 2013, Shoemaker et al 2007, Yoder et al 2013).

- There is no difference between extubation failure when HHHFNC is compared to nCPAP and no difference in those who went on to be diagnosed with bronchopulmonary dysplasia (Holleman-Duray et al 2007, Manley et al 2013, Yoder et al 2013).

- There are no differences in rates of PDA, intraventricular haemorrhage, periventricular leucomalacia, necrotising enterocolitis, laser eye surgery or sepsis (Holleman-Duray et al 2007, Shoemaker et al 2007).

- HHHFNC is as effective as nCPAP when managing apnoea of prematurity (Holleman-Duray et al 2007, Sreenan et al 2001).

- Infants treated with HHHFNC do not have an increased oxygen requirement when compared to infants treated with nCPAP (Sreenan et al 2001).

- Significantly reduced rate of nasal trauma compared to those treated with nCPAP (Kugelman et al 2014, Manley et al 2013, Yoder et al 2013).

- Significantly reduced rate of air leak for post extubation treatment compared to nCPAP (Fleeman et al 2019)

Benefits:

- Reduces work of breathing by improving gas exchange.

- Minimises nasal trauma when compared to nCPAP (Woodhead et al 2006, Collins et al 2013).
- Reduces risk of gaseous abdominal distension and therefore may improve feed tolerance.

- Delivery of humidified and heated gases protects the respiratory mucosa from drying and bleeding (Woodhead et al 2006). Delivery of cold, dry gases by other means can lead to bronchoconstriction, increased airway resistance and increased metabolic demand of conditioning the gases. Delivery of dry gases also leads to impaired lung compliance that negatively impacts upon respiratory distress (Dani et al 2009).

- May be tolerated better than nCPAP, reducing energy expenditure and improving growth (Holleman-Duray et al 2007, Shoemaker et al 2006).

- Infants do not require time off HHHFNC for nose breaks as with nCPAP.

- HHHFNC allows respiratory support to be provided alongside oral feeding.

- Optimises opportunities for parental care administration, including skin-to-skin and breastfeeding (Klingenberg et al 2009).

- Provides an alternative option for post-extubation respiratory support.

- Weight gain optimised in comparison to infants treated with nCPAP due to reduced metabolic demands, improved feed tolerance and earlier achievement of full feeds (Holleman-Duray et al 2007).

- Easy access to infants head for measuring head circumference, performing cranial ultrasounds or applying cerebral function monitors.

Drawbacks:

- Inability to measure and monitor airway pressure and therefore potential to over-distend the lungs
- Risk of pneumothorax.
- There are currently no studies / consensus on starting flow rates or weaning methods. These are likely to be dependent on gestation of infant, weight and degree of respiratory distress.
- Unknown impacts of HHFNC on the extremely premature or extreme low birth weight infant.

Indications:

- Non-invasive ventilation option in term and pre-term infant as step down treatment from mechanical ventilation or nCPAP or as first line treatment of:
    - Respiratory distress syndrome (surfactant deficient lung disease) / Grunting
    - Meconium aspiration syndrome
    - Respiratory acidosis
    - Chronic lung disease
    - Apnoea of prematurity
    - Post-operative respiratory support
    - Infants with nasal trauma secondary to nCPAP
    - Use in infants with facial deformities, which may mean nCPAP is difficult toapply.

- HHHFNC may be suitable for use in any infant irrespective of gestation; birth weight or age provided intubation and ventilation is not required. Caution, however, is advocated in the extremely premature and extreme low birth weight infants (Holleman-Durray et al 2007, Manley et al 2013, and Shoemaker et al 2007).

