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East of England Paediatric Critical Care Operational Delivery Network

Collaborative working to deliver high quality care to our children and their families

Heated Humidified High Flow Therapy Resource Book (HHHFT)

(Version 1.0 June 2020)

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Use in conjunction with East of England Paediatric Critical Care HHHFT Nursing Competency and the HHHFT Clinical Guideline

Further copies of all documents are available on our website:

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What is Heated Humidified High Flow Nasal Cannula Oxygen Therapy?

It is Heated Humidified High Flow Nasal Cannula Oxygen Therapy, often abbreviated to 'high flow', 'HHHFOT', 'HFNC' or referred to as the brand name of the chosen delivery interface.

HHHFT is a minimally invasive therapy that delivers blended air/ oxygen via a nasal cannula interface at different flow rates.

HHHFT is a comfortable and effective means of delivering oxygen and humidification to infants and children in respiratory distress

Where has it come from?

HHHFT has been adapted by paediatrics from the neonatal environment where it was developed as an alternative to CPAP for pre term infants who required higher levels of oxygen to maintain their oxygen saturation levels.

HHHFT is replacing traditional methods of oxygen delivery in paediatrics such as nasal cannula oxygen which has a limited flow which directly restricts the delivery of oxygen, face mask or head box oxygen which had several limitations.

Head box oxygen or an oxygen tent is a method of delivering higher concentrations of oxygen to infants. Only suitable for infants - older babies and children not able to tolerate it. There is a risk of asphyxiation (particularly with tents) Not good in an emergency situation as access to the infant difficult and does not allow for parental interaction/feeding.

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Clinical Guideline

East of England Paediatric Critical Care

NHS

Heated Humidified High flow therapy (HHHFT) for children and young people: An East of England Approach

Indications (not exhaustive)	Contraindications	Cautions
• High Oxygen requirement • Signs of respiratory distress • Post extubation if clinically indicated	• Nasal obstruction or craniofacial abnormalities • Trauma/Surgery to nasopharynx • Recurrent apnoeas • Respiratory arrest or peri-arrest state • Undrained pneumothorax	• Drained pneumothorax • Upper airway obstruction

Staffing ratios

Staff to patient ratio should be determined based on the assessment of the overall condition of the patient. A validated Paediatric early warning score (PEWS) should be used and other critical care interventions considered. Patient ratios should be adjusted accordingly and flexibility required as condition may change rapidly.

Acuity	Low risk/long term use of HHHFT	Medium risk	High risk
Descriptor	Actively weaning HHHFT or established on HHHFT as a long term therapy Mild or no respiratory distress	Acute phase, some stability established but not able to wean FiO2 below 0.40 currently. Moderate respiratory distress.	Acute initiation phase, severe respiratory distress observing for responsiveness to HHHFT. High PEWS
Nurse ratio	1:4 (1:3 < 2yrs)	1:2 or 3	1:1

Isolation for HHHFT is unnecessary unless condition indicates otherwise. Use of NHSE Infection prevention and control guidance recommended.

Commencing treatment

1. Select interface and equipment based on local availability and patient age and weight
   Note: Interface size should not exceed 50% of nares. If flow rate below cannot be achieved on correct interface then use max flow for interface
2. On initiation a competent clinician should observe patient for comfort and compliance. If necessary the flow can be increased to reach recommended range below over a 5 minute period.
3. Titrate FiO2 to maintain SpO2≥92 (or alternative patient range
4. Escalate or wean. To avoid rapid deterioration or unnecessary continuation on HHHFT review response to HHHFT and follow escalation or weaning criteria below

<12kg	2 l/min/kg
13-15kg	20-30 l/min
16-30kg	25-35 l/min
31-50kg	30-40 l/min
>50kg	40-50 l/min

Response to treatment

Sustained response to HHHFT Nursing ratio 1:4 (1:3<2yrs)	Response to HHHFT Nursing ratio 1:2 or 3 if cohort is ward level	Unresponsive to treatment
Wean FiO2 to 0.3-0.4 (depending on patient)	Moderate respiratory distress continues and/or FiO2>0.40-0.6	In 1st hour:
Halve the flow rate If no clinical deterioration is seen after 4 hours HHHFT can be discontinued **(or as soon as 1 hour if paediatric consultant confirms)** Restart at weaning flow rate if stopping HHHFT not tolerated	Re-assess ECC's** and continue on current HHHFT settings until ready to wean Continue to observe for any deterioration or red flags*	• Re-assess ECC's** • Ensure paediatric consultant has reviewed • Discussion with retrieval service • Discussion/review with anaesthetic reg • Closely observe for any red flags* **After 2nd hour or with any red flags:** •Consider NIV or IMV • Prepare patient, team and family for intubation

Patient transfer

If patient transfer is required then a suitable risk assessment tool such as the STOPP tool should be used. Where portable HHHFT is not available a senior clinician should assess the appropriate oxygen delivery based on direct patient assessment.

***Red Flags for immediate escalation**

- Any apnoeic/bradycardic episodes
- Increasing respiratory distress after HHHFT commenced
- Clinically tiring
- PEWS indicates immediate escalation to resus team
- FiO2>0.60

Immediate escalation

- Increase FiO2 to max
- Call 2222
- Prepare for intubation
- Liaise with retrieval team or on site L3PCC
- Communicate with the family

Monitoring and patient management
Coloured dots refer to corresponding patient acuity

- Continuous oxygen saturations • • •
- Observation frequency and escalation according to PEWS •
- Min hourly observations and escalation according to PEWS • •
- Consider continuous ECG if required • •
- 2 hrly mouth and nose care including pressure area check • • •
- Hourly documentation of FiO2, flow rate, and temperature as well as equipment specific checks • • •

****Essential Care Considerations (ECCs)**

- Optimised positioning (e.g. head elevation)
- Consider referral for physiotherapy assessment
- Secretion clearance if indicated and safe to do so
- Consider feeding regime alteration according to risk and underlying disease.
  - •High risk should be NBM with IV fluids
  - • Med risk should be assessed before feeding and fed with caution
- Psychosocial support, clear communication, play and distraction
- Minimal handling/cluster cares
- Blood gas analysis not essential and acidosis a late sign of failure

Nasal cannula come in different sizes but have a standard maximum flow rate of 2L in infants and an absolute maximum of 4L in older children. [3,4]

There is some evidence from observational studies that the use of HHHFT in the management of children with respiratory insufficiency may be associated with a reduced work of breathing, improved ventilation and a decrease in the need for intubation. [13]

A study called First-ABC is currently recruiting patients into a randomised controlled trial to compare effectiveness of HHHFT and CPAP in both acute illness and post extubation.

What is the mechanism of action?

There are several reasons why HHHFT is useful in paediatric patients, these are:

Washout of the nasopharyngeal dead space.

The washout of the nasopharyngeal dead space with a large amount of oxygen can improve the efficiency of ventilation, when we exhale the airways are filled with expired gas, higher in carbon dioxide and lower in oxygen than room air (21%) which we then breathe in again with the next breath. In acute respiratory failure, the compensatory mechanism of increasing the tidal volume in advertently increases the amount of mixed gas with each breath. With heated humidified high flow oxygen, the

upper airways are ‘bathed’ in the higher concentration of oxygen and so the subsequent breath has a higher concentration of oxygen and a lower concentration of carbon dioxide. A higher proportion of the respiratory time can participate in gas exchange. This is why we usually see a reduction in the respiratory rate and the work of breathing which indicates HHHFT is effective.

High flow rates

The higher flow means a reduction in the entrainment of room air (which is at a lower oxygen concentration) and therefore a more reliable delivery of oxygen. High flow rates result in an increase in tidal volumes, which should be possibly higher than the patient own tidal flow. In other words, the work of breathing is reduced, and the respiratory rate is reduced as the oxygen is delivered to the nasopharyngeal space for less effort. The beneficial effect of this is reduced if the patient is ‘open mouth breathing’.

Impact of humidification of gases.

There is a recognised reduction of metabolic cost (energy expenditure) required for gas conditioning.[5] Humidification of the gases to core temperature creating relative humidity of near to 100% consequently increases the water content in mucous, this can facilitate secretion removal and may help decrease the work of breathing, and reduce the risk of epithelial injury to the airway.[6] Improvement of airway conductance and pulmonary compliance by reduction of the cold air effect, lower humidity is associated with worsening function of airway epithelial cells inflammatory markers.[5]

weaned directly to low flow oxygen. This should be a decision made by senior nurses and medics.

Cleaning and disinfection.

You should be aware of which elements of the tubing etc is disposable or should be retained and cleaned; and of the procedure for cleaning, disinfection and storage of the device and ensure this procedure is completed following the end of treatment, including the changing of filters as required by the manufacturers.

Weaning

In general terms after a period of stability, the FiO2 is weaned to an agreed level followed by the flow, in a steady manner. It is important that you understand the procedure for weaning in your unit, including the procedure for identifying when a patient is potentially ready to wean, and who is able (in terms of grade of staff) to initiate weaning. Once weaning has commenced, it is important to continue to closely observe the patient for signs of respiratory distress and increasing oxygen requirement. Never disregard the parent's perspective/ opinion; they know their children best. Weaning should be stopped and the previous settings returned to if the patient does not seem to tolerate the weaning, this should be escalated without delay to the medic in charge of the patients care and or to the nurse in charge.

Weaning tools/guidelines

The East of England Network has a published guideline which has a weaning tool. Where this is in use in your trust you should be guided by its principles. Alternatively you should follow your trust policy.

Resource management

During peaks of capacity, and depending on availability of equipment for HHHFT provision in your units, it may become necessary to rationalise HHHFT devices. You should be encouraged to consider whether children with an oxygen requirement but without increased work of breathing could be managed on low flow oxygen therapy; likewise with patients nearly weaned off HHHFT whether they can be

Providing an end distending pressure in the lungs

High flow is capable of delivering both high concentrations of oxygen and potentially continuous distending pressure. [1]

Continuous distending pressure is created when a patients functional residual capacity is increased - additional gas is trapped in the alveoli at the end of expiration which causes them to be 'stented' open and allows for a prolonged opportunity for gaseous exchange to occur. The pressure delivered to the distal airway is difficult to measure and studies have found it is unpredictable, but will vary depending on delivery device, size and fit of the cannula, mouth leak (eg. during crying) and flow rates. [2]

Patient Comfort

As with any intervention, patient compliance inevitably has an effect on success, HHHFT minimises the dry mouth usually experienced with regular nasal cannula or face mask oxygen and is generally perceived to be more comfortable [8] Children may benefit from starting at a lower flow rate and increasing the flow over a few minutes to reach the desired max flow. Play therapy is also useful; remember to involve the play team as early as possible. Once stabilised the infant can be nursed in the parents arms, a child can eat and drink (if appropriate) and communicate much easier compared to with a face mask, which of course contributes to improved comfort.

How will I know if HHHFT is working?

It is imperative to continue close observation of the child, paying close attention to PEWS and parental opinions, and escalate any concerns without delay.

Studies have looked at response to therapy after 60mins and concluded that children who are responding to therapy should demonstrate both:

an improvement in oxygenation
reduction in respiratory rate

There are a few predictors to response in the literature, clinical indicators for failure of HHHFT therapy include

A lack of improvement in oxygenation
Thoraco-abdominal asynchrony
Neurological impairment
Very high respiratory rate, hypercarbia, respiratory acidosis

The severity of the illness (often those initially presenting at a later stage of their illness), and the level of oxygen requirement are predictors of response to treatment.[7] Good responders to HHHFT showed a reduction in heart rate, respiratory rate and work of breathing within 60-90 minutes.[11]

Indications (not exhaustive)

The most evidence in paediatrics is around the use of HHHFT with bronchiolitis. Outside of that, the data is extrapolated from adult or neonatal experience, although paediatric evidence is growing. HHHFT is increasingly being used for children presenting with respiratory distress or requiring supplementary oxygen.

HHHFT is also used as conjunctive therapy (alongside other interventions) despite a lack of evidence, to treat asthma, pneumonia, croup, during transport, for pre oxygenation (for anaesthetic/ intubation), post extubation respiratory support, and anecdotally has been used with patients who are not for intubation,

systems were associated with increased levels of comfort.[16] Clinical efficacy was not tested. It is probable that the higher the flow, the lower the delivery efficiency is.

It is not possible to effectively deliver nebulised therapy via a jet nebuliser with face mask at the same time as HHHFT, remember that the patient is receiving their tidal volume from the HHHFT and will draw minimal air from the surroundings, including any nebuliser mask. In order for the patient to draw in the flow from the nebuliser, the flow of the HHHFT should be either reduced or stopped, depending on the patient's condition and how they will manage.

If an in-line nebuliser is used, driven by an auxiliary oxygen flow, ensure the HHHFT flow is reduced so the maximum flow for the size of child or interface is not breached for the duration of the nebulisation. Not all medications are licensed for all nebuliser devices.

Safety

A spare oxygen delivery port (this may be a cylinder) and oxygen mask should be available at the bedside in case of sudden equipment failure or clinical deterioration.

Weaning

Weaning is the gradual reduction in the level of the respiratory support provided by HHHFT to a point that it can be safely discontinued.

Ready to wean?

Again, there is very little evidence in the literature surrounding the best way to wean from HHHFT, although there are some small studies that have demonstrated having a weaning protocol reduces the duration of the admission these tend to based on children in a PICU and with a diagnosis of bronchiolitis. Despite this lack of evidence most units using HHHFT will have a policy for weaning.

The Network guideline is included at the back of this document, if your trust is not using the network guideline, you should follow your trust policy for weaning.

to moving. Take the device and recommence HHHFT at the earliest opportunity.

Tracheostomy
It is possible to administer HHHFT via tracheostomy, providing the correct interface is available. The minimum flow rates for T-HHHFT may be different to those for HHHFT and should be checked. 10LPM is mentioned in the literature as the minimum flow rate but this may vary per device and interface selection.

Nebulisers
Nebuliser therapy is the conversion of a liquid medication into an aerosol, and derives from the latin '*nebula*' meaning cloud. The rationale for using nebulised medication is to maximise the speed and efficacy of the drug to produce a local reaction in the lungs. We know that about 12% of the medication reaches the lungs however; many factors will affect the efficacy. There is very little evidence around the use of nebulisers with HHHFT.

Patients receiving HHHFT may also require nebulised medication to complement their therapy. There are several adaptions for administering nebulisers either via or alongside HHHFT on the market. The three most common options are-

- Use a 'traditional' jet nebuliser system
- Vibrating mesh nebuliser such as Aerogen ®
- In line system provided by the device manufacturer compatible with tubing and interface.

A very small study which compared the comfort of jet nebulisers with a mesh vibration system for infants concluded that mesh vibration

but have a respiratory illness, to relieve symptoms for patients on palliative care/at end of life.
Duration of therapy will be determined by the disease cause but will vary from hours to weeks to longer term.[9]

Contraindications
There is a general consensus in the literature that contraindications to HHHFT include:

- Critically ill infants and children who require a higher level of respiratory support
- Pneumothorax
- Facial trauma
- Suspicion of basal skull fracture
- Upper airway obstruction
- Persistent epistaxis

Complications
Undesired side effects of HHHFT are rare, and therefore it is a fairly safe therapy [16] However, there are some noted complications that bedside nurses should be aware of.

Pneumothorax
As there is no integrated pressure relief valve (as in CPAP) there is the potential for the end distending pressure in the lungs to increase, which may lead to a pneumothorax. To avoid this ensure the cannulae only occupy 50% of the size of the nares, and use the recommended flow for the cannula size chosen.

Ensure the nares are occluded by the cannulae a maximum of 50%

Abdominal distention

This has occurred in a small number of children, watch for abdominal distention and exercise caution if intra-abdominal pathology is suspected.

Nasal irritation

Although less common than with CPAP devices, mucosal injury is a possibility and may lead to ulceration or nose bleeds.

Pressure Areas

Skin irritation and damage from medical devices is always a concern and can be minimised with frequent checks on pressure areas, and re positioning of equipment (this extends to all equipment –pay particular attention to saturation monitoring probes / ECG electrodes)

Infection

There is a theoretical chance of infection from contaminated water used for humidification, however only 1 case has been reported [12] which resulted in a modification to the manufacturing process.

Blocked cannulae

HHHFT device cannula may become entirely or partially blocked with secretions, and should be checked frequently particularly when there are copious secretions.

appropriately. HHHFT is an aerosol generating therapy; the correct universal precautions and enhanced PPE as necessary should be observed at all times. The tubing and interface must be changed as per the manufacturer's guidelines, and labelled with the date next due for change.

Red flags

A red flag is a sign or symptom that alerts to the possible presence of a serious or life threatening condition, whilst they are not diagnostic on their own, their presence warrants urgent further action. There should be no delay in initiating more invasive management when required.

- any apnoeas or bradycardic episodes
- increasing respiratory effort despite initiation of HHHFT
- PEWS triggering escalation
- FiO2 > 60%
- Respiratory acidosis

The SBAR (Situation, Background, Assessment, Recommendation) tool should be used when escalating any concerns about patient conditions.[14]

Transfers

Unless an after-market uninterrupted power supply (UPS) has been purchased it is not possible to transfer on HHHFT. Even with a fully charge UPS in situ, the running time is extremely limited. If a child needs transferred there needs to be careful consideration of their oxygen needs, clinical state and the necessity of the move. If the move is deemed necessary, consider the most appropriate staffing and equipment needed on the transfer and ensure the child is able to manage in high flow face mask or non re breathe mask oxygen prior

Positioning of the patient is important both for their own comfort and efficacy of the therapy, consider the patients preferences but also ensure their position enables optimum ventilation, so a head up, sitting up (or semi-recumbent) or prone position.

Hydration / Nutrition

It is important to maintain hydration and nutrition for the duration of the patient's time on HHHFT, a clinical decision must be made about the patient's suitability for oral or enteral nutrition and any restrictions or limitations that should be applied. Consider Nasogastric feeds (continuous or small bolus) for infants, breast feeding may be appropriate and assist with patient comfort, always observe for clinical deterioration associated with feeding and escalate any concerns. If feeding is not suitable, or sufficient then IV hydration should be used to supplement.

Documentation

As well as the patient observations and PEWS, the HHHFT settings should be recorded at least hourly and when any changes are made. These include but are not limited to FiO2, flow and temperature plus any device checks that are required. It is useful to note when any interventions are done as they may result in a temporary change in the patient's condition (such as hygiene cares, CXR, bloods etc.) as it is useful for assessing the patients response to treatment. Nurses should always check settings and PEWS at any handover of care.

Infection prevention and Control

Local guidance should be followed for infection prevention and control, children requiring isolation may need a lower nurse to patient ratio in order to ensure patient safety and care needs are met

Accidental strangulation

As with all medical devices and children, the risks of accidental strangulation should be mitigated against. Consider where the machine and associated wiring /tubing is best positioned; try to avoid having wires/tubing trailing across the patient/bed. Patients should be continually observed.

Starting HHHFT

Making the decision

A senior paediatric doctor should be involved in making the decision to commence HHHFT and it should be documented in the management plan in the patient's notes.

Target saturations should be documented.

Staff should be familiar with the equipment in use, and have received training on how to use it, including how to trouble shoot. Staff must have completed the equipment competency unless they are a novice and are being directly supervised.

Interface selection

The nares must not be more than 50% occluded by the cannulae; the gap is required in order to reduce the risk of hyper distention of the airways or gastric system. When selecting the interface the size if the nares, not the overall size or weight of the patient should be the only consideration. If the desired flow cannot be achieved the maximum flow for the correct size interface must be used.

Where enabled (depending on equipment) ensure the correct mode is selected on the device to match the interface chosen, and that any alarm parameters are set.

Flow

There is very little research into the optimal flow rates for HHHFT in children (outside of its use in bronchiolitis); many guidelines base the flow rates on patient's age or weight. The flow rates from the Network guideline are shown below but please refer to your trust guideline.

Patient Weight	Suggested flow rates
< 12 kgs	2L/min/kg
13—15 kgs	20-30 l/min
16—30 kgs	25—35 l/min
31—50 kgs	30 –40 l/min
> 50 kgs	40—50 l/min

Be mindful not to exceed the manufacturers maximum flow rates for the chosen interface.

It can be useful to start with a low flow rate to allow the patient to acclimatise and then progressively increase the flow to the desired setting over a few minutes as the patient tolerates.

FiO2

Care should be taken to administer only the level of oxygen required to maintain the saturations at the desired level, and reduce the work of breathing. When commencing HHHFT consider the amount of oxygen the child is currently requiring to ,maintain their oxygen saturations (via a short term measure – face mask or non re-breathe mask) as this will inform the level of oxygen required to start with.

HHHFT can deliver from 21% (room air) up to 100% FiO2 to the patients. Some guidelines state to commence at 50% and titrate the FiO2 according to the patients clinical condition, local guidelines should be followed.

Take care when using HHHFT with infants with not to occlude the nostril as there is a risk of creating a closed circuit which can lead to unpredictable levels of distal positive pressure. Remember, any ambient air that the patient draws in may affect the concentration of oxygen being delivered to the patient.

Temperature

When cold gases are administered via regular nasal cannulae/ facemask, the ability for the body to warm and humidify the gas is reduced and has a detrimental impact both on the pulmonary system and systemically, for example contributing to hypothermia in infants. When the inspired gases are heated as in HHHFT to 37 degrees Celsius, this creates relative humidity of nearly 100% which mimics the body's own ability to warm and humidify gases when breathed in through the nose.

Most devices have pre-configured temperature settings for each mode/size of prong in use; there may an option to alter the target temperature within set parameters. Consider this if a child is struggling with the heat.

Nursing care of the child on HHHFT

Observations

Local guidelines should be followed, but in all cases children requiring HHHFT should have continuous saturation monitoring and at least hourly recording of observations and PEWS score. Consideration should be given to the need for continuous ECG monitoring but may be dependent on patent condition and cooperation. If any other co morbidity or co-existing condition requires more frequent or additional observations these should be respected. Blood pressure should be measured on admission and a decision made about frequency of continued measurement.