Contraindications:

- Abnormality in anatomy of upper airway preventing use of nasal prongs
- Respiratory distress requiring ventilation
- Worsening clinical instability

Starting HHHFNC:

- Ensure infant meets indications for use
- In infants > 1kg, start a flow rate at 6L/Min with FiO2 adjusted to maintain saturations. Flow rates may be increased by 0.5-1L to a maximum of 8L/min if:
    - Increasing FiO2
    - Increasing pCO2
    - Increasing respiratory distress
    - To manage apnoea
- In infants < 1kg, starting flow rates 4-5L/min may be advocated as flow rates >6L/min should not be exceeded in this group of babies. It should be a senior decision to use flows >6 L/min in this group of babies. If respiratory support needs to be escalated further, BiPAP or mechanical ventilation need to be considered.
- Clinical assessment of infant after initiation of HHHFNC within 30 minutes and blood gas analysis within 2 hours to be considered.
- Continuous monitoring of heart rate, respiratory rate and oxygen saturations is required
- If persistent respiratory acidosis, apnoeas, increased work of breathing or FiO2 requirement 50-60% alternative respiratory support should be considered in the form of BiPAP or intubation and ventilation.

Weaning:

- Weaning is a clinical decision and can be considered if:
  - Reduced work of breathing
  - Reduction in respiratory rate
  - Stable capillary blood gases
  - No apnoeas
  - Stable oxygen requirements
- Aim to wean flow-rate towards 3L / min
- Once a flow-rate of 3L / min has been reached, consider stopping HHHFNC
- If oxygen support is still required, low-flow nasal cannula may be trialled.
- The suggested weaning guidance would be as follows, but every baby might need individualised weaning plan based on his/her clinical status
- Weight > 1kg:
  - If FiO2 21% aim to wean flow by 1L/min every 12 hours as tolerated
  - If FiO2 22- 25% aim to wean flow by 1 L / min 24 hourly as tolerated
  - If FiO2 25 - 30% cautious weaning 1L / min 24 - 48 hourly as tolerated
  - If FiO2 >30 % weaning may not be possible but a minimum flow rate of 4 L / min should be maintained.
- Weight < 1kg:
  - If FiO2 21% -25% aim to wean flow by 1 L/min every 24 hours as tolerated
  - If FiO2 25 - 30% cautious weaning 1 L / min 24 – 48 hourly as tolerated

  - If FiO2 >30 % weaning may not be possible but a minimum flow rate of 6 L / min should be maintained.

- Weaning is a clinical decision and a more cautious approach may be advocated based on individual clinical circumstances.

- Increase flow rate again if on weaning there is a significant increase in:
  - Respiratory rate
  - Work of breathing
    _ _ _ _ _ _ _
  - FiO2
  - pCO2
  - Desaturations
  - Apnoeas

If flow rates are increased, delay further attempts at weaning until a period of stability has again been reached for 24-48 hours.

Weaning can be quite challenging in babies who have bronchopulmonary dysplasia specially if they have high non-invasive support. It can be particularly tricky for babies to be weaned from nCPAP to HHHFNC. It would be most sensible to be guided by your local LTV team for babies with bronchopulmonary dysplasia.

Summary: Initiation and Weaning of HHHFNC

Indications for HHHFNC

- Non-invasive ventilation in term / pre-term infant
- Respiratory distress syndrome / Grunting
- Meconium aspiration syndrome
- Respiratory acidosis
- Respiratory support post-extubation or weaning from BiPAP
- Chronic lung disease
- Treatment & prevention of apnoea of prematurity

Start HHHFNC

- Commence 6 L / min if >1kg, 4L/min if <1kg
- FiO2 to maintain saturations
- Clinical assessment at 30 mins
- Blood gas within 2 hours
- Flow can by increased to 8 L / min if needed, if > 1kg or 6 L/min if <1kg

Clinical Improvement

YES

NO

Start Weaning

	FiO2 21%	FiO2 22-25%	FiO2 25 – 30%	FiO2 >30%
Weight > 1kg	Wean 1L / min 12hrly	Wean 1 L / min 24 hrly	Wean 1 L / min 24 - 48 hrly	Wean flow to minimum 4 L /min
Weight < 1kg	Wean 1 L /min 24hrly		Wean 1 L /min 24 - 48hrly	Wean flow to minimum of 6 L/min

- 24 hours stability at 3 L / min – discontinue HHHFNC
- Start low flow nasal cannula O2 if required to maintain saturations
- If increased WOB, RR or FiO2 return to previous settings and halt weaning for a further 24-48hrs

Consider

- BiPAP
- Intubation and ventilation

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Exceptional Circumstances Form

Form to be completed in the **exceptional** circumstances that the Trust is not able to follow ODN approved guidelines.

Details of person completing the form:	
Title:	Organisation:
First name:	Email contact address:
Surname:	Telephone contact number:
Title of document to be excepted from:	
Rationale why Trust is unable to adhere to the document:	
Signature of speciality Clinical Lead: Date:	Signature of Trust Nursing / Medical Director: Date:
Hard Copy Received by ODN (date and sign):	Date acknowledgement receipt sent out:

Please email form to: mandybaker6@nhs.net requesting receipt.

Send hard signed copy to: Mandy Baker
EOE ODN Executive Administrator
Box 93
Cambridge University Hospital
Hills Road
Cambridge CB2 0QQ

East of England Neonatal Benchmarking Group

Benchmark: Heated Humidified High Flow Nasal cannula Oxygen
Version 2.

Score relates to practice in (unit):	
Scored by:	**Date scored:**

Statement:
There are various manufacturers of HHHFNC including Vapotherm & Optiflow.
Heated Humidified High Flow Nasal Cannula (HHHFNC) delivers non-invasive respiratory support in neonates, in the form of oxygen or a mixture of oxygen and air at flow rates >1.0L/min. Delivery of high flow rates via standard nasal cannula is contraindicated due to the negative impact on the respiratory mucosa with delivery of cold and dry gases.
HHHFNC is an established and effective respiratory support used in new-born infants with mild respiratory distress syndrome, apnoea or after extubation or INSURE
HHHFNC has a number of physiological benefits, including:

- Non-drying to the upper airway mucosa
- More accurate Fio2 delivery
- Reduced barotrauma and abdominal distension compared to NCPAP
- Improves functional residual capacity, lung compliance and oxygenation
- Reduces inspiratory resistance and subsequently improves work of breathing.
- Aids carbon dioxide elimination

HHHFNC may reduce the length of/need for ventilation and following ventilation in neonates with respiratory distress syndrome may potentially reduce the incidence of Chronic Lung Disease

Standards: Careful observation will be necessary to reduce the risk of trauma related to HHHFNC therapy.
Regular on-going assessments are instrumental in the success or failure of the infant on HHHFNC

Patient Group: Any infant cared for in a neonatal unit that requires respiratory support from HHHFNC

Triggers for the development of the benchmark:
Standardising practice
Including evidence into practice
Professional concerns
Documentation
Education

Criteria for scoring: Max. 6 infants nursed on HHHFNC in the last month will be assessed visually and their documentation reviewed.

Key Factors		**Individual scores**	**Possible total**
1.1	There is an evidence-based guideline to support clinical practice.		**3**
2.2	Patient Interface & HHHFNC Delivery System		**6**
3.3	Nursing Care/ documentation of infant receiving HHHFNC		**7**
4.4	Education and training		**5**

Factor 1: There is an evidence-based guideline to support clinical practice
Evidence based practice guidelines ensure that care delivered to the infant is of the highest standard.

Clinical guidelines are systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific circumstances, statements about different aspects of the patients' condition and the care to be given.

Factor 2: Patient Interface & HHHFNC Delivery System
In order to minimise the risk of potential damage caused by the HHFNCO2 interface, each time the system is set up it should be measured correctly and set up so as to not cause any pressure on the nares or septum.

Factor 3: Nursing Care of infant receiving HHHFNC
The on-going care of the infant on HHHFNC is primarily the responsibility of the registered nurse, who will ensure its safe and effective delivery.

With increased use of nasal HHHFNC in neonates there is evidence of decreased incidence of chronic lung disease and barotrauma.

Factor 4: Education and training.
Caregivers need to understand the HHHFNC system they are using to be able to troubleshoot and prevent complications.

Statements to justify scores/local action plans: